

National Soil Survey Handbook

Table of Contents

Parts 600 to 604 – General

Part 600 – Introduction

Subpart A – General Information

- 600.0 The Mission of the Soil Science Division, Natural Resources Conservation Service
- 600.1 Purpose
- 600.2 National Cooperative Soil Survey (NCSS) Standards
- 600.3 Principal References and Their Maintenance
- 600.4 Conventions and Terminology
- 600.5 Standards of the National Cooperative Soil Survey

Subpart B – Exhibits

- 600.10 List of Technical References
- 600.11 Tracking Flowchart for NSSH Amendments (After Figure 503-D2: Workflow for National-Level Directives Approval in Title 120, National Directives Management Manual, 2017)

Part 601 – National Cooperative Soil Survey Organization

Subpart A – General Information

- 601.0 Definition
- 601.1 NRCS Organization and Responsibilities

Subpart B – Appendix

- 601.10 Primary Federal Partners

Part 602 – Conferences of the National Cooperative Soil Survey

Subpart A – General Information

- 602.0 Definition

Subpart B – Exhibits

- 602.10 Bylaws of the National Cooperative Soil Survey Conference
- 602.11 Bylaws of the Western Regional Cooperative Soil Survey Conference
- 602.12 Bylaws of the Northeast Regional Cooperative Soil Survey Conference
- 602.13 Bylaws of the North Central Regional Soil Survey Conference (Revised June 7, 2012)
- 602.14 Bylaws of the Southern Regional Cooperative Soil Survey Conference
- 602.15 Conducting NCSS Regional Conferences

Parts 605 to 612 – Operations And Management

Part 606 – Working Agreements

Subpart A – General Information

- 606.0 Definition
- 606.1 Policy and Responsibilities

Subpart B – Exhibits

- 606.10 Template Statement of Commitment for Soil Survey and Ecological Site Inventory Projects

Part 607 – Initial Survey Preparation

Subpart A – General Information

- 607.0 Purpose
- 607.1 Policy and Responsibilities
- 607.2 Preliminary Survey Activities

Subpart B – Exhibits

- 607.10 Reference Materials for Soil Surveys
- 607.11 Example of a Procedure for Geodatabase Development, File Naming, Archiving, and Quality Assurance

Part 608 – Program Management

Subpart A – General Information

- 608.0 Definition and Purpose
- 608.1 Responsibilities and Organization
- 608.2 Soil Survey Area Designation
- 608.3 Areas of Limited Access, Denied Access Areas, and Areas Not Completed
- 608.4 Determining Workloads
- 608.5 Priorities for Soil Survey Activities
- 608.6 Planning Workflow
- 608.7 Goals and Progress
- 608.8 Developing Other Schedules for Soil Survey Operations
- 608.9 Status Maps

Subpart B – Exhibits

- 608.10 Long-Range Plan for Initial Soil Surveys
- 608.11 Annual Plan of Operations for Initial Soil Surveys
- 608.12 Goal and Progress Guidelines

Part 609 – Quality Control, Quality Assurance, and Soil Correlation

Subpart A – General Information

- 609.0 Definition and Purpose of Quality Control and Quality Assurance
- 609.1 Policy and Responsibilities for Quality Control and Quality Assurance

- 609.2 Soil Correlation
- 609.3 Seamless Soil Survey
- 609.4 Quality Control Reviews
- 609.5 Quality Assurance Reviews
- 609.6 Field Assistance Visits
- 609.7 Final Soil Survey Field Activities for Initial Soil Survey Projects
- 609.8 General Soil Maps, Index Maps, and Location Maps

Subpart B – Exhibits

- 609.10 Format for Correlation Document
- 609.11 List of Soil Property or Quality Attributes for Joining
- 609.12 Quality Control Template for Initial Soil Surveys (subject to change to reflect local conditions)
- 609.13 Outline of Items Considered in an Operations Management Review or Program Operations Review for Soil Survey
- 609.14 Initial Field Review Checklist for Initial Soil Surveys
- 609.15 Quality Assurance Worksheet for Initial Soil Surveys (subject to change by the SSRs to reflect local conditions)
- 609.16 Progress Field Review Checklist for Initial Soil Surveys
- 609.17 Final Field Review Checklist for Initial Soil Surveys
- 609.18 Project Review Checklist for MLRA Soil Surveys
- 609.19 Quality Assurance Worksheet for MLRA Soil Surveys (subject to change by the SSRs to reflect local conditions)

Part 610 – Updating Soil Surveys

Subpart A – General Information

- 610.0 Definition and Purpose
- 610.1 Policy and Responsibilities
- 610.2 Inventory and Assessment
- 610.3 Update Strategies
- 610.4 Project Plan
- 610.5 Prioritizing and Ranking
- 610.6 Long-Range Plan
- 610.7 Annual Plan of Operation (APO)
- 610.8 Certification of Soils Data
- 610.9 Publication of Soils Data

Subpart B – Exhibits

- 610.10 Agency Resources Concerns
- 610.11 Information Items for the Inventory and Assessment
- 610.12 Resources for the Inventory and Assessment
- 610.13 Sample Project Evaluation Worksheet
- 610.14 Project Plan Checklist
- 610.15 Example of a Project Evaluation Ranking Procedure

- 610.16 Project Description Examples

Parts 613 to 616 – Soil Classification

Part 614 – Applying Soil Taxonomy

Subpart A – General Information

- 614.0 Definition and Purpose
- 614.1 Policy and Responsibilities
- 614.2 National Soil Classification System
- 614.3 Use of the National Soil Classification System in Soil Surveys
- 614.4 Soil Taxonomy Committees, Work Groups, and Referees
- 614.5 Procedures for Amending Soil Taxonomy
- 614.6 The Soil Series

Subpart B – Exhibits

- 614.10 Flow Chart of Amendment Process
- 614.11 Example of an Official Soil Series Description in HTML
- 614.12 Explanation and Content of a Soil Series Description
- 614.13 Rounding Numbers from Laboratory Data
- 614.14 Significant Digits for Soil Property or Quality Measurements Used as Criteria in Soil Taxonomy

Parts 617 to 625 – Soil Interpretations

Part 617 – Soil Survey Interpretations

Subpart A – General Information

- 617.0 Purpose
- 617.1 Responsibilities
- 617.2 Interpretations for Map Unit Components and Map Units
- 617.3 Developing and Maintaining Interpretation Guides and Ratings
- 617.4 Reviewing and Implementing Soil Interpretative Technologies
- 617.5 The National Soil Information System
- 617.6 Presenting Soil Interpretations
- 617.7 Updating Soil Interpretations
- 617.8 Coordinating Soil Survey Interpretations
- 617.9 Writing Soil Interpretation Criteria
- 617.10 Documenting Soil Interpretation Criteria
- 617.11 Requirements for Naming Reports and Interpretations
- 617.12 Interpretation Overrides

Subpart B – Exhibits

- 617.20 Example of Descriptions for Documenting Interpretations

Part 618 – Soil Properties and Qualities

Subpart A – General Information

- 618.0 Definition and Purpose
- 618.1 Responsibilities
- 618.2 Collecting, Testing, and Populating Soil Property Data
- 618.3 Soil Properties and Soil Qualities
- 618.4 Albedo, Dry
- 618.5 Artifacts in the Soil
- 618.6 Available Water Capacity
- 618.7 Bulk Density, One-Third Bar
- 618.8 Bulk Density, Oven Dry
- 618.9 Bulk Density, Satiated
- 618.10 Calcium Carbonate Equivalent
- 618.11 Cation-Exchange Capacity NH₄OAc pH 7
- 618.12 Climatic Setting
- 618.13 Continuous Inundation Class, Depth, and Month
- 618.14 Corrosion
- 618.15 Crop Name and Yield
- 618.16 Diagnostic Horizon Feature – Depth to Bottom
- 618.17 Diagnostic Horizon Feature – Depth to Top
- 618.18 Diagnostic Horizon Feature – Kind
- 618.19 Drainage Class
- 618.20 Effective Cation-Exchange Capacity
- 618.21 Electrical Conductivity
- 618.22 Electrical Conductivity 1:5 (volume)
- 618.23 Elevation
- 618.24 Engineering Classification
- 618.25 Erosion Accelerated, Kind
- 618.26 Erosion Class
- 618.27 Excavation Difficulty Classes
- 618.28 Exchangeable Sodium
- 618.29 Extractable Acidity
- 618.30 Extractable Aluminum
- 618.31 Flooding Frequency Class, Duration Class, Inundation Type, and Month
- 618.32 Fragments in the Soil
- 618.33 Free Iron Oxides
- 618.34 Frost Action, Potential
- 618.35 Gypsum
- 618.36 Horizon Depth to Bottom
- 618.37 Horizon Depth to Top

- 618.38 Horizon Designation
- 618.39 Horizon Thickness
- 618.40 Hydrologic Group
- 618.41 Landscape, Landform, Microfeature, Anthroscape, Anthropogenic Landform, and Anthropogenic Microfeature
- 618.42 Linear Extensibility Percent
- 618.43 Liquid Limit
- 618.44 Organic Matter
- 618.45 Parent Material, Kind, Modifier, and Origin
- 618.46 Particle Density
- 618.47 Particle Size
- 618.48 Percent Passing Sieves
- 618.49 Plasticity Index
- 618.50 Ponding Depth, Duration Class, Frequency Class, and Month
- 618.51 Pores
- 618.52 Reaction
- 618.53 Restriction Kind, Depth, Thickness, and Hardness
- 618.54 Saturated Hydraulic Conductivity
- 618.55 Slope Aspect
- 618.56 Slope Gradient
- 618.57 Slope Length, USLE
- 618.58 Sodium Adsorption Ratio
- 618.59 Soil Erodibility Factors, USLE, RUSLE2
- 618.60 Soil Erodibility Factors for WEPP
- 618.61 Soil Moisture Status
- 618.62 Soil Slippage Potential
- 618.63 Soil Temperature
- 618.64 Subsidence, Initial and Total
- 618.65 Sum of Bases
- 618.66 Surface Fragments
- 618.67 T Factor
- 618.68 Taxonomic Family Temperature Class
- 618.69 Taxonomic Moisture Class
- 618.70 Taxonomic Moisture Subclass (Subclasses of Soil Moisture Regimes)
- 618.71 Taxonomic Temperature Regime (Soil Temperature Regimes)
- 618.72 Texture Class, Texture Modifier, and Terms Used in Lieu of Texture
- 618.73 Von Post Humification Scale
- 618.74 Water, One-Tenth Bar
- 618.75 Water, One-Third Bar
- 618.76 Water, 15 Bar
- 618.77 Water, Satiated
- 618.78 Water Temperature
- 618.79 Wind Erodibility Group and Index

Subpart B – Exhibits

- 618.80 Guides for Estimating Risk of Corrosion Potential for Uncoated Steel
- 618.81 Guide for Estimating Risk of Corrosion Potential for Concrete
- 618.82 Crop Names and Units of Measure
- 618.83 Classification of Soils and Soil-Aggregate Mixtures for the AASHTO System
- 618.84 Potential Frost Action
- 618.85 Distribution of Design Freezing Index Values in the Continental United States
- 618.86 Estimating LL and PI from Percent and Type of Clay
- 618.87 Texture Triangle and Particle-Size Limits of AASHTO, USDA, and Unified Classification Systems
- 618.88 Guide for Estimating Ksat from Soil Properties
- 618.89 Guide to Estimating Water Movement Through Bedrock for Layers Designated as R and Cr
- 618.90 Rock Fragment Modifier of Texture
- 618.91 Soil Erodibility Nomograph
- 618.92 Kw Value Associated With Various Fragment Contents
- 618.93 General Guidelines for Assigning Soil Loss Tolerance "T"
- 618.94 Texture Class, Texture Modifier, and Terms Used in Lieu of Texture
- 618.95 Wind Erodibility Groups (WEG) and Index
- 618.96 Key Landforms and Their Susceptibility to Slippage
- 618.97 Example Worksheets for Soil Moisture State by Month and Depth
- 618.98 NASIS Calculation for Estimating AASHTO Group Index
- 618.99 NASIS Calculation for Estimating Cation-Exchange Capacity
- 618.100 NASIS Calculation for Estimating Effective Cation-Exchange Capacity
- 618.101 NASIS Calculation for Estimating Extractable Acidity
- 618.102 NASIS Calculation for Estimating Liquid Limit and Plasticity Index
- 618.103 NASIS Calculation for Estimating Particle Size
- 618.104 NASIS Calculation for Estimating Rock Fragments and Percent Passing Sieves
- 618.105 NASIS Calculation for Estimating Water Content Data
- 618.106 References

Part 621 – Soil Potential Ratings

Subpart A – General Information

- 621.0 Definition and Purpose
- 621.1 Responsibilities
- 621.2 General
- 621.3 Developing Soil Potential Ratings
- 621.4 Steps in Preparing Soil Potential Ratings
- 621.5 Collecting Data
- 621.6 Definition of Soil Potential Classes
- 621.7 Soil Potential Index Concept
- 621.8 Procedures for Preparing Soil Potential Ratings
- 621.9 Defining Soil Use, Performance Standards, and Criteria for Evaluation

- 621.10 Terminology for Limitations and Corrective Measures
- 621.11 Format for Presenting Soil Potential Ratings

Subpart B – Exhibits

- 621.12 Analysis of Preparations and Procedures for Soil Potential Ratings
- 621.13 Soil Potential Ratings for Forest Land (Beta County)
- 621.14 Soil Potential for Dwellings Without Basements
- 621.15 List of Corrective Measures and Cost
- 621.16 Reserved (Worksheet for Preparing Soil Potential Ratings)
- 621.17 Explanation of Worksheets for Preparing Soil Potential Ratings for Forest Land (Beta County)
- 621.18 Reserved (Worksheet for Preparing Soil Potential Ratings for Forest Land (Beta County))
- 621.19 Reserved (Worksheet for Preparing Soil Potential Ratings for Septic Tank Absorption Fields (Sigma County))
- 621.20 Reserved (Worksheet for Preparing Soil Potential Ratings for Dwellings Without Basements (Alpha County))
- 621.21 Explanation of Soil Potential Ratings for Maps or Reports
- 621.22 Soil Potential Ratings for Septic Tank Absorption Fields
- 621.23 Soil Potential Ratings for Cropland
- 621.24 Soil Potential Ratings and Corrective Measures for Cropland, Pastureland, Forest Land, and Residential Land

Part 622 – Interpretative Groups

Subpart A – General Information

- 622.0 Definition and Purpose
- 622.1 Procedures and Responsibilities
- 622.2 Land Capability Classification
- 622.3 Farmland Classification
- 622.4 Highly Erodible Land – Highly Erodible Soil Map Unit List
- 622.5 Hydric Soils
- 622.6 Ecological Sites
- 622.7 Windbreaks
- 622.8 Wildlife Habitat
- 622.9 Plant Name, Common
- 622.10 Plant Name, Scientific
- 622.11 Ecological Site ID
- 622.12 Ecological Site Name
- 622.13 Earth Cover, Kind

Subpart B – Exhibits

- 622.20 Prime and Unique Farmlands
- 622.21 Example of Soil Properties and Qualities Used to Assign Land Capability Classes
- 622.22 Guide for Assigning Land Capability Classes to All Map Unit Components in California

- 622.23 Guides for Assigning Land Capability Subclasses to Soil Map Unit Components in California
- 622.24 Guide for Assigning Land Capability Units to Soil Map Unit Components in California
- 622.25 Guide for Assigning Land Capability Classes to All Map Unit Components in Indiana
- 622.26 Guide for Assigning Land Capability Subclasses to Soil Map Unit Components in Indiana

Part 624 – Soil Quality

Subpart A – General Information

- 624.0 Definition and Purpose
- 624.1 Quality Concepts

Subpart B – Exhibits

- 624.10 Soil Quality Test Kit (Instruction Manual)
- 624.11 References

Parts 626 to 636 – Soil Survey Field Procedures

Part 627 – Legend Development and Data Collection

Subpart A – General Information

- 627.0 Definition and Purpose
- 627.1 Policy and Responsibilities
- 627.2 Field Studies for Legend Development
- 627.3 Map Units of Soil Surveys
- 627.4 Map Unit Components
- 627.5 Terms Used in Naming Map Units
- 627.6 Phases Used to Name Soil Map Units
- 627.7 Soil Performance Data Collection
- 627.8 Documentation
- 627.9 Ecological Site and Soil Correlation Procedures

Subpart B – Exhibits

- 627.10 Miscellaneous Areas
- 627.11 Example of Form NRCS-SOI-1, "Soil Crop Yield Data"
- 627.12 Instructions for Completing Form NRCS-SOI-1, "Soil Crop Yield Data"
- 627.13 Identification Legend of Map Unit Symbols and Names
- 627.14 Form NRCS-SOI-37A, "Feature and Symbol Legend for Soil Survey"
- 627.15 Ecological Site and Soil Correlation Checklist
- 627.16 Ecological Site Checklist
- 627.17 Matrix of Investigation Intensity of Soil Surveys and Documentation

Part 629 – Glossary Of Landform and Geologic Terms

Subpart A – General Information

- 629.0 Definition and Purpose
- 629.1 Responsibilities
- 629.2 Definitions
- 629.3 References

Subpart B – Exhibits

- 629.10 Lists of Landscape, Landform, Microfeature, and Anthropogenic Feature Terms Contained in the Glossary
- 629.11 List of Materials or Material-Related, Structure, or Morphological-Feature Terms Contained in the Glossary
- 629.12 Genesis-Process Terms and Geologic Time Terms Contained in the Glossary
- 629.13 North American Glacial Episodes and General Geologic Time Scale
- 629.14 Till Terms
- 629.15 Pyroclastic Terms

Part 630 – Benchmark Soils

Subpart A – General Information

- 630.0 Definition and Purpose
- 630.1 Policy and Responsibilities
- 630.2 Criteria for Selecting or Revising Benchmark Soils
- 630.3 Maintaining a Record of Benchmark Soil Data Needs

Subpart B – Exhibits

- 630.10 Sample Narrative Record for Benchmark Soils

Part 631 – Soil Survey Investigations

Subpart A – General Information

- 631.0 Definition and Purpose
- 631.1 Policy and Responsibilities
- 631.2 Kinds of Projects
- 631.3 Laboratory Investigation Methods
- 631.4 Field Investigation Methods
- 631.5 Investigations Planning
- 631.6 Requesting Assistance
- 631.7 Laboratory Databases

Subpart B – Exhibits

- 631.10 Research Work Plan Checklist
- 631.11 Example Research Work Plan
- 631.12 Example of a Soil Characterization Work Plan

Parts 637 to 643 – Soil Survey Information Systems

Part 638 – Soil Data Systems

General Information

- 638.0 Definition and Purpose
- 638.1 Procedures and Responsibilities
- 638.2 Components of the National Soil Information System
- 638.3 Managing Soil Spatial and Tabular Databases
- 638.4 Soil Survey Goals and Progress
- 638.5 Distribution of Soils Data

Part 639 – National Soil Information System (NASIS)

Subpart A – General Information

- 639.0 Definition and Purpose
- 639.1 Policy and Responsibilities
- 639.2 Soil Survey Application Security Policy
- 639.3 NASIS Organization and Database Objects
- 639.4 Guidelines for Changing, Adding, or Deleting Soil Property Data Elements

Subpart B – Exhibits

- 639.10 Proposed Amendment to Soil Data Dictionary

Parts 644 to 646 – Soil Survey Publications

Part 644 – Delivering Soil Survey Information

Subpart A – General Information

- 644.0 Definition and Purpose
- 644.1 Types of Soil Survey Delivery
- 644.2 Policy and Responsibilities
- 644.3 Soil Survey Products
- 644.4 Development of Point Data
- 644.5 Development of Detailed Soil Survey Information
- 644.6 Development of a Complete Soil Survey Publication
- 644.7 Development of the U.S. General Soil Map

Subpart B – Exhibits

- 644.10 Sections of a Soil Survey Publication
- 644.11 Record Sheet for Collating State Orders for Published Soil Surveys
- 644.12 Example of Letter to Senator – Notification of Availability of Soil Survey

Parts 647 to 650 – Soil Maps

Part 647 – Soil Map Development

Subpart A – General Information

- 647.0 Definition and Purpose
- 647.1 Procedures and Responsibilities
- 647.2 Imagery
- 647.3 SSURGO Characteristics
- 647.4 Data Capture Specifications
- 647.5 Archiving
- 647.6 Digital Map Finishing and Print-on-Demand Maps

Subpart B – Exhibits

- 647.10 Soil Survey Geographic Data Certification
- 647.11 Digital Map Finishing and Print-on-Demand Maps Flowchart
- 647.12 Digital Map Finishing and Print-on-Demand Maps Specifications
- 647.13 Digital Map Finishing Checklist
- 647.14 Digital Map Finishing Certification
- 647.15 Glossary
- 647.16 SSURGO Metadata Template

Part 648 – Digital Soil Mapping – Raster Products for Soil Survey

Subpart A – General Information

- 648.0 Definition and Purpose
- 648.1 Raster Soil Surveys
- 648.2 Soil Landscapes of the United States
- 648.3 Accuracy and Uncertainty
- 648.4 References

Subpart B – Exhibits

- 648-10 Glossary
- 648-11 Digital Soil Mapping Workflow
- 648-12 Raster Soil Survey Areas
- 648-13 Map Scale
- 648-14 Digital Soil Mapping Project – Final Correlation Document Example
- 648-15 Metadata
- 648-16 References

Part 649 – Land Resource Areas

Subpart A – General Information

- 649.0 Definition and Purpose
- 649.1 Policy and Responsibilities
- 649.2 Descriptions
- 649.3 Land Resource Area Attributes
- 649.4 Cartographic Standards
- 649.5 Names and Symbols

- 649.6 Coding System for Hierarchical Land Resource Areas for Ecological Sites
- 649.7 Establishing or Revising Land Resource Areas
- 649.8 Publication

Subpart B – Exhibits

- 649.10 References

Parts 651 to 659 – Information Delivery

Part 651 – Advance Soil Survey Information

General Information

- 651.0 Definition and Purpose
- 651.1 Policy and Responsibilities
- 651.2 General
- 651.3 Restrictions
- 651.4 Providing Quality Assurance, Quality Control, and Review
- 651.5 Labeling of Advance Soil Survey Information

Part 655 – Technical Soil Services

General Information

- 655.0 Definition
- 655.1 Types of Service
- 655.2 Policy
- 655.3 Responsibilities

Part 656 – Coastal Zone Soil Survey (CZSS)

Subpart A – General Information

- 656.0 Definition and Purpose
- 656.1 Boating Safety
- 656.2 CZSS Laboratory Sample Collection Methods
- 656.3 CZSS Laboratory Sample Analysis Methods
- 656.4 CZSS Cartographic Standards

Part 600 – Introduction

Subpart A – General Information

600.0 The Mission of the Soil Science Division, Natural Resources Conservation Service

The Soil Science Division provides leadership and service to produce and deliver scientifically based soil information to help society understand, value, and wisely manage global resources.

600.1 Purpose

The National Soil Survey Handbook and other technical and procedural references provide the standards, guidelines, definitions, policy, responsibilities, and procedures for conducting the National Cooperative Soil Survey (NCSS) in the United States.

600.2 National Cooperative Soil Survey (NCSS) Standards

NCSS standards are common or shared procedures that enhance technology transfer, data sharing, and communications among soil survey participants. They apply to various soil survey functions. The references listed in part 600, subpart B, section 600.10, contain standards.

600.3 Principal References and Their Maintenance

A. The three principal publications guiding the NCSS are the Soil Survey Manual, “Soil Taxonomy,” and the National Soil Survey Handbook. Part 600, subpart B, section 600.10, lists other technical references that are important in gathering and applying soil knowledge. The following paragraphs describe how these publications are revised and how they apply to the NCSS in the United States.

B. The Soil Survey Manual

The purpose of Agriculture Handbook 18, the Soil Survey Manual, is to provide the major principles and concepts for making and using soil surveys and the standards and conventions for describing soils. The manual is intended primarily for use by soil scientists engaged in making and interpreting soil surveys. It is also the basic reference for soil survey users who desire to learn the scientific methods that form the basis for soil surveys. It discusses general procedures to illustrate and explain the principles and concepts, but the National Soil Survey Handbook presents current operational procedures of NRCS in more detail.(2) Amendments may be issued to the Soil Survey Manual as NRCS directives. Proposals to amend the manual may originate from any interested individual or group participating in the NCSS or from staffs of foreign soil survey organizations. The originating group or author forwards the proposal to the national leader for soil survey standards.

C. “Soil Taxonomy” and “Keys to Soil Taxonomy”

Agriculture Handbook 436, second edition (1999), “Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys,” provides the common base for the organization of knowledge about soils and the standards for their classification. “Keys to Soil Taxonomy,” which is periodically revised, provides excerpts of “Soil Taxonomy” that can be readily used in the field and contains all the approved revisions and amendments to “Soil Taxonomy.” Procedures to amend “Soil Taxonomy” are outlined in part 614 of this handbook.

D. The National Soil Survey Handbook

- (1) Unlike manuals in eDirectives, which “issue policies and procedures on a specific subject,” the National Soil Survey Handbook provides guidelines, definitions, responsibilities, and how-to procedures for conducting the NRCS part of the NCSS (Title 120, National Directives Management Manual (NDMM)). It contains information relative to planning and managing soil surveys, collecting and maintaining soil survey information, and distributing the information to users. The National Soil Survey Handbook provides specific information about the field activities, correlation, interpretation, publication, and dissemination of soil surveys of the NCSS.
- (2) The National Soil Survey Center updates the National Soil Survey Handbook on a periodic basis. Any member of the NCSS may suggest changes or additions to the handbook. The originating author sends the proposed changes or additions, along with an explanation of and support for the need for the change or addition, to the national leader for soil survey standards at the National Soil Survey Center. The center reviews proposed changes, amendments, and additions at least annually. The director of the Soil Science Division issues approved amendments and notifies users of the National Soil Survey Handbook. This handbook is not to be amended or supplemented by regional or local offices.

E. User Manuals

User manuals contain procedures for conducting soil survey activities, such as those related to the electronic storage and display of soil information. Examples are the user guides for the National Soil Information System.

F. Guides

Guides provide special information and criteria for various functions, such as interpreting soils and updating major land resource areas. Regional guides may be developed and used as needed to supplement national guides.

600.4 Conventions and Terminology

The following are conventions and terminology used in the National Soil Survey Handbook. Unless otherwise stated, all information provided herein are standards of the National Cooperative Soil Survey.

- (1) Policy.—A principle to be followed to guide decisions to achieve a desired outcome. Policy differs from procedure or protocol in that a policy contains the “what” and the “why” only. Procedures or protocols also include the “what,” “how,” “where,” and “when.” Policies are determined and adopted by the Chief and may be delegated to other senior staff within NRCS. Protocols and procedures are developed by the senior managers to implement policy. Title 130, General Manual, Part 407, “National Policy,” states that policies are adopted to ensure—
 - (i) Conformance to laws and rules.
 - (ii) Implementation of Executive orders and other Executive direction.
 - (iii) Program quality control.
 - (iv) Accountability.
 - (v) Quality, consistency, and coordination in products and services.
- (2) Standard.—An established requirement defining technical criteria, methods, processes, or practices that must be accomplished or adhered to in order to ensure mission objectives are being met. Soil survey standards include sets of definitions and specifications. The definitions are standardized to ensure that everyone is using terminology that has the same meaning. Standards ensure consistency and repeatability of field procedures and analytical procedures

so that soil surveys meet user needs and processes are repeatable in all locations. Standards may also apply to the results or performance of the soil survey information and data.

- (3) Procedure.—An established or official step-by-step set of instructions for completing a task.
- (4) Protocol.—Mandatory steps or a system of rules that detail the correct conduct and procedures to be followed in formal situations to ensure policy is adhered to. An example of this would be the process for amending the National Soil Survey Handbook.
- (5) Process.—Chronological set of linked steps or actions for accomplishing a task.
- (6) Guideline.—Any document that aims to streamline particular processes according to a set routine. By definition, following a guideline is never mandatory. Guidelines are an essential part of the larger process of governance. They may be issued and used by an organization to make the actions of its employees or divisions more predictable and, presumably, of higher quality.
- (7) Method.—An established means for completing an action. There may be more than one method available to accomplish a task.
- (8) Exhibit.—An example, typically showing a completed product. Exhibits do not imply that protocols, policy, or standards were followed unless explicitly stated that such is the case. (An exhibit may be an example of what not to do.)

600.5 Standards of the National Cooperative Soil Survey

A. The procedures and guidance (a.k.a., “standards”) used in the Soil Survey Program are dynamic and may change. Standards are critical to the success of developing and delivering accurate and consistent soil survey information to the public.

B. Standards are a set of rules or criteria. They serve as the metric to determine if mission objectives are being met. Standards may take on a number of forms and be developed in a number of ways. Soil survey standards include sets of definitions and specifications. The definitions are standardized to ensure everyone is using terminology that has the same meaning. Standards apply to the use of specific processes, procedures, or methodologies in order ensure consistency and repeatability of field procedures and analytical procedures. They can also apply to the results or performance of the soil survey information and data. Many of the standards used by the NCSS are applied nationally and internationally by the soil science discipline.

C. Soil survey standards should convey requirements clearly and concisely. For standards to be meaningful, they must be written, maintained, and readily available to reference and they must be followed in conducting and delivering soil survey products. Specific rules are followed in the development, modification, and maintenance of standards. Soil survey standards are managed and maintained by the Soil Survey Standards Branch at the National Soil Survey Center. Requests for changes or additions in soil survey standards should be directed to the national leader for soil survey standards.

D. The flowchart in part 600, subpart B, section 600.11, shows the steps that guide revision of the National Soil Survey Handbook (120-NDMM).

Part 600 – Introduction

Subpart B – Exhibits

600.10 List of Technical References

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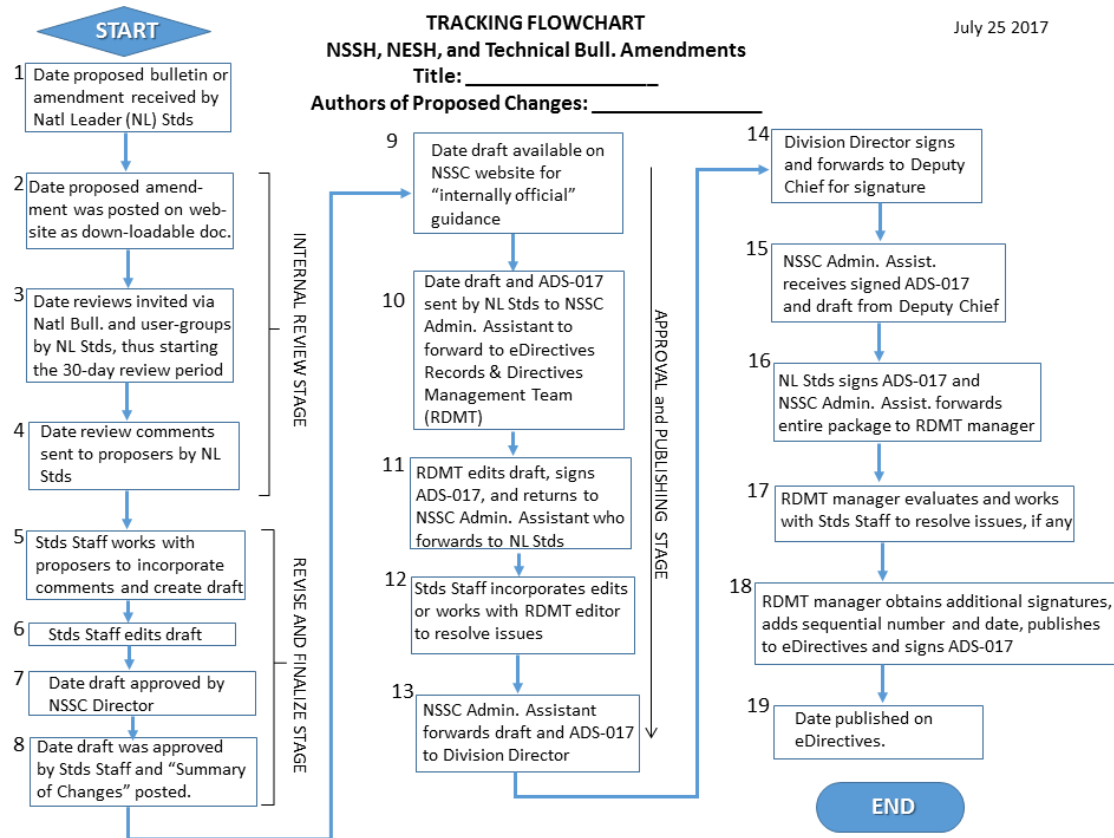
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600.11 Tracking Flowchart for NSSH Amendments

(After Figure 503-D2: Workflow for National-Level Directives Approval in Title 120, National Directives Management Manual, 2017)



Part 601 – National Cooperative Soil Survey Organization

Subpart A – General Information

601.0 Definition

A. The National Cooperative Soil Survey (NCSS) is a nationwide partnership of Federal, regional, State, and local agencies and private entities and institutions. This partnership works to cooperatively investigate, inventory, document, classify, interpret, disseminate, and publish information about soils of the United States and its trust territories and commonwealths. The activities of the NCSS are carried out on national, regional (such as the major land resource area, or MLRA), and State levels.

B. NRCS is responsible for the leadership of soil survey activities of the U.S. Department of Agriculture, for the leadership and coordination of NCSS activities, and for the extension of soil survey technology to global applications. Additional information about the Soil Survey Program is in the NRCS general manual (<http://directives.sc.egov.usda.gov/RollupViewer.aspx?hid=16988>) under.

C. Primary Federal agency NCSS participants include the Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), Department of Defense (DoD), Forest Service (FS), National Park Service (NPS), and NRCS. Part 601, subpart B, section 601.10, has a short description of the roles of these partners. In addition to these Federal agency partners, there are numerous State and local partners participating in the NCSS. Information about the organization and responsibilities of partner agencies is contained in their policy documents.

601.1 NRCS Organization and Responsibilities

A. This section provides information about many of the responsibilities of various offices within NRCS as they pertain to the National Cooperative Soil Survey Program.

B. NCSS Responsibilities of the Soil Survey Office (SSO)

- (1) Conducting an inventory and assessment of existing soil survey and ecological site information to identify deficiencies and make recommendations for improvement
- (2) Developing a long-range plan and associated project plans for updating soil survey and ecological site information in the MLRA soil survey area
- (3) Managing the soil survey and ecological site activities, including fieldwork, correlation, the National Soil Information System (NASIS) database, and geospatial information within the MLRA soil survey area
- (4) Supervising and training staff members
- (5) Controlling the quality of all phases of the soil survey and ecological site activities to ensure they meet NCSS standards
- (6) Conducting progressive correlation during the course of all survey activities
- (7) Ensuring seamless soil survey products across political and physiographic boundaries in the survey area
- (8) Providing leadership for the technical team by identifying survey update needs and carrying out the completion of priority projects (see part 608, section 608.1G)
- (9) Preparing for quality assurance reviews conducted by the soil survey regional office (SSR)
- (10) Ensuring that findings and recommendations identified in the SSR quality assurance reviews are addressed and implemented in a timely manner
- (11) Preparing drafts of official soil series descriptions (OSDs) and ecological site descriptions (ESDs)

C. NCSS Responsibilities of the Resource Soil Scientist

- (1) Assisting the State soil scientist with the development, coordination, and maintenance of field office technical guides and soil interpretations
- (2) Conducting onsite soils investigations according to agency authorities
- (3) Evaluating and assisting field offices in maintaining the official soil survey information
- (4) Coordinating with the soil survey office and State office to make any needed changes in the official soil survey data
- (5) Providing assistance in the use of soil information for the implementation of NRCS programs
- (6) Providing interdisciplinary advice and expertise to solve resource problems
- (7) Assisting with special soil studies, including collecting additional site and soil information on the performance and behavior of correlated soil map units
- (8) Training NRCS staffs and the public to understand and utilize soil survey data and information
- (9) Assisting the State soil scientist with the development and dissemination of soil information and in promoting soil survey
- (10) Assisting the State soil scientist in evaluating the adequacy of existing soil survey maps, data, and interpretations through participation on the SSO technical team

D. NCSS Responsibilities of the State Soil Scientist

- (1) Providing technical soil services to other staffs and leadership to resource soil scientists
- (2) Developing cooperative relationships to enhance the funding, progress, use, and understanding of soil surveys
- (3) Serving as the primary liaison to State NCSS cooperators, including hosting an annual meeting to evaluate and document soil survey needs and make recommendations for soil survey and ecological site activities
- (4) Planning and prioritizing activities of technical soil services
- (5) Periodically hosting the regional or national NCSS conference
- (6) Documenting the needs for updating soil survey maps, data, and interpretations
- (7) Serve as a member of the management team(s) for the SSRs serving the State (refer to part 608, section 608.1F)
- (8) Assisting soil survey users in understanding and applying soil survey information
- (9) Coordinating the development of localized soil interpretations
- (10) Marketing soil survey information
- (11) Providing statewide leadership in the application and use of soil survey information, including general soil maps, geomorphic maps, and block diagrams
- (12) Ensuring the technical content, coordination, and quality of soil information in the field office technical guides
- (13) Providing advice and expertise on soil-related issues to all NRCS conservation programs
- (14) Posting updated soil survey data to the Soil Data Warehouse
- (15) Assisting in national soil program initiatives
- (16) Interpreting and distributing a State subset of the NASIS data
- (17) Providing leadership in identifying the need for new soil survey information and interpretations within the State
- (18) Providing leadership for the development of new soil survey applications, technology, and information delivery within the State

E. NCSS Responsibilities of the State Conservationist (STC)

- (1) Serving (or designating someone to serve) on the Board of Advisors to provide advice, counsel, and broad management direction to the soil survey regional director and

- management team to ensure soil survey operations and ecological site activities are relevant to agency goals, priorities, and conservation needs
- (2) Reviewing the progress and performance of soil survey and ecological site activities in the region in relation to agency goals and priorities and provide feedback to the associate director for soil operations for consideration during periodic performance reviews and annual evaluations of soil survey regional directors
- (3) Reviewing and concurring with management team recommendations on project priorities for soil survey and ecological site activities, ensuring that local needs are in balance with State and national issues, or providing alternate advice

F. NCSS Responsibilities of the Soil Survey Regional Office (SSR)

- (1) Providing leadership in the production and quality assurance of soil survey and ecological site information
- (2) Convening the annual meetings or teleconferences of the Board of Advisors
- (3) Developing standard operating procedures for the soil survey region that outline the responsibilities and specifications for conducting soil surveys and ecological site activities
- (4) Planning and managing the SSR activities in cooperation with State soil scientists, cooperators, and other stakeholders
- (5) Coordinating with National Soil Survey Center (NSSC) soil scientists and other disciplines, as appropriate, to maintain and improve soil surveys
- (6) Securing technical advice, expertise, and review from other disciplines for soil interpretations and technical reports
- (7) Providing technical support and guidance to soil survey offices
- (8) Conducting quality assurance reviews
- (9) Providing supplemental training in all aspects of soil survey operations as may be needed (beyond that provided by the Soil Science Division) to soil survey office staffs through technical notes, onsite visits, workshops, and similar activities
- (10) Providing quality assurance for NASIS, OSDs and ESDs, the Soil Survey Geographic (SSURGO) database, the Digital General Soil Map of the United States (STATSGO2) database, and technical reports
- (11) Developing soil correlation documents for initial soil surveys
- (12) Maintaining the national OSD and soil classification (SC) databases for soil series mapped in the region
- (13) Providing MLRA-specific correlation guidelines for technical issues, such as soil temperature and moisture regimes and their associated ecological zones and vegetation, and any other MLRA-specific information
- (14) Providing leadership for the coordinated collection of soil characterization data and investigations in the region related to soil survey
- (15) Providing leadership in collecting, analyzing, and interpreting soil performance and characterization data
- (16) Coordinating proposed revisions to boundaries of major land resource areas with States and the NSSC

G. NCSS Responsibilities of the National Technology Support Center Core Team Soil Scientist

- (1) Providing assistance to States and soil survey regional offices in developing and implementing strategies to coordinate and deliver soil survey data and interpretations to meet specific program needs, such as ranking systems and eligibility criteria for the Conservation Reserve Program (CRP) and the Environmental Quality Incentives Program (EQIP)
- (2) Providing technical assistance and guidance in developing interpretive criteria to meet State's specialized interpretive needs
- (3) Promoting the use and integration of soil survey information in public and program policies

H. NCSS Responsibilities of the National Soil Survey Center

- (1) Providing leadership in the development of guidelines, standards, and procedures for all technical phases of NCSS work
- (2) Maintaining and improving the scientific basis for the NCSS program
- (3) Maintaining national soil survey standards, which are contained in the National Soil Survey Handbook, Soil Survey Manual, Soil Taxonomy, Soil Survey Laboratory Methods Manual, and other topical handbooks for mapping, classification, interpretation, investigation, laboratory analysis, and data management
- (4) Developing and maintaining the National Ecological Site Handbook
- (5) Assisting international, national, SSR, State, and soil survey office staffs in soil survey and ecological site activities
- (6) Coordinating with the National Employee Development Center to plan and deliver training for the Soil Science Division, including training in soil survey procedures, soil classification, pedology, geomorphic principles and application, interpretations, investigations, soil survey project management, technical soil services, ecological site inventory, and data management
- (7) Supplementing basic soil survey information with laboratory and field data on the properties and behavior of soils
- (8) Providing liaisons to each of the NCSS regional conferences

I. NCSS Responsibilities of the Geospatial Research Unit, National Soil Survey Center

- (1) Promoting partnerships with educational institutions, private industry, and government agencies to research and develop technologies that will enhance the production and utilization of soil information
- (2) Addressing future soil information dissemination in partnership with the National Geospatial Center of Excellence by developing technologies to support distribution
- (3) Implementing functional user-friendly applications by delivering them to the appropriate functional unit for their use

J. NCSS Responsibilities of National Headquarters

- (1) Formulating national policies regarding the Soil Survey Program and Ecological Site Program
- (2) Formulating policy regarding the integration of technical soil services within NRCS and with other agencies
- (3) Representing NRCS agency interests to the NCSS
- (4) Providing leadership for the Federal part of the NCSS
- (5) Chairing and coordinating the NCSS and its activities
- (6) Developing and maintaining relationships and contacts with NCSS cooperators
- (7) Developing soil science-related policies, procedures, and implementation strategies for maintaining and coordinating States' Field Office Technical Guides, with primary emphasis on section II
- (8) Developing, reviewing, and recommending program policy
- (9) Providing technical expertise to the Agricultural Research Service, university research stations, and others in the use and application of soils and soil survey information for the development of environmental models such as RUSLE2, WEPS, WIN-PST, WEPP, and EPIC
- (10) Providing technical expertise to task forces, committees, and work groups dealing with natural resource issues, such as air, water, and soil quality, and related legal, social, and policy concerns

Part 601 – National Cooperative Soil Survey Organization

Subpart B – Appendix

601.10 Primary Federal Partners

- A. This subpart provides brief descriptions of the roles of the five primary Federal partners in NCSS. Descriptions were prepared in 2006 by representatives of each agency. The most current information is contained in each agency's own policy documents.

B. Bureau of Indian Affairs (BIA)

BIA is the primary contact for soil surveys on the 93.7 million acres of Native American lands. Soil surveys are primarily at 1:24,000 scale to support decision-making processes for land management. Soil surveys are needed for farming, community planning, land development, and grazing and forest management. Soil survey and ecological site data are necessary for land health assessments, grazing permit renewal, energy and mineral permitting and leasing, restoration of natural fire processes, restoration of the health of the land, maintenance of clean water and air, and invasive plant control. Soil information is fundamental in assessing soil capabilities, limitations, and vulnerability to degradation and loss of capacity so that the health of the land can be sustained. Because Native American lands are considered private lands, NRCS has the responsibility to complete soil surveys on Native American lands. Soil surveys are completed in conjunction with BIA soil scientists and other staff.

C. Bureau of Land Management (BLM)

- (1) BLM manages approximately 261 million acres of public land, located primarily in 12 western States. The mission of BLM is to sustain the health, diversity, and productivity of public land for the use and enjoyment of present and future generations. BLM-administered land include a diverse mosaic of grassland, shrub land, forest, desert, and arctic and alpine ecosystems on extensive landscapes that range from nearly level playas to steep, rugged mountains. These landscapes and ecosystems contain a wide variety of soils with diverse properties that can significantly affect use and management. BLM manages a wide variety of resources and uses, including energy and minerals, livestock forage, fish and wildlife habitat, timber, wild horse and burro populations, watershed values, wilderness and recreation areas, and cultural and other natural heritage values. BLM administers public land within a framework of numerous laws and regulations, including FLPMA, NEPA, and State water-quality laws. Soils are one of the most fundamental natural resources on public land. Soils sustain the health, diversity, and productivity of the land. Soil quality and health are the driving forces that determine these factors.
- (2) Soil surveys are primarily at 1:24,000 scale to support decision-making processes for land management. Soil survey and ecological site data are necessary for rangeland health assessments, grazing permit renewal, energy and mineral permitting and leasing, restoration of natural fire processes, restoration of the health of the land, maintenance of clean water and air, and invasive plant control. Soil information is fundamental in assessing soil capabilities, limitations, and vulnerability to degradation and loss of capacity so that the health of the land can be sustained. The information and interpretations provided in soil surveys are helpful in managing all activities on public land that disturb the soil. Most soil and ecological mapping on public land has been accomplished through reimbursable agreements with NRCS.

D. Department of Defense (DoD)

- (1) DoD manages about 50 million acres and is divided into five main agencies. The Army has about 17 million acres of mission land, the Air Force has about 9 million acres, the Navy has about 2 million acres, the Marine Corps has about 1 million acres, and the Army Corps of Engineers has about 15 million acres. The remainder is divided up by smaller agencies.
- (2) DoD has two missions on its installations. The first mission is to train soldiers, marines, airmen, and sailors in conditions as close as possible to those under which they may have to fight. The second mission is to manage the conservation of natural resources. Managing the conservation of natural resources allows for the first mission.
- (3) The Sikes Act, as amended, requires each component service (Army, Air Force, Navy, and Marine Corps) to have an integrated natural resources management plan (INRMP) for each installation and training site that has significant natural resources. The INRMP describes the installation's natural resources and its management strategy for sustaining them while supporting the installation's military mission.
- (4) Each service's natural resources management implementing guidelines require a soil planning-level survey as part of an installation's INRMP. A soil planning-level survey is equivalent to an NCSS soil survey product at an order-2 level of detail. Each service either names NRCS as the source from which to obtain soils data or requires that the soil survey be done according to NCSS standards and procedures. Each installation's mission normally dictates the level of detail needed. The Army's standard is a 1:12,000-scale soil survey to support installations where millions of miles are used for land-intensive mission training, including vehicle use (from ATVs to main battle tanks). On installations that DoD is closing, those involved in clean-up efforts often require order-2 soil surveys to understand the effects of chemicals and constituents of concern and how to safely manage their transport. Installations that need a soil survey enter into an agreement with NRCS through the SSRs in which the installation is located. At the installation's request, the soil survey may be restricted from public access due to national security concerns.

E. Forest Service (FS)

- (1) The national forests (formerly called forest reserves) originated with the Forest Reserve Act of 1891, which allowed the President to establish forest reserves from timber-covered public domain land. National forests and grasslands encompass 193 million acres of land. There are 155 national forests and 20 grasslands. Congress established the Forest Service to provide quality water and timber for the Nation's benefit. The Forest Service manages national forests for multiple uses (including recreation) and benefits and for the sustained yield of renewable resources such as water, forage, wildlife, and wood. Managing for multiple uses means managing resources under the best combination of uses to benefit the American people while ensuring the productivity of the land and protecting the quality of the environment.
- (2) The National Forest System uses soil resource inventories and terrestrial ecological unit inventories to develop land and resource management plans as well as project plans. The Forest Service pursues an ecological approach to land stewardship. This approach has increased the need for soil resource inventories to collect and classify vegetation data in conjunction with progressive inventories. Soil surveys in the eastern United States have been completed primarily through agreements with NRCS. In the western States, soil surveys are typically completed by Forest Service staff.

F. National Park Service (NPS)

- (1) NPS is the steward for natural resources on nearly 85 million acres of public land. Management policies and guidelines for soil resource management are contained in NPS-77, Natural Resources Management. The NPS management policies state: "The NPS will actively seek to understand and preserve the soil resources of parks and to prevent, to the extent possible, the unnatural erosion, physical removal, or contamination of the soil, or its

- contamination of other resources.” The NPS Soil Inventory and Monitoring Program uses the appropriate detailed geospatial soil databases to define the distribution of soil types; determine their physical, chemical, and biological characteristics; provide interpretations needed to assess soil capabilities, limitations, and vulnerabilities to degradation; promote a soil conservation ethic; and support soil resources management, vital signs monitoring, ecological restoration activities, and agency decisions on the development of facilities.
- (2) Soil management objectives are to—
- (i) Preserve intact, functioning, natural systems by preserving native soils and the processes of soil genesis in a condition undisturbed by humans.
 - (ii) Maintain significant cultural objects and scenes by conserving soils in a manner consistent with the associated historic practices and by minimizing soil erosion to the extent possible.
 - (iii) Protect property and provide safety by ensuring that developments and their management take into account soil limitations, behavior, and hazards.
 - (iv) Minimize soil loss and disturbance caused by special use activities and ensure that soils retain their productivity and potential for reclamation. NPS typically works with NRCS, through interagency agreements, to support soil survey crews, which map NPS lands as well as refine or develop ecological site descriptions to meet agency needs.

Part 602 - Conferences of the National Cooperative Soil Survey

Subpart A - General Information

602.0 Definition

A. According to the NRCS General Manual, Title 430, Part 402, "The National Cooperative Soil Survey (NCSS) is a nationwide partnership of Federal, regional, State, and local agencies; private entities; and institutions that cooperatively inventory, investigate, classify, interpret, disseminate, and maintain information about the soils of the United States and its trust territories and commonwealths. The cooperators promote the understanding and appropriate use of soil information. NRCS provides leadership for the NCSS."

The NCSS coordinates technically and operationally at national, regional, and State levels. Its activities relate to the technology for the collection, management, and presentation of information about the properties, patterns, and responses of soils and to other joint concerns, such as training and coordinated research and operations. Workshops, meetings, and conferences at each level resolve concerns and address proposals and recommendations for the cooperative soil survey (see also part 601, subpart A, section 601.0 of this handbook).

B. The National Cooperative Soil Survey Conference

The national conference primarily discusses subjects of national concern to NCSS. The Soil and Plant Science Division director calls the conference in odd-numbered years after consulting with the conference steering committee. NRCS publishes the proceedings of the conference and distributes copies to the cooperators in NCSS. The conference bylaws specify the objectives, membership, and committees. Refer to part 602, subpart B, section 602.10, for the bylaws of the NCSS Conference. Guidance on conducting NCSS conferences is provided in section 602.15.

C. NCSS Regional Conferences

The NCSS regional conferences primarily discuss subjects of regional concern. Each region convenes a soil survey conference in even-numbered years. The four regions correspond to the agricultural experiment station regions and are the North Central, Northeast, Southern, and Western. The conference steering committee publishes the conference proceedings and distributes copies to regional NCSS cooperators and others. The conference bylaws specify the objectives, membership, and committee responsibilities. Refer to part 602, subpart B, sections 602.11, 602.12, 602.13, and 602.14, for the bylaws of the four NCSS regional conferences. Guidance on conducting NCSS conferences is provided in section 602.15.

D. NCSS State Conferences

The NCSS State conferences primarily discuss subjects of State concern. The NRCS State soil scientist annually convenes a State conference. Attendees include cooperators and others who contribute to NCSS activities and principal users of soil survey information within the State. Working agreements govern activities of NCSS within the State.

E. Joint Regional or State Conferences

Joint regional or State conferences between two or more regions or States may be held with the agreement of the participants involved.

Part 602 – Conferences of the National Cooperative Soil Survey

Subpart B – Exhibits

602.10 Bylaws of the National Cooperative Soil Survey Conference

Article I. Name

Section 1.0 The name of the conference is the National Cooperative Soil Survey (NCSS) Conference.

Article II. Objectives

Section 1.0 The objectives of the conference are to: (1) contribute to the general human welfare by promoting the use and understanding of soil resource information, and (2) develop recommendations for courses of action, including national policies and procedures, related to soil surveys and soil resource information.

Article III. Membership and Participants

Section 1.0 Participants of the national conference consist of:

Section 1.0.1 NCSS members

Section 1.0.2 Individuals invited by the steering committee.

Article IV. Regional Conferences

Section 1.0 Regional conferences are organized in the northeast, north-central, southern, and western regions of the United States.

Section 2.0 Each regional conference adopts its own purpose, policies, and procedures, provided these are consistent with the bylaws and objectives of the NCSS National Conference.

Article V. Executive Services

Section 1.0 The National Headquarters Soil and Plant Science Division Staff of the Natural Resources Conservation Service (NRCS) provides the national and regional conferences with executive services.

Section 1.1 Responsibilities of the NRCS Soil and Plant Science Division Staff include:

Section 1.1.1 Carrying out administrative duties assigned by the national steering committee.

Section 1.1.2 Making regional and national committee reports and conference planning documents available on the NCSS website.

Section 1.1.3 Issuing announcements and invitations.

Title 430 – National Soil Survey Handbook

- Section 1.1.4* Preparing and distributing the program.
- Section 1.1.5* Assigning a recorder to the national business meeting and posting the minutes on the NCSS website.
- Section 1.1.6* Maintaining the national conference mailing list (specifically, the responsibility of the National Soil Survey Center director).
- Section 1.1.7* Carrying out duties as assigned in the Timeline of Activities.
- Section 1.1.8* Distributing bylaws to new chairs and vice-chairs.
- Section 2.0* The host NCSS University or cooperating partner shall provide logistical support for the conferences.
- Section 3.0* The Soil and Plant Science Division director assigns a liaison to each of the regional conferences. Liaison responsibilities are described in section 602.15, Coordination Activities.

Article VI. Steering Committee

- Section 1.0* The National Conference Steering Committee organizes and oversees the National Conference.
- Section 1.1* The steering committee membership consists of:
- Section 1.1.1* The Soil and Plant Science Division director, NRCS, who is the chair.
- Section 1.1.2* At least three members from Federal agencies including the U.S. Forest Service and/or the Bureau of Land Management.
- Section 1.1.3* At least four university NCSS member representatives. These would preferably include one from each respective regional conference, one from the 1890 College from the vicinity of the next conference, and one from the Tribal College from the vicinity of the next conference.
- Section 1.1.4* NRCS employees selected by the SPSP director.
- Section 1.1.5* A private sector or professional society soil and/or ecological scientist, as available.
- Section 2.0* The national conference steering committee vice-chairs shall be the host NCSS University member (or other partner) and the NRCS State soil scientist of host State. The NRCS State soil scientist of the current conference serves in an advisory capacity to the steering committee for the following conference.
- Section 3.0* Responsibilities of the steering committee, in accordance with the Timeline of Activities in section 602.15, include:
- Section 3.1.1* Determining the agenda.

- Section 3.1.2* Ensuring the names of committee chairs are posted on the NCSS website.
- Section 3.1.3* Assessing prior conference recommendations and assigning any additional charges to the committee chairs.
- Section 3.1.4* Recommending committee members to committee chairs.
- Section 3.1.5* Inviting additional individuals or organizations from the United States or other countries with soil science or related professional interests.
- Section 3.1.6* Determining the place and date of the conference.
- Section 3.1.7* Organizing the program and selecting the presiding chairs for the sessions.
- Section 3.1.8* Assembling in joint session to conduct the national business meeting during the conference, including committee reports. All votes shall provide the opportunity for participation of all NCSS membership.
- Section 3.1.9* Providing conference business meeting minutes for publication on the NCSS website.
- Section 3.1.10* Ensuring that the charges and objectives for standing and ad hoc committees are defined on the NCSS website.
- Section 3.1.11* Creating and maintaining a conference planning guide for continuity from conference to conference. The guide is submitted to NRCS Executive Services staff for posting on the NCSS website.
- Section 4.0* Fifty percent of the national conference steering committee constitutes a quorum for the transaction of business. Items are passed by a majority of members present or corresponding. The chair does not vote except in the case of a tie vote.

Article VII. Meetings

- Section 1.0* The national conference convenes every 2 years, in odd-numbered years, to meet the objectives of the national conference, including the presentation and discussion of committee reports, exchange of ideas, and transaction of business. It consists of committee sessions and general sessions. It also provides opportunity for the discussion of items members bring before the national conference.
- Section 2.0* The meeting site for the national conference rotates among the four regions of the NCSS. Each region hosts the national conference based on a set rotation. The National meeting will not be held in the same State as a prior regional conference. The rotation among the regions for recent past and future national conferences is the following:

Host Region	Year
Northeast	2019
Southern	2021
North Central	2023
Western	2025

Northeast	2027
Southern	2029
North Central	2031

Article VIII. Standing and Ad hoc Committees

- Section 1.0* The steering committee publishes the names of standing and ad hoc committee chairs, according to the Timeline of Activities in section 602.15. Regional committee chairs are members of the corresponding national committees.
- Section 2.0* Committee membership is open to any member of the NCSS partnership.
- Section 3.0* Responsibilities of the national standing and ad hoc conference committees, in accordance with the Timeline of Activities in section 602.15, include:
- Section 3.1* Chairs will conduct a committee meeting at the conference to report actions on prior conference recommendations and solicit new recommendations.
- Section 3.2* Chairs will report to the conference business meeting the progress made on prior and new recommendations.
- Section 3.3* Each committee establishes an action register for recommendations, including responsible individuals and timelines.
- Section 3.4* Standing committees of the national and regional conferences are as follows:
- a. Standards
 - b. Bylaws
 - c. Taxonomy
 - d. Research Priorities
 - e. Technology
 - f. Soils and Ecosystem Dynamics
 - g. Interpretations

Standards

This committee solicits and reviews proposed changes to existing handbooks, manuals, and soil database elements. The committee proposes new standards with input from the NCSS.

Bylaws

This committee proposes, solicits, and reviews changes to the bylaws. This committee meets as needed based on proposals brought forward by NCSS members.

Taxonomy

This committee proposes, solicits, and reviews taxonomy updates. It provides a forum to discuss proposed changes and distributes discussion notes.

Research Priorities

This committee reviews, identifies, and prioritizes research needs that meet the NCSS objectives.

Technology

This committee reviews, identifies, and prioritizes technological advances that promote the objectives of all partners.

Soil and Ecosystem Dynamics

This committee reviews, identifies, and prioritizes data needs, data collection, data storage, standards, and dissemination methods related to ecological site descriptions and dynamic soil properties.

Interpretations

This committee reviews, identifies, and prioritizes interpretation needs and delivery methods for soils and ecological site information.

Section 4.0 Ad hoc committees are proposed by members to the conference steering committee to address emerging issues relevant to the NCSS objectives. Charges shall be defined, and chair and vice-chair recommended. Once approved by the conference steering committee, a notice will go out to conference members. The committee will operate according to the committee responsibilities and Time of Activities in section 602.15. The duration of the ad hoc committee will be determined by whether the objectives and outcomes have been met. Consideration of advancement to a standing committee will be considered at the conference business meetings. Ad hoc committees are listed on the NCSS website.

Section 5.0 Each committee has a chair and a vice-chair. The vice-chair becomes the chair of the committee for the following conference and provided a copy of the bylaws. Nominations for the vice-chair are solicited 2 months prior to the conference and a vote is held 1 month prior to the conference. The vice-chair is announced at the meeting and recorded in the minutes. The term of the chair starts when appointed and finishes with the end of the next conference. The outgoing chair ensures the current mailing list is accessible to the new chair. A secretary, or recorder, may be elected by the committee or appointed by the chair.

Article IX. Amendments

Section 1.0 The bylaws may be amended with a majority vote of the NCSS members. Proposed amendments will be circulated for comment prior to the conference. Voting on the amendments will take place up to the conference. Eligible voters are not restricted to conference attendees. An amendment is, unless otherwise provided therein, effective immediately upon adoption and remains in effect until changed.

Amendments to these bylaws will be published in this handbook within 3 months of approval by the members.

These bylaws were amended on May 20, 2019, and approved at the business meeting of the NCSS conference on June 10, 2019.

602.11 Bylaws of the Western Regional Cooperative Soil Survey Conference

Article I. Name

Section 1.0 Conference Name

The name of the conference is the Western Regional Cooperative Soil Survey Conference. It consists of representatives from the area within the boundaries of the following 13 western States and U.S. territories: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Nevada, New Mexico, Montana, Oregon, Pacific Islands Area, Utah, Washington, and Wyoming.

Article II. Objectives

Section 1.0 Objectives and Purposes

The objectives and purposes of the Western Regional Cooperative Soil Survey Conference are to bring together representatives of the western States in the National Cooperative Soil Survey for discussion of technical and scientific questions. Through the actions of committees and conference discussions, experience is summarized and clarified for the benefit of all; new areas are explored; procedures are synthesized; and ideas are exchanged and disseminated. The conference also functions as a clearinghouse for recommendations and proposals received from individual members and State conferences for transmittal to the National Cooperative Soil Survey Conference. The conference promotes the use of soil resource information by others and develops recommendations for courses of action, including national policies and procedures, that relate to making soil surveys and using soil resource data and information.

Article III. Membership and Participants

Section 1.0 Permanent Membership

Permanent membership of the conference consists of:

1. National leader for Soil Survey Standards who serves as executive secretary for the conference steering committee
2. NRCS State soil scientists
3. Soil survey regional directors
4. Representatives from western State experiment stations and land grant universities
5. Regional soil scientists from the 7 western U.S. Forest Service regions (or their representative) – Northern Region, Rocky Mountain Region, Southwest Region, Intermountain Region, Pacific Southwest Region, Pacific Northwest Region, and Alaska Region
6. USDI, Bureau of Land Management (BLM) State soil scientist or State soil liaison (or their representative) from 11 western States – Alaska, Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon/Washington, Utah, and Wyoming
7. Representatives from 7 western USDI, Bureau of Indian Affairs (BIA) regions – Alaska Region, Navajo Region, Northwest Region, Pacific Region, Rocky Mountain Region, Southwest Region, and Western Region
8. NCSS representative from the USDI National Park Service (NPS)
9. President-elect or delegated representative from the Consulting Soil Scientists Division (S12) of the Soil Science Society of America
10. Program manager for Land Suitability and Water Quality, USDI, Bureau of Reclamation (BOR)

11. A representative from USDI Corps of Engineers (COE)
12. Federal Lands Advisory Group (FLAG)

Section 2.0

Associate Membership

Invitations may be extended to other individuals to participate in committee work or for a specific conference or conferences. A representative from the NRCS National Geospatial Center of Excellence (NGCE), a representative from the NRCS Information Technology Center (ITC), and a representative from the USFS Remote Sensing Application Center are associate conference members. Any soil scientist, technical specialist, or other individual of any local, State, or Federal agency or interest group whose participation could benefit particular objectives or projects of the conference may be invited to participate. Any permanent member of the conference may invite one additional participant. If a permanent member wishes to invite more than one guest (or associate member), the request should be cleared through the chair or vice-chair of the conference, or the chair of the steering committee. Names of all associate members of a specific conference should be provided to the conference chair.

Article IV. Conference Officers

Section 1.0

Conference Officers

A chair, vice-chair, and secretary are elected to serve for a 2-year term. Their tenure runs from the end of a conference to the end of the following conference. Elections are held during the biennial business meeting. Conference officers are from the State hosting the next conference. Officers rotate among the agencies. That is to say, the chair-elect represents an agency different from that of the past chair. Similarly, the vice-chair and secretary are from agencies different from those of their predecessors.

Section 2.0

Responsibilities of the Chair (specific tasks may be delegated to the vice-chair)

1. Plans and manages the biennial conference.
2. Serves as a steering committee member.
3. Presides at the conference business meeting.
4. Issues conference announcements and invitations.
5. Organizes the conference program.
6. Selects presiding chair for the various sessions.
7. Develops the conference agenda and has copies of the agenda prepared and distributed.
8. Makes necessary arrangements for lodging accommodations for conference participants, for food functions, if any, for meeting rooms (including committee rooms), for a field trip, and for local transport for other official functions.
9. Assembles, reproduces, and distributes the conference proceedings.
10. Provides for appropriate conference publicity.
11. Arranges for conference guest speakers.
12. Presides over the conference business meeting.
13. Serves on the conference steering committee for the following conference.

Section 3.0

Responsibilities of the Vice-Chair

1. Serves as a steering committee member.
2. Acts for the conference chair in the chair's absence or disability.
3. Assists the conference chair in carrying out his/her responsibilities and performs other duties as assigned by the conference chair.
4. Compiles and maintains the conference mailing list.

Section 4.0 Responsibilities of the Secretary

1. Maintains minutes of the conference business meetings and those of other conference meetings as assigned by the conference chair.
2. Obtains copies of all committee reports and papers presented at the conference and makes copies available to all conference members.
3. Compiles the conference proceedings and assists the chair in their duplication and distribution.

Article V. Meetings

Section 1.0 Time of Meetings

The conference convenes every 2 years, in even-numbered years. It convenes the third week in June, unless a different date was selected by the conference steering committee.

Section 2.0 Location of Meetings

The conference is on a rotational basis throughout the region according to the following schedule. (States may trade years to host the conference for good cause and upon approval by a majority vote of the conference members at the business meeting preceding the next conference.)

Year	State
2024	Montana
2026	Hawaii/PIA
2028	Colorado
2030	Wyoming
2032	Utah
2034	Washington
2036	Nevada
2038	California
2040	Oregon
2042	Alaska
2044	Idaho
2046	Arizona
2048	New Mexico
2050	Montana
2052	Hawaii/PIA

Article VI. Committees

Section 1.0 Kinds and Functions of Committees

The conference has permanent standing and ad hoc committees. Duly constituted official committees accomplish most conference work. The kinds of committees and their charges are determined by the steering committee, based on the recommendations of the conference members. Committee members are appointed by the steering committee after first determining the interests of conference members. Each committee prepares and makes an official report at the designated time at each biennial conference.

Committee reports are duplicated and copies distributed as follows:

1. One copy to each permanent member (whether present or not) and to each participant in the conference.

2. One final copy to the conference secretary for inclusion in the conference proceedings. This copy includes all revisions approved by the conference.

Much of the work of committees is, of necessity, conducted by correspondence during the interval between conferences.

Section 2.0 Committee Structure

Each committee has a chair and co-chair. A secretary, or recorder, may be elected by the committee or appointed by the chair, if necessary. Committee chairs are selected by the steering committee or are elected by the conference. Chairs for the standing committees should rotate at the conclusion of each conference and should be the co-chair of the committee. Chairs are recommended by the committees and approved by the steering committee at least 4 months prior to the conference. Term of responsibility starts at the end of one conference and finishes with the end of the next. The committee chairs are responsible for prompt submission of their reports to the chair of the steering committee, and the chair duplicates and distributes the reports. This should be done prior to the beginning of the conference.

Section 3.0 Committee Chair Responsibilities

Committee chairs are charged with the responsibility of initiating and carrying forward the work of the committee. They provide their committee members with the charges as directed by the steering committee and with additional instructions they deem necessary to complete the committee charge(s). Committee chairs initiate committee work at the earliest possible date to assure completion by the next scheduled conference.

Committee chairs also give a verbal summary of committee actions and recommendations at designated times during the conference.

Section 4.0 Permanent Standing Committees

Permanent standing committees are established by the bylaws of the National Cooperative Soil Survey Conference as contained in part 602, subpart A, section 602.00 and subpart B, Exhibits, section 602.10.

- Soil Survey Standards
- Bylaws
- Research Needs
- Applied Technology

Section 5.0 Conference Steering Committee

The conference chair also serves as the chair of the conference steering committee. The national leader for Soil Survey Standards serves as the permanent executive secretary of the steering committee. The steering committee formulates policy on conference membership and participation. Final approval or disapproval of policy changes is by vote, during the biennial business meeting of the conference. The steering committee assures that there is a balance among States and among agencies for each committee so that no one State or agency dominates any single committee.

The conference steering committee consists of the following five members:

1. Conference chair
2. Conference vice-chair
3. Conference secretary
4. Executive secretary

5. Past conference chair

Section 6.0 Responsibilities of the Conference Steering Committee

Conference steering committee responsibilities include, but are not limited to:

1. Meet about 1 year prior to the conference to plan the meeting agenda, establish conference committees, and develop committee charges. (The steering committee chair calls the meeting.)
2. Formulate statements of conference policy.
3. Formulate committee charges as recommended by the conference.
4. Select a committee chair and committee members as recommended by the conference.
5. Review conference activities and develop an executive summary of conference recommendations.
6. Send applicable conference recommendations to the steering committee chair of the National Cooperative Soil Survey Conference.
7. Send applicable conference recommendations to the soil survey leaders of appropriate agencies for consideration and possible implementation.
8. Establish and maintain liaisons between the conference and:
 - The national and other regional conferences
 - State conservationists of the 13 western States and the Pacific Islands area
 - West Regional Soil Consortium
 - Directors of the western experiment stations
 - State, regional, and national offices of the NRCS, U.S. Forest Service, Bureau of Indian Affairs, Bureau of Land Management, National Park Service, American Indian Tribes, and Consulting Soil Scientists Division (S12) of the Soil Science Society of America
 - NRCS institutes and centers
 - Other committees or work groups associated with the conference
 - Others as identified by the steering committee
9. Meet immediately after the conference to summarize recommendations and propose actions to be taken.

At least 60 percent of the conference steering committee constitutes a quorum for the transaction of business. Items are passed by a majority of members present. The chair does not vote except in the case of a tie vote.

Section 7.0 Ad Hoc Committees

Ad hoc committees may be established by the steering committee as needed to meet specific needs and/or goals.

Section 8.0 Regional Hydric Soils Committee

A regional Hydric Soils committee shall be established with the following charge: This committee maintains a formal mechanism within the West Region to identify, document, prioritize, communicate, and address the critical research and development issues related to hydric soils.

Article VII. Conference Advisors

Section 1.0 Conference Advisors

Conference advisors are invited to the conference and act in an advisory capacity to assist in items related to agency line and policy. Advisors to the conference are the state conservationist (STC) of the host State, or as selected by the conference, the experiment station director for the host State, or as selected by the conference, and a Forest Service

Title 430 – National Soil Survey Handbook
regional forester and a BLM State director as selected by the conference.

Article VIII. Historical Records

Section 1.0 Conference Historical Records

The executive secretary of the conference steering committee maintains a permanent, cumulative file of conference programs, correspondence, committee reports, proceedings, bylaws, and other material generated by or related to the conference.

Article IX. Representatives to the National NCSS Conferences

Section 1.0 The steering committee chair and at least one permanent member selected by the steering committee chair will represent this conference at the National Cooperative Soil Survey Conference. Representatives will report back to conference.

Section 2.0 Each committee of the Western Regional Cooperative Soil Survey Conference will have representation at each national committee during the National Cooperative Soil Survey Conference.

Article X. Amendments

Section 1.0 Amendments

Any part of these bylaws may be amended for purposes, policy, and procedures at any time by ballot with a majority vote of the permanent membership or by the present membership during the Western Conference. An amendment is, unless otherwise provided therein, effective immediately upon adoption and remains in effect until changed or deleted.

Bylaws Amended June 2004
Bylaws Amended June 22, 2010
Bylaws Amended April 2011
Bylaws Amended June 28, 2012
Bylaws Amended September 2022

602.12 Bylaws of the Northeast Regional Cooperative Soil Survey Conference

Article I. Name

Section 1.0 The name of the conference is the Northeast Cooperative Soil Survey Conference, abbreviated as NECSSC.

Article II. Objectives

Section 1.0 The objectives of the biennial Northeast Cooperative Soil Survey Conference are to bring together representatives of the National Cooperative Soil Survey in the northeastern States to address technical and scientific questions concerning soil resources and contribute to the general human welfare by promoting the use and understanding of soil resource information. Through the actions of committees and conference discussions, experience is summarized and clarified for the benefit of all; new areas are explored; procedures are synthesized; and ideas are exchanged and disseminated. The conference functions as a clearinghouse for recommendations and proposals received from individual members and State conferences for transmittal to the National Cooperative Soil Survey Conference.

Article III. Membership and Participants

Section 1.0 Members and participants of the conference are:

Section 1.1 The NRCS State soil scientist or designee responsible for each of the 13 northeastern States: Connecticut, Delaware, Maine, Maryland (also representing the District of Columbia), Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia.

Section 1.2 The university soil science representatives of each of the 13 northeastern States.

Section 1.3 The national NRCS representative assigned by the NRCS director of the Soil and Plant Science Division (SPSD).

Section 1.4 The NRCS soil survey regional directors whose regions include any part of the 13 northeastern States.

Section 1.5 The lead soil scientist from the Eastern Region Technical Center.

Section 1.6 Representatives from the soils staff of the following:

Section 1.6.1 The Eastern Region, National Forest System

Section 1.6.2 The Southern Region, National Forest System

Section 1.6.3 The Northeastern Area, State, and Private Forestry entities

Section 1.7 Other applicable federal, State, and university partners.

Section 1.8 A designated representative from the host State’s consulting soil scientists or applicable regional association, if available, representing the private sector.

Section 1.9 Other applicable conference-purpose-related organizations and individuals.

Article IV. Executive Services

Section 1.0 The NRCS National Headquarters staff for the Soil and Plant Science Division provides the national and regional conferences with executive services.

Section 2.0 Responsibilities of the NRCS Soil and Plant Science Division staff include:

Section 2.1 Carrying out administrative duties assigned by the national steering committee.

Section 2.2 Making regional and national committee reports and conference planning documents available on the NCSS website.

Section 2.3 Issuing announcements and invitations.

Section 2.4 Preparing and distributing the program.

Section 2.5 Posting the minutes on the NCSS website.

Section 2.6 Maintaining the national conference mailing list (specifically, the responsibility of the National Soil Survey Center director).

Section 2.7 Carrying out duties as assigned in the Timeline of Activities.

Section 3.0 The host NCSS university or cooperating partner shall provide logistical support for the conferences.

Section 4.0 The Soil and Plant Science Division director assigns a liaison to each of the regional conferences. Liaison responsibilities are described in section 602.15, Coordination Activities.

Article V. Organization and Management

Section 1.0 Steering Committee

The steering committee assists in the planning and management of biennial meetings, including ensuring the selection of the standing and ad hoc committee chairs and the formulation of committee memberships.

Section 2.0 Steering Committee Membership

The steering committee consists of the following members:

Section 2.1 The National NRCS liaison assigned by the NRCS director of the Soil and Plant Science Division.

- Section 2.2* The steering committee chair who also serves as the conference chair.
- Section 2.3* The steering committee vice-chair who also serves as the conference vice-chair.
- Section 2.4* A private sector or professional society soil and/or ecological scientist, as available.
- Section 2.5* Representatives of NCSS Federal agencies as applicable/available.
- Section 2.6* Additional membership as determined by the steering committee.
- Section 3.0* The NRCS State soil scientist of the current conference serves in an advisory capacity to the steering committee for the following conference.
- Section 4.0* The host State's university NCSS representative and the host State's NRCS State soil scientist will serve as conference chair and vice-chair. The roles are to be determined by the steering committee to best meet conference objectives.
- Section 5.0* Fifty percent of the steering committee constitutes a quorum for the transaction of business. Decisions are made by majority vote.
- Section 6.0* Responsibilities of the steering committee, in accordance with the Timeline of Activities in section 602.15, include:
- Section 6.1* Determining the agenda.
- Section 6.2* Ensuring the names of committee chairs are submitted to the Soil and Plant Science Division for posting on the NCSS website.
- Section 6.3* Assessing prior conference recommendations and coordinating charges to the committee chairs.
- Section 6.4* Recommending committee members to committee chairs.
- Section 6.5* Determining the place and date of the conference.
- Section 6.6* Sending invitations to all speakers or panel members and representatives from other regions.
- Section 6.7* Offering report presentation opportunity to appropriate university representatives.
- Section 6.8* Notifying all speakers, panel members, and experiment station representatives in writing that a brief written summary of their presentation will be requested to be included in the conference's proceedings.
- Section 6.9* Facilitating arrangements for lodging accommodations, food functions, meeting rooms, and local transport for official functions.
- Section 6.10* Organizing the program and selecting the presiding chairs for the conference sessions.

- Section 6.11* Assembling in joint session to conduct the Northeast Cooperative Soil Survey business meeting during the conference, including committee reports. The opportunity for voting will be provided to all regional conference membership.
- Section 6.12* Providing conference business meeting minutes for publication on the NCSS website.
- Section 6.13* Ensuring that the charges and objectives for standing and ad hoc committees are defined and included on the NCSS website.
- Section 6.14* Compiling and providing the proceedings of the conference to the SPSD for publication on the NCSS website.
- Section 6.15* Ensuring standing and ad hoc committee and business meeting reports are collected for publication on the NCSS conference website.
- Section 6.16* Maintaining communications with applicable university leadership, east region's State conservationists, applicable regional and national offices of the U.S. Forest Service and other cooperating and participating agencies, the National Cooperative Soil Survey Conference, and the host State's society of consulting soil scientists or applicable regional association.

Section 7.0 The steering committee chair serves as the conference chair. Responsibilities include:

- Section 7.1* Functioning as chair of the biennial conference.
- Section 7.2* Presiding over the conference.
- Section 7.3* Presiding at the conference business meeting.

Section 8.0 The steering committee vice-chair serves as the conference vice-chair. Responsibilities include:

- Section 8.1* Acting for the chair in the chair's absence.
- Section 8.2* Ensuring that the conference proceedings are assembled and distributed to the SPSD for inclusion on the conference website.

Article VI. Conference Business Meeting

- Section 1.0* A business meeting is held including all interested NCSS members to consider and vote on conference proposals; consider standing and ad hoc committee reports and proposals; establish, dissolve, rename, and/or repurpose standing and ad hoc committees as applicable; vote on acceptance of committee reports; prioritize committee recommendations as applicable, and identify and address issues and determine disposition.
- Section 2.0* Motions are presented and decided per "Robert's Rules of Order."
- Section 3.0* Decisions are determined by conference majority.
- Section 4.0* The conference chair ensures that a recorder documents the proceedings of the business meeting.

Article VII. Time and Place of Conference

Section 1.0 The conference convenes every 2 years, in even-numbered years. The date and location are confirmed by the steering committee, based on this suggested rotation. They may be adjusted if necessary.

Host State(s)	Year
Massachusetts	2024
New Jersey	2026
Pennsylvania	2028
Connecticut/Rhode Island	2030
Maine	2032
New Hampshire/Vermont	2034
New York	2036
West Virginia	2038

Article VIII. Representatives to the National and Regional Soil Survey Conferences

Section 1.0 The University chair/vice-chair is encouraged to attend the national conference the year prior to the regional conference.

Section 2.0 One NRCS member of the regional conference steering team is encouraged to attend the national conference prior to the regional conference.

Article IX. Conference Standing and Ad Hoc Committees

Section 1.0 Standing and ad hoc committees are established to meet conference objectives. Committee establishment, status as to ad hoc or standing, and charges are proposed by conference membership. Standing and ad hoc committees can be established, dissolved, renamed, and/or repurposed at the discretion of the conference members, through a motion at the business meeting.

Section 2.0 Each committee has a chair and a chair elect. The chair elect becomes the chair of the committee for the following conference and is provided a copy of the bylaws. Nominations for the chair elect are solicited 2 months prior to the conference, and a vote is held 1 month prior to the conference. The chair elect is announced at the business meeting and recorded in the minutes. The term of the chair starts when appointed and finishes with the end of the next conference. The outgoing chair ensures the current committee membership list is accessible to the new chair. A secretary, or recorder, is elected by the committee or appointed by the chair.

- Section 3.0* Committee membership is open to any member of the Northeast Cooperative Soil Survey partnership. All conference participants are encouraged, and NRCS participants are expected, to join at least one committee. The steering committee publishes the names of standing and ad hoc committee chairs, according to the Timeline of Activities in section 602.15.
- Section 4.0* Regional committee chairs are members of the corresponding/applicable national committees.
- Section 5.0* Responsibilities of the regional standing and ad hoc conference committees, in accordance with the Timeline of Activities in section 602.15, include:
- Section 5.1* Chairs will conduct committee meetings prior to the conference to review charges based on prior conference proceedings and recommendations and advance work toward objectives. Committees set meetings as needed to accomplish charges and prepare reports for the intervening national conference.
 - Section 5.2* Chairs will conduct committee meetings at the conference to report actions on objectives and prior conference recommendations and solicit new recommendations.
 - Section 5.3* Each committee establishes an action register for accepted recommendations, including responsible individuals and timelines.
 - Section 5.4* Each committee will categorize, and document identified issues, concerns, and actions pertaining to the charges of the other standing and ad hoc committees to ensure communication, and coordination, and appropriate action.
 - Section 5.5* Each committee will make a report of their proceedings, including progress made on prior and new recommendations, and specific proposals and decisions for conference approval. The report must identify the committee chair for the following conference and include the names of all committee members, identified committee function overlap issues, needs, actions and concerns itemized per applicable standing or ad hoc committee, and the action register.
 - Section 5.6* Chairs will present committee recommendations, actions, and proposals for conference consideration at the conference business meeting.
 - Section 5.7* The chairs of each committee (steering, standing, and ad hoc) will submit reports promptly to the conference vice-chair or designee, who ensures that the conference proceedings are assembled and distributed to the Soil and Plant Science Division NCSS liaisons for inclusion on the conference website. The liaisons will work with the assigned SPSP staff who will post the materials.
- Section 6.0* Standing committees of the Northeast Regional Conferences are as follows:
- Section 6.1* Bylaws.—This committee solicits, and reviews proposed changes to the bylaws. Its objective is to facilitate smooth operation of the conference, ensure continuity of committee work outcomes, and ensure coordination between regional and appropriate national standing and ad hoc committees by outlining procedures for conducting the conference.
 - Section 6.2* Taxonomy.—This committee proposes, solicits, and reviews taxonomy updates. It provides a forum to discuss proposed changes and distributes discussion notes.

Title 430 – National Soil Survey Handbook

- Section 6.3* Standards. – This committee solicits, and reviews proposed changes to existing handbooks, manuals, and soil database elements. The committee proposes new standards with input from the NCSS.
- Section 6.4* Research Priorities.—This committee maintains a formal mechanism within the Northeast Region to identify, document, prioritize, and address the critical research and development issues related to soil science, soil survey, and technical soil services.
- Section 6.5* Technologies.—This committee identifies, reviews, assesses, and reports on technologies that can be developed and implemented in soil science, soil survey, and technical soil services within the Northeast Region to increase efficiency and quality.
- Section 6.6* Hydric Soils.—This committee maintains a formal mechanism within the Northeast Region to identify, document, prioritize, communicate, and address the critical research and development issues related to hydric soils.
- Section 6.7* Coastal Zone/Subaqueous Soils.—This committee maintains a formal mechanism within the Northeast Region to identify, document, and prioritize the critical research and development needs related to coastal zone and subaqueous soils.
- Section 6.8* Soil and Ecosystem Dynamics.—This committee identifies, evaluates, and proposes methods, policy and standards aimed at improving the development, efficiency and utility of the Ecological Site Inventory and measurement and interpretations of dynamic soil properties.
- Section 6.9* Interpretations.—This committee reviews, identifies, and prioritizes interpretation needs within the Northeast Region and delivery methods for soils and ecological site information.
- Section 7.0* Ad hoc committees are proposed by conference members to address emerging issues relevant to the conference objectives. Ad hoc committee establishment is determined by majority vote at the conference business meeting. Charges shall be defined, and chair recommended. The committee will operate according to the Time of Activities in section 602.15. The duration of the ad hoc committee will be determined by whether or not the objectives and outcomes have been met. Status change to a standing committee, as applicable, will be considered at the conference business meetings. Ad hoc committees are listed on the conference website.
- Section 8.0* Ad hoc committees of the Northeast Regional Conferences are as follows:
- Section 8.1* Urban Soils.—This committee develops and maintains support of urban soils. It identifies, reviews, and prioritizes methods to address the critical research, education, conservation, restoration, and sustainable use and demand of issues related to urban soils.
- Section 9.0* The National Cooperative Soil Survey conference standing committees are: Standards, Bylaws, Taxonomy, Interpretations, Research Priorities, Technology, and Soil and Ecosystem Dynamics.

Article X. Silver Spade Award

- Section 1.0* This award is presented every 2 years at the conference meeting. It is presented to a member of the conference who has contributed outstanding regional and/or national service to soil survey, technical soil services, soils research, and/or soils education. One or two individuals can be selected for the award every 2 years.

Title 430 – National Soil Survey Handbook

Section 1.1 The selection committee is made up of past award recipients. The last award recipient acts as chair of the selection committee. If multiple awards were given at the previous meeting, the chair of the selected committee is elected by the committee.

Section 1.2 The recipients of the award become members of the Silver Spade Club.

Article XI. Amendments

Section 1.0 Any part of these bylaws of purpose, policies, and procedures of the NECSS may be amended any time by majority agreement of the conference participants.

Bylaws adopted January 16, 1976
Bylaws amended June 25, 1982
Bylaws amended June 15, 1984
Bylaws amended June 20, 1986
Bylaws amended June 17, 1988
Bylaws amended June 10, 1994
Bylaws amended June 13, 1996
Bylaws amended June 22, 2000
Bylaws amended May 25, 2006
Bylaws amended June 5, 2008
Bylaws amended June 10, 2010
Bylaws amended June 21, 2012
Bylaws amended June 24, 2020
Bylaws amended June 2022

602.13 Bylaws of the North Central Regional Soil Survey Conference (Revised June 7, 2012)

Article I. Name

The name of the conference is the North Central Regional Soil Survey Conference. The letters NCRSSC may be used as the official acronym of the conference.

Article II. Purpose

The purpose of the conference is to bring together North Central States representatives of the National Cooperative Soil Survey (NCSS) to discuss technical issues and to provide a means of deciding and communicating the goals of the Soil Survey Program. Through the actions of committees and conference discussions, experience is summarized and clarified for the benefit of all; new areas are explored; procedures are proposed; and ideas are exchanged and disseminated. The conference also functions as a clearinghouse for recommendations and proposals received from individual members and State conferences for transmittal to the National Cooperative Soil Survey Conference (NCSSC). It also acts on recommendations from the national conference and other regional conferences.

Article III. Membership

Participants of the conference are the National Cooperative Soil Survey soil scientists of Federal, State, and university organizations; local units of government; and private organizations of the North Central Region (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin). The national leader for Soil Survey Research and Laboratory of the Natural Resources Conservation Service (NRCS) Soil and Plant Science Division serves as liaison to the NCRSSC, maintains a membership list for the conference, and provides the list to the incoming chair. If the position of national leader for Soil Survey Research and Laboratory is vacant, the liaison role is filled as designated by the director of the Soil and Plant Science Division. All cooperating agencies and organizations are responsible for providing current membership information to the Soil and Plant Science Division liaison. All soil scientists or other technical specialists of any cooperating agency or organization whose participation would be helpful for particular objectives or projects of the conference, including those from the host State, may be members.

Article IV. Meetings

Section 1. Time.

The conference ordinarily convenes every 2 years, in even-numbered years. Time of year is determined by the conference chair. Additional meetings may be called by request of the steering committee or the conference with the administrative approval of the participating agencies and organizations.

Section 2. Host State.

The host State is determined two meetings in advance (e.g., the 2006 conference selected the host State for 2010 and the 2008 conference selected the host State for 2012). During the conference, business meeting invitations from the various States are considered and voted upon. A simple majority vote decides the host State. The conference may be held at any suitable location within the host State. The State

rotation for the NCRSSC is as follows: North Dakota, Kansas, Ohio, Nebraska, Iowa, Minnesota, Illinois, South Dakota, Missouri, Michigan, Wisconsin, and Indiana.

Section 3. Separate Meetings.

University agricultural experiment station representatives to the North Central Regional Committee No. 3 (NCERA-3) on soil surveys meet during the conference. Concurrently, soil scientists of the other cooperating agencies meet to discuss their issues.

Section 4. Basic Structure of Regional Conference.

Although the agenda for each conference varies depending upon current issues and items of interest, the following is a basic recommended list of items that could be included in a North Central Regional Soil Survey Conference. This list can be used as an aid for States planning future conference meetings:

1. Welcome by cooperating host State agencies.
2. Reports by cooperating agencies such as NRCS, NCERA-3, Forest Service (FS), Bureau of Land Management (BLM), Bureau of Indian Affairs (BIA), and others, if applicable.
3. Reports from soil survey regional offices (SSRs) within the North Central Region.
4. Time allotted for breakout sessions for NRCS and NCERA-3, and others as needed.
5. Time allotted for committees to meet and discuss charges presented to them by the steering committee as well as time allotted for conference attendees to make input to each committee's activities.
6. Time allotted for committee reports to the conference.
7. Time allotted for a business meeting toward the end of the conference.
8. A half- or full-day field trip to look at soil-related problems or landscapes of interest in the area.

Article V. Steering Committee, Committee Officers, and Committee Chairs

Section 1. The conference always has a steering committee.

The steering committee consists of:

- NRCS State soil scientist of host State
- The university representative for host State
- NRCS and university representative from the next host State
- Past NCRSSC chair and co-chair
- National leader for Soil Survey Research and Laboratory of the Soil and Plant Science Division
- Soil survey regional director for the host site
- The chair of the five standing committees

Officers rotate among agencies. That is, the chair must be of a different agency than the past chair. Similarly, the secretary must be of a different agency than the past secretary. At each biennial conference a secretary is elected for the succeeding conference. The secretary (whoever will be the next NCRSSC chair—either the NRCS State soil scientist or university representative) becomes chair when his/her successor is elected. When an officer is unable to complete his/her term of office, the steering committee appoints a successor.

Responsibilities of the steering committee include the following:

- Meet once after the business meeting of each conference and, if necessary, meet at other times.
- Assist in the selection of special participants in a specific regional conference.
- Assist in the formulation of charges to committees.
- Compile, edit, and distribute the NCRSSC Proceedings to all conference attendees within 120 days after the conference.
- Forward action items, recommendations, and resolutions to the national leader for Soil Survey Research and Laboratory of the Soil and Plant Science Division and to the director of Soil and Plant Science Division.

Section 2. Conference Officers.

A. Chair.

The chair is from the host State. Responsibilities include the following (specific tasks may be delegated to the secretary):

1. Functions as head of the steering committee.
2. Plans and manages the biennial conference.
3. Determines, in consultation with the steering committee, the kinds of committees; selects the committee chairs and assistant chairs; formulates and transmits charges to committees; and appoints committee members.
4. Issues announcements of and invitations to the conference.
5. Writes the program and has copies prepared and distributed to the members.
6. Makes necessary arrangements for food and lodging accommodations, special food functions, meeting rooms (including committee rooms), and local transport for official functions.
7. Provides appropriate publicity for the conference.
8. Presides at the business meeting of the conference.
9. Makes arrangements for a half- or full-day field trip.

B. Secretary.

The secretary is from the State that will host the next biennial conference. The secretary for the succeeding conference (in 2 years) is elected by simple majority vote at the NCRSSC business meeting.

Responsibilities of the secretary include the following:

1. Assists in the planning and management of the conference.
2. Assists in the selection of committee chairs and assistant chairs and in the selection of committee members.

3. Assumes responsibility for taking the minutes of all business meetings, collecting final reports from committees, and collecting any papers or presentations given during the conference.
4. Assumes responsibility for forwarding all conference minutes, reports, and papers to the national leader for Soil Survey Research and Laboratory of the Soil and Plant Science Division for the final preparation and distribution of the NCRSSC Proceedings.
5. Updates the conference membership list (given to him/her by the chair upon conclusion of each conference) and provides the list to the national leader for Soil Survey Research and Laboratory of the Soil and Plant Science Division.

Section 3. Committee Chairs.

The conference chair in consultation with the steering committee selects the chair and co- chair for each committee.

Article VI. Committees

Section 1. Most of the technical work of the conference is accomplished by constituted committees. The committees of the conference are determined by the steering committee. Some committees are continued from the previous conference. Permanent or standing committees, ad hoc committees, and task force groups are considered to be committees of the conference. The conference has standing committees on: standards, research priorities, new technology, interpretations, and soil and ecosystem dynamics. These standing committees communicate with their corresponding standing committee of the National Cooperative Soil Survey Conference.

Section 2. The committee chair selects a secretary, or recorder. Committee members are selected after considering steering committee recommendations, national conference recommendations, individual interests, technical proficiency, and continuity of the work. They are not limited to members of the National Cooperative Soil Survey.

Section 3. Each committee commonly conducts its work by correspondence among committee members. Most of the committee's communications are by correspondence. Copies of all correspondence among members of the steering committee are sent to each member of the committee. Committee chairs provide their committee members with the charges as assigned by the steering committee and procedure for committee operation. Committee chairs are charged with responsibility for initiating and carrying forward this work. Chairs should initiate committee work at the earliest possible date. Each committee meets during the conference and permits other conference attendees to have input into each committee's activities.

Section 4. Each committee chair sends copies of a final committee report to the secretary within 30 days after the conference.

Section 5. The chairs or representatives of the five standing committees are expected to participate in the corresponding standing committee of the National Cooperative

Soil Survey Conference and are expected to attend the next national conference. Their role is to ensure that concerns of the regional standing committee are communicated to the corresponding national standing committee and that information from the national committee is communicated back to the regional committee.

Article VII. Representation to the National Soil Survey Conference

Voting members of the National Cooperative Soil Survey Conference include the national leader for Soil Survey Research and Laboratory of the Soil and Plant Science Division and a NCERA-3 (State) delegate from the current host State for the NCRSSC. The NCERA-3 representative also serves on the steering committee for the NCSSC. Two additional delegates to the NCSSC include one NRCS soil scientist and one NCERA-3 (State) representative (with appropriate administrative approval). The NRCS soil scientist is chosen by simple majority vote during the separate Federal session. The second NCERA-3 delegate comes from the next NCRSSC host State and is assigned the task of presenting the NCRSSC report at the NCSSC. Both NCERA-3 delegates are chosen by simple majority vote during the separate NCERA-3 session at the NCRSSC.

Article VIII. Historical Record

A cumulative file of conference programs is turned over to each incoming conference chairman. A cumulative file is kept at the office of the national leader for Soil Survey Research and Laboratory of the Soil and Plant Science Division.

Article IX. Amendments

The bylaws may be amended at any time by a simple majority vote of the participants attending the biennial business meeting. An amendment is, unless otherwise provided therein, effective immediately upon adoption and remains in effect until changed.

602.14 Bylaws of the Southern Regional Cooperative Soil Survey Conference

Article I. Name

Section 1.0 Conference Name

The name of the conference is the Southern Regional Cooperative Soil Survey Conference.

Section 2.0 Conference Geographic Area

The Southern Region corresponds to the Agricultural Experiment Station Southern Region and includes the Caribbean area and the following 12 States: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas. The Southern Region also corresponds to U.S. Forest Service Region 8, excluding the State of Virginia.

Article II. Objectives

Section 1.0 Objective and Purpose

The objective and purpose of the Southern Regional Cooperative Soil Survey Conference is to bring together representatives of the National Cooperative Soil Survey in the southern States for discussion of technical and scientific questions. Through the actions of committees and conference discussions, experience is summarized and clarified for the benefit of all; new areas are explored; procedures are synthesized; and ideas are exchanged and disseminated. The conference also functions as a clearinghouse for recommendations and proposals received from individual members and State conferences for transmittal to the National Cooperative Soil Survey Conference. The conference promotes the use of soil resource information by others and develops recommendations for courses of action, including national policies and procedures that relate to making soil surveys and using soil resource data and information.

Article III. Membership and Participants

Section 1.0 Permanent Membership

Permanent membership of the conference will consist of:

1. National leader for Soil Survey Interpretations, who serves as National Soil Survey Center liaison to the conference.
2. Soil technology specialists from the Central and Eastern National Technology Support Centers.
3. Representatives from southern State experiment stations and 1890 land grant universities and other universities in the Southern Region.
4. Regional soil scientists from U.S. Forest Service Region 8.
5. NRCS State soil scientists and soil survey regional directors (or their representatives) from the 12 southern States (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas) and the Caribbean area.
6. Representatives from U.S. Department of the Interior (USDI), Bureau of Indian Affairs (BIA) Eastern, Eastern Oklahoma, Southern Plains, and Southwest Regions.
7. Representative from Tennessee Valley Authority.
8. NCSS soils representative from the USDI National Park Service (NPS).

9. President-elect or delegated representative from the Consulting Soil Scientists Division (S12) of the Soil Science Society of America.
10. Representative from the National Association of Tribal Historic Prevention Officers (NATHPO).
11. Representative from the U.S. Army Corps of Engineers (COE).

Section 2.0 Associate Membership

Invitations may be extended to a number of other individuals to participate in committee work or for a specific conference or conferences. Any soil scientist, technical specialist, or other individual of any local, State, or federal agency or interest group whose participation could benefit particular objectives or projects of the conference may be invited to participate. Any permanent member of the conference may invite one additional participant. If a permanent member wishes to invite more than one guest (or associate member), the request should be cleared through the chair or vice-chair of the conference, or the chair of the steering committee. Names of all associate members of a specific conference should be provided to the conference chair.

Article IV. Conference Officers

Section 1.0 Conference Officers

A chair and vice-chair of the conference serve for a 2-year term and on a rotating basis. The rotation schedule is listed in Table 1. Their tenure runs from the end of a conference to the end of the following conference. Conference officers are from the State hosting the next conference.

Section 2.0 Responsibilities of the Chair (specific tasks may be delegated to the vice-chair)

1. Plan and manage the biennial conference.
2. Serve as co-chair of the regional steering committee.
3. Preside at the conference business meeting.
4. Issue conference announcements and invitations.
5. Organize the conference program.
6. Select presiding chair for the various sessions.
7. Develop the conference agenda and have copies of the agenda prepared and distributed.
8. Make necessary arrangements for lodging accommodations for conference participants, for food functions, if any, for meeting rooms (including committee rooms), for a field trip, and for local transport for other official functions.
9. Assemble, reproduce, and distribute the conference proceedings.
10. Provide for appropriate conference publicity.
11. Arrange for conference guest speakers.
12. Preside over the conference business meetings.
13. Serve as 1 of 2 southern conference voting members at the following National Cooperative Soil Survey Conference.

Section 3.0 Responsibilities of the Vice-Chair

1. Serve as a steering committee member.
2. Act for the conference chair in the chair's absence or disability.
3. Assist the conference chair in carrying out his/her responsibilities, and perform other duties as assigned by the conference chair.
4. Compile and maintain the conference mailing list.
5. Serve as conference secretary:

Title 430 – National Soil Survey Handbook

- Maintain minutes of conference business meetings and other conference meetings as assigned by the conference chair.
 - Obtain copies of all committee reports and papers presented at the conference and make copies available to all conference members.
 - Compile the conference proceedings and assist the chair in their duplication and distribution.
6. Serve as 1 of 2 Southern Conference voting members at the following National Cooperative Soil Survey Conference.

Article V. Meetings

Section 1.0 Time of Meetings

The conference convenes every 2 years, in even-numbered years. It convenes in either May or June unless a different date was agreed to by a majority of permanent conference members at the previous conference.

Section 2.0 Location of Meetings

The conference is on a rotational basis throughout the region, as indicated in Table 1. (States may trade years to host the conference for good cause and upon approval by a majority vote of the conference members at the business meeting preceding the next conference.)

Table 1. Southern Soil Survey Conference Structures

Year	State	Conference Chair	Conference Vice-Chair	Steering Committee Chair	Steering Committee Co-Chair	Steering SPSP Regional Director	NRCS Soil Taxonomy Co-Chair	NRCS Standards Co-Chair
2022	SC	SSS-SC	EXP STA - SC	Central NTSC	SPSD Liaison	Northeast Region	South Central Region	Southeast Region
2024	LA	EXP STA – LA	SSS-LA	East NTSC	SPSD Liaison	South central Region	Southeast	Northeast Region
2026	AL	SSS-AL	EXP STA - AL	Central NTSC	SPSD Liaison	Southeast Region	Northeast Region	South Central Region
2028	GA	EXP STA-GA	SSS-GA	East NTSC	SPSD Liaison	Northeast Region	South Central Region	Southeast Region
2030	MS	SSS-MS	EXP STA - MS	Central NTSC	SPSD Liaison	South Central Region	Southeast Region	Northeast Region
2032	OK	EXP STA-OK	SSS-OK	East NTSC	SPSD Liaison	Southeast Region	Northeast Region	South Central Region
2034	FL	SSS-FL	EXP STA-FL	Central NTSC	SPSD Liaison	Northeast Region	South Central Region	Southeast Region
2036	TX	EXP STA-TX	SSS-TX	East NTSC	SPSD Liaison	South Central Region	Southeast Region	Northeast Region
2038	KY	SSS-KY	EXP STA-KY	Central NTS	SPSD Liaison	Southeast Region	Northeast Region	South Central Region
2040	TN	EXP STA-TN	SSS-TN	East NTSC	SPSD Liaison	Northeast Region	South Central Region	Southeast Region
2042	PR	SSS-PR	EXP STA-PR	Central NTS	SPSD Liaison	South Central Region	Southeast Region	Northeast Region
2044	NC	EXP STA-NC	SSS-NC	East NTSC	SPSD Liaison	Southeast Region	Northeast Region	South Central Region
2048	AR	SSS-AR	EXP STA-AR	Central NTS	SPSD Liaison	Northeast Region	South Central Region	Southeast Region

Article VI. Committees

Section 1.0 Kinds and Functions of Committees

The conference has permanent standing and ad hoc committees. Duly constituted official committees accomplish most conference work. The kinds of committees and their charges are determined by the steering committee and recommendations from the conference members. Each committee makes an official report at the designated time at each biennial conference. Committee reports are copied and distributed as follows:

1. One copy to each permanent member (whether present or not) and to each participant in the conference.
2. One final copy to the conference vice-chair for inclusion in the conference proceedings. This copy includes all revisions approved by the conference. Much of the work of committees is, of necessity, conducted by correspondence and teleconferences during the interval between conferences.

Section 2.0 Committee Structure

Each committee has co-chairs, one from NRCS and the other an NCSS cooperator.

Section 3.0 Committee Co-Chair Responsibilities

Committee co-chairs are charged with the responsibility of initiating and carrying forward assigned work. They provide their committee members with the charges as directed by the steering committee and with additional instructions they deem necessary to complete the committee charge(s). Committee co-chairs initiate committee work at the earliest possible date to assure completion by the next scheduled conference. Committee co-chairs are responsible for prompt submission of their reports to the co-chairs of the steering committee, who then duplicate and distribute committee reports in the conference proceedings.

Committee co-chairs also give a report of committee actions and recommendations at designated times during the conference.

Section 4.0 Conference Steering Committee

The conference steering committee is co-chaired by the soil technology specialist from the designated National Technology Support Center (NTSC) (see Table 1) and the liaison from the NRCS National Soil Survey Center. The steering committee formulates policy on conference membership and participation. Final approval or disapproval of policy changes is by vote, during the biennial business meeting of the conference. The steering committee assures that there is a balance among States and agencies on each committee; that is to say, no one State or agency will dominate any single committee.

The conference steering committee shall consist of the following seven members:

1. Co-chair: Soil technology specialist from the designated NTSC
2. Co-chair: Liaison from the Soil and Plant Science Division
3. The soil technology specialist from the NTSC not acting as co-chair
4. Current conference chair
5. Current conference vice-chair
6. Past conference chair
7. Current Soil and Plant Science Division representative

Section 5.0 Responsibilities of the Conference Steering Committee

Conference steering committee responsibilities include but are not limited to:

1. Co-chairs call a meeting of the committee about 1 year prior to the conference.
2. Committee plans the meeting agenda, develops charges for permanent standing committees, and formulates statements of conference policy.
3. Committee selects co-chairs and establishes ad hoc committees at least 4 months prior to the conference.
4. Committee reviews conference activities and develops an executive summary of conference recommendations.
5. Committee sends applicable conference recommendations to the steering committee chair of the National Cooperative Soil Survey Conference.
6. Committee sends applicable conference recommendations to the soil survey leaders of appropriate agencies for consideration and possible implementation.
7. Committee establishes and maintains liaisons between the conference and—
 - The national and other regional conferences
 - State conservationists of 12 southern States and the Caribbean area
 - Directors of the southern experiment stations
 - National Congress of American Indians
 - State, regional, and national offices of NRCS, U.S. Forest Service, Bureau of Indian Affairs, National Park Service, American Indian Tribes, and Consulting Soil Scientists Division (S12) of the Soil Science Society of America
 - NRCS centers
 - Other committees or work groups associated with the conference
 - Others as identified by the steering committee
8. Committee meets immediately after the conference to summarize recommendations and propose actions to be taken.

Participation by 50 percent or more of the conference steering committee shall constitute a quorum for the transaction of business. Items shall be passed by a majority of members present. The co-chairs do not vote except in the case of a tie vote.

Section 6.0 Permanent Standing Committees

Permanent standing committees are established by the National Cooperative Soil Survey Conference bylaws as contained in part 602, subpart A, section 602.00 and subpart B, Exhibits, section 602.10.

1. Soil taxonomy and standards
2. Research priorities
3. New technology
4. Soil interpretation criteria review

Section 7.0 Ad Hoc Committees

Ad hoc committees may be established by the steering committee as needed to meet specific needs and/or goals as related to the standing committees.

Section 8.0 Coordination of Activities

Refer to Part 602 Conferences of the National Cooperative Soil Survey, Section 602.15 Conducting NCSS Conferences.

Article VII. Conference Advisors

Section 1.0 Conference Advisors

Conference advisors are invited to the conference and shall act in an advisory capacity to assist in items related to agency line and policy. Advisors to the conference are the state conservationist (STC) of the host State, or as selected by the conference, the experiment station director for the host State, or as selected by the conference, and a Forest Service regional forester.

Article VIII. Historical Records

Section 1.0 Conference Historical Records

The Soil and Plant Science Division will maintain a permanent, cumulative file of conference programs, correspondence, committee reports, proceedings, bylaws, and other material generated by or related to the conference.

Article IX. Amendments

Section 1.0 Amendments

Any part of these bylaws may be amended for purposes, policy, and procedures at any time by ballot with a majority vote of the permanent membership. Participation by 50 percent or more of the conference permanent membership shall constitute a quorum for the transaction of business. The co-chairs do not vote except in the case of a tie vote. An amendment shall, unless otherwise provided therein, be effective immediately upon adoption and shall remain in effect until changed or deleted.

Bylaws Action	Date
Adopted	June 9, 1960
Amended	July 11, 1968
Amended	May 7, 1970
Amended	May 25, 1984
Amended	June 22, 1990
Amended	April 19, 1996
Amended	June 26, 1998
Amended	June 15, 2010
Amended	May 21, 2020
Amended	June 2022

602.15 Conducting NCSS Conferences

Communication within and between the National Cooperative Soil Survey (NCSS) regional and national conferences is essential. If the conferences are to remain an effective means of conducting business, and all partners are to be afforded effective means to contribute, then direction is needed on how communications happen within the conferences.

Steering committees and liaisons should coordinate with committee chairs to help ensure that meeting time is allocated appropriately among important conference activities, including working sessions for standing and ad hoc committees, updates, information exchange, and field trips. Meeting conference objectives requires coordination and continued feedback from the membership and from regular, ongoing work committees throughout the year. Timely execution of planning efforts for regional and national conferences is necessary to ensure participation in the preconference activity.

Coordination Activities

The Soil and Plant Science Division director assigns a liaison to each of the regional conferences and may be chosen from any NCSS member. The role of the liaison is to help ensure good communication between the regional and national conferences. Activities that can help accomplish this goal include: ensuring all steering committee members are familiar with the specific guidance given in the regional conference bylaws, helping the steering committee develop the agenda for the regional conference and adequately address issues of concern from the past national conference or current national committee deliberations, and helping ensure that all issues from regional conferences are identified in the conference report and that the report is presented and/or made available to participants at the next national conference.

The chair of each regional standing committee should attend the next national conference to ensure that issues of concern raised in regional committee deliberations are reported to the national conference and to provide clarification and counsel to the national committee regarding those issues. This individual should also ensure that discussions of the national committee are well understood during deliberations of the regional committee during the year following the national conference.

The regional steering committee, with the assistance of the assigned liaison, should ensure that the issues raised by any regional ad hoc committee are directed to all appropriate members of the national conference and that feedback is directed to the ad hoc committee so that committee members are aware of the disposition of their concern.

Regional standing and ad hoc committee chairs will provide a report to members of the national conference steering committee and the chair of each of the national standing committees or related national conference personnel as follows: within 30 days of the end of the regional conference, 90 days before the next national conference, and within 90 days of the next regional conference. In addition, any individual who has responsibility for a subject matter addressed as an item of concern or a recommendation should be provided a copy. The reports are presented at conference committee meetings.

To meet NCSS objectives, it is critical to have continuity from one conference to the next. The Timeline of Activities facilitates continuity.

Timeline of Activities

<u>Conference date</u> <u>minus</u>	<u>Activity</u>
23 months	Steering committee and committee chairs provide reports, including names of the new committee chairs and vice-chairs, to the Soil and Plant Science Division for posting on the NCSS website, and to the national conference liaisons for communication to the corresponding national or regional committees. Executive Services staff distribute bylaws to incoming committee chairs and vice-chairs.
22 months	Soil and Plant Science Division publishes proceedings on conference websites. Committee chairs solicit new committee members through the NCSS.
20 months	Committees convene to review objectives and charges as assigned based on prior conference proceedings and recommendations. Committees set meetings as needed to discuss and accomplish charges and to prepare reports for the intervening regional or national conferences. The steering committee meets to review recommendations and assess further action.
15 months	Committees submit mid-term report to the intervening regional or national conference committees; report is published on the NCSS website and in the NCSS newsletter.
12 months	Conference steering committee begins holding planning meetings monthly, or more frequently if needed.
9 months	Conference, including dates and location, is announced by posting on the NCSS website and sending information to member lists.
6 months	Committees meet to review intervening meeting proceedings and begin drafting recommendations.
3 months	Committee chairs submit draft reports to steering committee for distribution to NCSS members. Requests for new committee vice-chair nominations are solicited.
At conference	Committee reports are presented during committee meetings. Report recommendations are submitted to the business meeting for discussion. Committee vice-chairs are chosen by the committees and names are submitted to the business meeting.

Part 606 – Working Agreements

Subpart A – General Information

606.0 Definition

Working agreements are a basis of understanding for cooperative work with other agencies and organizations. These agreements include memoranda of understanding (MOUs) and reimbursable agreements. NRCS or any public agency may initiate working agreements relating to soil survey and ecological site activities. If another Federal agency initiates a working agreement, the name of the document and the format may be different from those used by NRCS. Cooperators operate within their own sphere of authority. Title 120, General Manual, Part 401, provides policy guidelines on agreements. An MOU is not a contract, and the plans and specifications agreed upon and contained therein are not legally binding for the agencies that sign it. The MOU may provide for other working agreements, such as cooperative agreements or interagency agreements, for transfer of funds, services, space, or equipment.

606.1 Policy and Responsibilities

- A. Soil survey and ecological site inventory projects will reference working agreements whenever substantial involvement from a cooperator is required. This includes, but is not limited to:
 - (1) Initial soil survey projects.
 - (2) Field-oriented soil survey and ecological site projects on Federal lands.
 - (3) Sponsored soil survey and ecological site projects with financial assistance, or in-kind contributions.
- B. MOUs record the intent of collaboration between NRCS and one or more cooperators on making and updating soil survey and ecological site information as outlined in the Code of Federal Regulations Section 611.10.
- C. Reimbursable agreements may be initiated to direct funds to soil survey, ecological site inventory, or other projects. When NRCS is to receive outside funds, services, or office space, the director of the Soil and Plant Science Division ensures the preparation of a reimbursable agreement. Common types of reimbursable agreements include:
 - (1) Interagency agreements between Federal agencies if program funding authority for each agency provides specific authority.
 - (2) Cooperative agreements between NRCS and States, counties, soil conservation districts, tribal governments, Cooperative Ecosystem Studies Units (CESU), planning agencies, other local government units, or non-governmental organizations (NGO) if program funding authority for each agency provides specific authority.
- D. A Statement of Commitment (see part 606B for template) will be prepared for all soil survey and ecological site inventory projects on Federal lands and/or requiring significant interagency cooperation (and not otherwise directed by a reimbursable agreement). The Statement of Commitment identifies agreed to items and points-of-contact on active cooperative projects.

E. Other Documents Required for Planning and Managing Soil Survey Projects

(1) Soil survey offices are required to have—

- (i) Soil survey and ecological site inventory project plans prepared, reviewed, and approved in accordance with administrative guidance. These plans describe the work to be accomplished in addressing priority needs through the duration of the project.
- (ii) A long-range plan. This plan describes what is needed throughout the assigned area to address soil survey needs and bring all previous work up to a common, modern standard. The highest priority needs are identified and used to develop specific project plans.
- (iii) An annual plan of operations.

(2) See parts 608 and 610 of this handbook for additional information about these documents.

F. MOUs of national scope reference a Statement of Commitment (see part 606B for template) to document more unique details and technical specifications for specific soil survey and ecological site inventory projects. In circumstances where a national MOU cannot be referenced, a regional MOU may be formed that reference a Statement of Commitment.

Part 606 – Working Agreements

Subpart B – Exhibits

606.10 Template Statement of Commitment for Soil Survey and Ecological Site Inventory Projects

STATEMENT OF COMMITMENT

Between

UNITED STATES DEPARTMENT OF AGRICULTURE

NATURAL RESOURCES CONSERVATION SERVICE

And

Name of Cooperating Agency

FOR

Title of Project as Concurred by Management Team or Approved by Regional Director

Date of Project Approval

1. BACKGROUND AND OBJECTIVES

Project Description: This is an executive summary, or abstract, of the project (see Part 610, Subpart B, Exhibits, Section 610.14 – Project Description: First Section for guidance).

Project Extent: Total Project Acres

Project Land Category Acres:
Breakdown of Acres per Land Category

Insert Map of Project w/ Legend

Dedicated Project Staff: List Dedicated Staff and Title

Note: This can include both NRCS-SPSD and cooperator staff that are dedicated to assisting in the completion of the proposed project when the Statement of Commitment is signed. Do not include any additional resources needed. Additional resources should be included in internal project details.

Soil Resource Inventory Methodology: List the method(s) that will be used to develop the deliverables.

Desired Outcome: List the deliverables (do not include scale, order, resolution).

Example – Initial Soil Survey Mapping, MLRA Soil Survey Update, Ecological Site Development, Raster Soil Survey, Interpretation Review, and etc.

Project Milestones and Scheduled Dates: Identify the tasks and their scheduled start and completion dates to outline specifics of an expected project timeline. This includes the field campaign, technical or progress reviews, quality control, quality assurance, and certification. NASIS Pangaea Queries for project templates may provide general assistance with identifying common milestones for specific field projects. Pare down to the most relevant milestones to cooperator. If needed, contact delegated liaison for assistance in completing this portion of the Statement of Commitment.

2. STATEMENT OF COMMITMENT

The Natural Resources Conservation Service (NRCS) will:

- A. Provide staff to conduct work for the duration of the project.
- B. Coordinate with cooperator to design special and ecological investigations, as applicable, including but not limited to:
 - o Dynamic Soil Properties
 - o Soil Hydrology
 - o Ecological Site Development
 - o Dynamic Soil Survey

- C. Draft an appropriate safety plan in coordination with cooperating agency to comply with regulations of both agencies named within the Statement of Commitment. Safety training will be a cooperative effort provisioned by and the responsibility of NRCS and partner agency in accordance with OSHA regulations.
- D. Collect field documentation according to the standards of the National Cooperative Soil Survey (NCSS) found in approved reference publications such as the Soil Survey Manual (SSM; 2017) and National Soil Survey Handbook (NSSH).
- E. Where needed or requested, furnish detailed sampling plans (locations or zones) to cooperating agency contacts with at least/at minimum two weeks' advance notice to facilitate clearance and cooperative work.
- F. Conduct operations with care to minimize landscape impact and comply with laws and regulations applicable to the project area.
- G. Provide technical review of special interpretive criteria as requested by Cooperating Agency. The criteria must be designed to use existing soil database elements within the structure of the National Soils Information System database (NASIS) and must be delivered through Web Soil Survey (WSS) for correlated map units that have undergone quality control and quality assurance following NSSH standards.
- H. Provide quality control and quality assurance of the data collected and posted to Web Soil Survey and other publications means.
- I. Periodically (no more than bi-annually in frequency) make available certified soil mapping when complete throughout the term of the project. Where adequate quality control (QC), quality assurance (QA) and data certification has been completed, correlated soil information will be delivered annually through the refresh of official data as part of agency mission to make available data to facilitate practical use.
- J. Provide sufficient technology, hardware, software and digital data to produce spatial and tabular databases meeting standards defined in the SSM (2017) and NSSH. Provide field equipment, supplies, vehicles for transportation, and office space for staff assigned to this project.
- K. Develop timelines and workload analyses to be maintained and updated annually and attached to progress reviews and/or reports. Report all progress promptly and keep progress records and maps current. Invite personnel from cooperating agency to all progress and final field review. Progress field reviews and final field reviews will be conducted and reported to cooperating agency prior to any final publication.
- L. Provide annual review of all information specified in this document and amend annual progress report with adjusted timelines, as needed, to inform cooperating agency points-of-contact.

- M. Provide training opportunities (including OJT) in Soil Survey and Ecological Site Inventory.

The (Name of Cooperating Agency) will:

- A. Make accessible any existing remote sensing data, special studies, research reports, range production data, habitat type data, cover data, pedon descriptions, or other inventory data to enhance and accelerate the soil survey mapping process. Collaborate with NRCS personnel and other cooperators on technology transfer.
- B. Furnish background environmental knowledge and provide technical interdisciplinary support in the field and in consultation. This includes, but is not limited to, assistance with inventory, data collection and technical content to support the development of Ecological Site Descriptions (ESDs). Where available, provide seasonal staff or agency staff to assist with field work.
- C. Provide technical interdisciplinary support and documentation for any specialized interpretations. Specialized interpretative requests involving ratings, properties, or interpretations must be provided to NRCS.
- D. Arrange for cultural, biological or facilities clearance as necessary to implement furnished NRCS sampling plans. Return clearance of furnished sampling plans with adequate planning time for field sampling to be completed.
- E. Provide NRCS staff safety training as part of a cooperative effort deemed necessary for completion of project as outlined.
- F. Provide assistance with logistics as well as use of lodging or camping facilities on-site, if available, for ecologists and soil scientists during the field mapping portion of the soil survey. This includes assistance with radio communication where deemed necessary, and keys or gate combinations to access areas normally off limits to the public.
- G. Provide assistance with access, including trails, roads, locked gates, etc. Where available, provide pack animals and guides, or allow Soil Survey staff to travel on already planned pack trips.
- H. Provide information regarding laws and regulations applicable to the jurisdiction or project area.
- I. Alert NRCS staff of any existing or potential logging projects taking place, and of any road closures due to washouts, etc.

3. KEY POINTS OF CONTACT

All communications and notices regarding this Statement of Commitment shall be directed to the following key administrative and technical points of contact for each party.

For the “Cooperating Agency”:

Administrative Point of Contact:

Technical Point of Contact:

For the NRCS (Servicing Agency):

Administrative Point of Contact:

Soil Survey Regional Director

Technical Point of Contact:

MLRA Soil Survey Leader or Local Point of Contact

Responsible Liaison:

Soil & Plant Science Division Delegated Liaison

4. ACCEPTANCE AND APPROVAL

The following authorized representatives of the parties have signed below, thereby executing this Statement of Commitment.

For the Cooperating Agency:

Administrative Point of Contact

For the Natural Resource Conservation Service:

Soil Survey Regional Director

Part 607 – Initial Soil Survey Preparation

Subpart A – General Information

607.0 Purpose

This part of the National Soil Survey Handbook (NSSH) is focused on initial soil surveys. In rare cases, existing soil surveys require such extensive revision that complete remapping is required. The extensive revision of non-MLRA soil survey areas has been phased out and replaced with the process of updating map units on an MLRA basis. Updating soil surveys is addressed in part 610 of this handbook. The purpose of initial soil survey preparation is to ensure the efficient use of staff time and equipment and to meet the intent of the soil survey. The preparations help the soil survey office staff understand the intent and specifications detailed in the memorandum of understanding (MOU) and the specific timeline and deliverables detailed in the plan of operation.

607.1 Policy and Responsibilities

A. The MLRA Regionwide MOU

The MLRA regionwide MOU outlines technical standards and responsibilities of cooperators within the soil survey region and is applicable to initial soil survey projects being conducted within the region.

B. The Soil Survey Project Long-Range Plan

The soil survey project long-range plan (along with the project soil survey area MOU, if one is used) specifies the deliverables and sets the time period for the completion of the soil survey. The time period specified for an initial soil survey project is recorded in the NASIS “Legend” table. Although initial soil surveys are planned and organized to complete a defined soil survey area, these survey areas are essentially a subset of the MLRA soil survey area and need to be managed within that larger physiographic context. Initial soil survey projects are scheduled for completion within about a 5-year period. Staffing should correspond to this scheduled completion period. If estimated completion time of an initial soil survey project is more than about 5 years, staffing should be reconsidered or the project should be subdivided into more manageable areas.

C. The State Soil Scientist

The State soil scientist fosters relationships with the cooperators in the project and provides input on the technical soil survey needs of the area.

D. The Soil Survey Regional Office

The soil survey regional office (SSRO) provides technical support and guidance for conducting the survey in a coordinated fashion within the MLRA soil survey region. It also provides quality assurance as the project progresses (see part 609 for more information).

E. The Soil Survey Office

The soil survey office (SSO) is responsible for—

- (i) Reviewing the MLRA regionwide MOU and the soil survey area MOU (if applicable).
- (ii) Preparing both long-range and annual plans of operation to complete the initial soil survey project.
- (iii) Preparing and indexing the base maps (options may include contact prints of aerial photos, digital orthophoto quadrangle images for on-screen digitizing, etc.).
- (iv) Collecting and reviewing reference material, including digital data analysis.
- (v) Acquiring and assembling equipment.
- (vi) Making preliminary field studies.
- (vii) Preparing an initial descriptive legend based on the field studies.
- (viii) Initiating the collection of soil performance data to support soil interpretations.
- (ix) Ensuring that map unit design meets program needs.
- (x) Preparing to perform progressive correlation in a manner that ensures that the initial soil survey project is coordinated with the overall MLRA soil survey project.

607.2 Preliminary Survey Activities

A. MOU and the Long-Range Plan

- (1) After the soil survey field staff has gained some familiarity with the survey area, the MLRA regionwide MOU, the long-range plan, and the local MOU are reviewed jointly with the soil survey regional office, the State soil scientist, the line officer representing the lead agency, and representatives from each major cooperator. The following items are reviewed:
 - (i) Survey objectives and specifications
 - (ii) The role and function of each cooperating agency
 - (iii) The mapping base suitability in relation to landforms and soil complexity of the area
 - (iv) Interpretation needs for regulations and programs
 - (v) Needs for laboratory and soil investigations for soil classification and soil interpretations
 - (vi) Adequacy of plans to digitize, map finish, and electronically publish
 - (vii) Any directive to restrict information deemed to be sensitive to national security (see part 606, section 606.1, of this handbook)
- (2) If changes are needed later, the soil survey regional director or the appropriate supervisor of the lead agency is notified. If the soil survey regional director and appropriate supervisor concur, the long-range plan and, where applicable, the MOU for the survey area are amended as outlined in part 606, section 606.1B, of this handbook. The board of advisors for the MLRA soil survey region, or similar management body as applicable, is consulted as necessary.

B. Preparation of Aerial Photo Field Sheets (if used)

Use of digital map base materials is preferred because of their inherent efficiencies, but in some cases paper copies of aerial photo field sheets are used.

- (i) The field sheets are properly identified to aid in their use and to ensure recovery of the sheets if they are lost. If NRCS is the lead agency, each field sheet displays the following information:
 - USDA, NRCS, and the full names of the cooperating agencies
 - The total acreage of the soil survey area on the field sheet

- The soil survey area name and State and the field sheet number
 - The names of the soil scientists who mapped the sheet and the date that the field sheet was completed
 - The telephone number of the soil survey office
 - The email address of the MLRA soil survey leader
- (ii) The note “ADVANCE COPY SUBJECT TO CHANGE,” the name of the soil survey area, the field sheet number, a bar scale, and a north arrow are placed on the front of all field sheets distributed to users.

C. Preparation of Digital Data Mapping Base

- (1) The NRCS, Forest Service, National Park Service, Bureau of Land Management, or other lead agency identifies and acquires the appropriate spatial data layers necessary to create and maintain a soils map digitally. Responsibilities include—
- (i) Locating sources and obtaining geospatial data for production soil survey.
 - (ii) Checking for correct spatial data extent (location).
 - (iii) Reviewing metadata for usability.
 - (iv) Processing and preparing the digital spatial data layers using appropriate map projections and file format conversions. When available, all digital layers should have the same—
 - Coordinate system
 - Quality standards
 - Portable format
 - Scale
- (2) The soil survey regional office provides guidance on the appropriate procedures to be used to ensure consistency in developing the geodatabase, naming and archiving files, and performing quality assurance activities. See part 607, subpart B, section 607.11, for an example.

D. Reference Material

Reference material is gathered, reviewed, and summarized before the preliminary fieldwork begins. The kinds of reference material that may be available and useful are listed in part 607, subpart B, section 607.10. Sources of reference material are as follows:

- (i) The U.S. Department of the Interior, Geological Survey, and State geological surveys or comparable State agencies with other names
- (ii) The U.S. Department of Agriculture’s National Agriculture Statistics Service
- (iii) The U.S. Department of Agriculture’s Forest Service
- (iv) The U.S. Department of Agriculture’s Agriculture Research Service
- (v) The U.S. Department of the Interior’s Bureau of Reclamation
- (vi) The U.S. Department of Commerce’s United States Census Bureau
- (vii) The U.S. Department of the Interior’s Bureau of Indian Affairs
- (viii) The U.S. Department of the Interior’s Fish and Wildlife Service
- (ix) The U.S. Department of the Interior’s Bureau of Land Management
- (x) The libraries of local schools, universities, municipalities, historical societies, and State agencies
- (xi) Local weather stations
- (xii) Knowledgeable people such as faculty members of universities; representatives of NRCS, the soil conservation district, the cooperative extension service, and the Farm Services Agency; vocational agriculture teachers; local representatives of planning

boards, sanitation departments, and State and county highway departments; agricultural product dealers; the State organization of professional soil scientists; and State and local geologists

- (xiii) Local and State data clearinghouses
- (xiv) State university and college data sets

E. Assembly of Equipment

- (1) The kinds and use of equipment are discussed in chapter 4 of the Soil Survey Manual.
- (2) A digital camera is necessary in all soil survey areas. The camera should be available to take photos when opportunities arise. Labeling and filing photographs in a systematic manner allows easy retrieval.
- (3) Office computers, scanners, plotters, field data collection and recording devices, and similar equipment improve and enhance data analysis, revision, and summary.
- (4) At minimum, an office laboratory space and equipment is necessary to conduct basic soil analyses for such properties as reaction (pH), conductivity (EC), analysis of particle-size distribution, carbonate equivalence, and similar tests. Ovens, scales, and measuring and mixing equipment, as well as chemicals necessary to support such analyses, are required.

Part 607 – Initial Soil Survey Preparation

Subpart B – Exhibits

607.10 Reference Materials for Soil Surveys

A. Soil Surveys in the MLRA

- Older soil surveys of the current survey area and nearby areas
- Soil surveys of adjoining areas
- Soil surveys for conservation planning
- Soil survey quality control data, including field notes and documentation
- Soil survey quality assurance documents
- Soil correlation memoranda and amendments

B. Reference Maps

- Original field sheets
- Maps of major land resource areas
- General soil map
- All available aerial photography and other remote-sensing coverage
- U.S. Geological Survey topographic and slope maps
- Public land surveys
- Maps and text on geology, geomorphology, geography, and water resources
- Maps and text on vegetation and land use
- Climatic maps and data
- Maps of flood plains
- Maps and text on air resources
- U.S. Fish and Wildlife Service wetland maps

C. Reports and Inventories

- Census reports
- Reports of crop-reporting services
- River basin reports
- State, regional, or county land use plans and regulations
- Resource conservation and development work plans
- Public lands management reports and inventories
- Bulletins and reports of State agricultural experiment stations
- National Food Security Act Manual and similar manuals
- National Resource Inventory data
- Field office technical guides
- Soil laboratory data

D. Scientific and Research Reports and Data

- Theses and dissertations of college or university students
- International Taxonomy Committee reports, such as those on wet soils, Aridisols, and Andisols
- Articles in scientific and technical journals
- Well logs from local or State agencies
- NRCS drainage, irrigation, and erosion-control guides and maps
- Percolation test results from local agencies
- Highway soil test data
- Climate data
- Geomorphology studies

E. Forestry, Range, and Wildlife Inventories and Studies

- Forest inventories
- Range inventories
- Studies and reports on wildlife habitat recreational sites

F. Official Soil Series and Soil Interpretations

- Soil interpretations information in the databases for the taxa assumed to be in the survey area
- Official soil series descriptions
- Archived copies of previous official series descriptions and soil interpretation records

G. Databases

- Pedon database
- National Soil Information System
- Digital General Soil Map of the United States
- Soil Survey Geographic (SSURGO) database

H. Digital Data

- Digital orthophotography
- Digital raster graphic
- Digital elevation model
- Multi-spectral data
- Common land units
- USFS terrestrial ecological unit inventories
- Digital hydrography, transportation, etc.
- Digital remote sensing, such as Landsat and Moderate Resolution Imaging Spectroradiometer (MODIS)

607.11 Example of a Procedure for Geodatabase Development, File Naming, Archiving, and Quality Assurance

A. Geodatabase Development

- (1) Set up geodatabases with topology and import data layers.
 - Use the standards for file naming
 - Create a geodatabase
 - Import data into the geodatabase
 - Project data to the desired geographic location
 - Create a feature dataset
 - Import template feature classes
 - Set up domains
- (2) Set up the map environment for creating digital soils data.
 - Create a map and add data layers
 - Customize a map, using—
 - Toolbars and menus
 - Symbolology
 - Image display
 - Create a layer overview
 - Add or delete fields and calculate values
 - Set selectable layers
- (3) Utilize various software in combination with appropriate data sets to accurately draft and revise soil mapping on screen.
- (4) Import, create, and display georeferenced information to validate soil map accuracy.
- (5) Create metadata to capture data sources and processes used in the development of digital mapping.

B. File Naming System

The geodatabase is named as follows: State abbreviation followed by county or parish FIPS code, “OFFICIAL,” and the current date (two-digit month, day, and year) (e.g., PG695_OFFICIAL_072105).

C. Archiving

In order to protect electronic data from accidental loss or software or hardware failure, certain archiving procedures are implemented.

- (1) The MLRA soil survey leader or project leader establishes an office archive procedure and communicates it to all soil scientists working on the project.
- (2) The project leader adds metadata notes into the geodatabase, compacts the geodatabase, and makes a copy of it using the copy and paste function in ArcCatalog. The copy is then renamed by changing “OFFICIAL” to “GIS” and using the current date (e.g., PG695_GIS_072205).

- (3) The project leader confirms that metadata notes are kept to record scale of digitizing and imagery used. Brief metadata entries are made in the “Abstract” section of the metadata in ArcCatalog for each geodatabase version that is sent for archiving. Notes in the “Abstract” and “Purpose” sections may also be made for feature classes.
- (4) The following schedule should be followed to safeguard the geodatabase:
 - Daily.—All new or edited soil mapping data is backed up to hard drive storage at the soil survey office. A separate copy of the geodatabase is therefore saved on a hard drive separate from that of the active file being edited.
 - Edits are frequently saved during an edit session in case the software crashes. Saving edits is different from saving the geodatabase.
 - Topology is frequently validated, and errors are fixed while editing.
 - The geodatabases are compacted in ArcCatalog.
 - Weekly.—All new or edited soil mapping data is copied onto a CD or DVD and stored offsite for security. Updates can be added to previous media in order to maintain an archive of edited versions.
 - Monthly.—When soil mapping data are being updated, a copy of the geodatabase is sent by compressing it into a WinZip file and attaching this file to an email (or on a CD or DVD) to designated GIS staff. If no edits have been made, this is not necessary.
 - Annually.—After completing a 100-percent quality control review of the digital data, the project leader sends a copy of the overall geodatabase to the soil survey regional office for quality assurance.

D. Quality Assurance

- (1) The MLRA soil survey leader completes a 100-percent quality control review of digital data, validates topology for the entire feature class, and fixes identified errors. After the quality control review is completed, a copy of the geodatabase is renamed (e.g., PG675_QA_current date) and then sent to the soil survey regional office for quality assurance.
- (2) A soil data quality specialist compares digital data with the field sheets during annual reviews or field assistance visits and discusses differences. For soil survey offices that use only digital mapping data, the review evaluates landscape registration and map unit concepts. An additional brief review is completed at the end of the survey.
- (3) The soil survey regional office reviews monthly copies for quality of boundary line work and geodatabase properties.
- (4) Offices that have soil mapping on paper field sheets perform a 100-percent review of progressive digitizing when the soil survey is completed or when interim data are finalized.

Part 608 – Program Management

Subpart A – General Information

608.0 Definition and Purpose

A. Definition

Soil Survey Program management is the administrative phase of the National Cooperative Soil Survey (NCSS) that provides guidelines for a systematic approach to administering and coordinating soil survey activities.

B. Purpose

Soil Survey Program management ensures that the effective planning, scheduling, coordination, and organization needed to produce and maintain quality soil survey information are initiated as timely and as efficiently as possible. All initial soil surveys and all update soil surveys of major land resource areas (MLRAs) are managed on a project basis.

608.1 Responsibilities and Organization

A. The NCSS is directed, administered, managed, performed, and supported at various organizational levels within NRCS. Soil scientists and other specialists carry out soil survey activities at numerous management and technical support levels within NRCS and through coordination with NCSS partners. Additional information about responsibilities at various levels of the organization can be found in section 608.7C and in Title 430, General Manual, Part 402.

B. National Headquarters Office (NHQ)

(1) The director of the Soil Science Division—

- (i) Provides overall direction, policy, guidance, and leadership for the NCSS within NRCS.
- (ii) Coordinates the National Cooperative Soil Survey with NCSS partners.
- (iii) Distributes fund allocations for Soil Survey Program activities to the States and soil survey regional offices (SSRs).
- (iv) Establishes soil survey goals for the program and monitors progress made.
- (v) Ensures the Soil Science Division is represented and soil survey information is incorporated into external agency and all applicable NRCS business and programs at the national level.
- (vi) Supervises senior staff of the Soil Science Division, including the director of the National Soil Survey Center, associate director for soil survey programs, associate director for soil operations, national leader for world soil resources, and other functional branches.

(2) The associate director for soil operations—

- (i) Provides management, direction, and administrative support for soil survey activities in the SSRs to ensure compliance with agency goals and priorities.
- (ii) Supervises the soil survey regional directors.
- (iii) Approves the MLRA regionwide memorandum of understanding (MOU) for the soil survey regions, including any proposed amendments, and ensures that the soil survey needs of the regions are addressed.
- (iv) Approves annual business plans for SSRs.
- (v) Serves as an ex officio member of the board of advisors for the SSRs.

(3) The associate director for soil survey programs—

- (i) Develops annual Soil Survey Program budget (President's Budget) and allocations.
- (ii) Develops responses to congressional, White House, and departmental enquiries on the Soil Survey Program.
- (iii) Manages Soil Survey Program allocation transfers and agreements at a national level.
- (iv) Develops agency goals and annual and long-range plans and conducts performance analysis for the Soil Survey Program.
- (v) Conducts Soil Survey Program civil rights analysis and compliance.
- (vi) Serves as the lead contact for the NCSS activities, including coordination with other national leaders, States, regional soil survey offices, and NCSS partners, for planning and coordinating regional and national NCSS conferences.

C. National Soil Survey Center (NSSC)

- (1) The director of the NSSC supervises seven functional branches grouped under six national leaders for—
 - (i) Soil Survey Research and Laboratory.
 - (ii) Soil Survey Standards.
 - (iii) Soil Business Systems.
 - (iv) Soil Survey Interpretations.
 - (v) Technical Soil Services.
 - (vi) Soil Quality and Ecosystems.
- (2) The activities of the functional branches of the NSSC include—
 - (i) Leading program functions in their respective areas.
 - (ii) Coordinating national technical standards.
 - (iii) Developing procedures that guide soil survey operations.
 - (iv) Developing and delivering technical training.
 - (v) Performing soil survey research, investigations, and laboratory assistance.
 - (vi) Providing leadership and support to States for technical soil service activities.
 - (vii) Maintaining soil survey data and information systems.
 - (viii) Providing National Soil Information System (NASIS) technical support.
 - (ix) Coordinating with the Information Technology Center.
 - (x) Maintaining soil survey area symbols, names, and acreage.
 - (xi) Maintaining the Web pages for the Soils Hotline and Soil Science Division.
 - (xii) Developing and integrating spatial science and technologies to assist soil survey users.
 - (xiii) Researching and developing field-based technologies for efficient and accurate data collection.

D. Soil Survey Regional Offices

The directors of the SSRs—

- (i) Lead the production and quality assurance of soil survey and ecological site information and products.
- (ii) Lead the classification, correlation, interpretation, and joining of spatial and attribute data within and between soil survey areas.
- (iii) Coordinate and support activities of the board of advisors (BoA) by communicating soil survey region priorities, work plans, and progress to ensure that soil survey operations are relevant to agency goals and priorities and to conservation needs.
- (iv) Coordinate activities of the management teams and ensure development of standard operating procedures that identify business steps, structure, and team member responsibilities.
- (v) Review and approve project plans.
- (vi) Coordinate mapping goals and progress reporting throughout the soil survey region.

- (vii) Provide quality assurance for the development and correlation of ecological site descriptions.
- (viii) Support State soil scientists in coordinating with Federal land management agencies to ensure that NCSS standards are followed and partner needs are met.
- (ix) Supervise SSR staff and the MLRA soil survey office (SSO) leaders located within their soil survey region.
- (x) Provide administrative support to the SSOs within their soil survey region.
- (xi) Provide legend administration for the soil survey areas.
- (xii) Develop standard operating procedures as necessary for quality assurance within their soil survey region.
- (xiii) Report progress related to field reviews and correlations.
- (xiv) Where applicable, report compilation certification status.

E. Board of Advisors

- (1) The BoA consists of the State Conservationist, or designee, from each State served by the SSR. Representatives from Federal, State, university, and other NCSS partners are invited to serve as members, as applicable. The soil survey regional director provides the necessary staff to plan work, conduct meetings, and present information. Specific operating procedures are developed by the BOA members as necessary.
- (2) The BoA members—
 - (i) Serve as a review board to provide advice, counsel, and broad management direction to the soil survey regional director and management team to ensure soil survey operations and ecological site activities are relevant to agency goals, priorities, and conservation needs.
 - (ii) Review the progress and provide feedback of soil survey and ecological site activities in the region in relation to agency goals and priorities and provide feedback to the associate director for soil operations for consideration during periodic performance reviews and annual evaluations of soil survey regional directors.
 - (iii) Review and concur with management team recommendations on project priorities for soil survey and ecological site activities, ensuring that local needs are in balance with State and national issues, or provide alternate advice.

F. Soil Survey Management Team

- (1) The management team consists of the soil survey regional directors, State soil scientists, State resource conservationists, and appropriate other State technical leaders as needed. Representatives from Federal, State, university, and other partners are invited to serve as members, as applicable. The management team develops specific operating procedures, which outline structure, chairmanship, and roles, to best serve the needs of the soil survey region.
- (2) The management team—
 - (i) Reviews and concurs with technical team recommendations on project priorities for soil survey and ecological site activities, ensuring that local needs are in balance with State and national issues, or provide alternate advice.
 - (ii) Review technical team recommendations regarding approval of project plans, SSO annual plans of operation, and soil survey memoranda of understanding within the soil survey region, including any proposed amendments, and provides concurrence or alternate advice.
 - (iii) Assist the soil survey regional director in administering the technical soil service activities of the soil survey offices.

G. Soil Survey Technical Team

- (1) The technical team for the SSO consists of the SSO staff, SSR staff (i.e., senior regional soil scientist, soil data quality specialist, and regional ecological site specialist, as appropriate), applicable resource soil scientists, applicable NCSS partners, and other applicable discipline specialists from field, area, State, or regional offices. The SSO leader serves as chair. Specific operating procedures are developed by the technical team as necessary for their assigned MLRAs.
- (2) The technical team—
 - (i) Gathers and consolidates each State's needs in an SSO long-range plan of operations.
 - (ii) Develops proposed project priorities.
 - (iii) Assists the MLRA SSO leader in developing draft project plans and SSO annual plans of operation for management team review, then formulates recommendations for approval by the SSR.
 - (iv) Participates in quality control activities, as appropriate.

H. National Geospatial Center of Excellence (NGCE)

The director of the NGCE—

- (i) Assists in the acquisition and processing of imagery and other digital data layers.
- (ii) Stores and distributes geospatial data.
- (iii) Develops standards and specifications and provides quality assurance for spatial soil data capture.
- (iv) Develops geospatial Web services.
- (v) Maintains print-on-demand map services.
- (vi) Provides assistance to the NCSS Program in the development and application of new technology related to cartography, remote sensing, GPS, and geospatial data.

I. State Offices

The State soil scientists (SSSs) and State resource conservationists (SRCs)—

- (i) Advise and assist the State Conservationist in allocating resources to soil survey, ecological site, and technical soil services in their area of responsibility.
- (ii) Provide technical soil and ecological site services within their State.
- (iii) Develop local soil and ecological site interpretations.
- (iv) Direct (and in some cases, supervise) resource soil scientists and other technical specialists.
- (v) Develop cooperative relationships and serve as liaisons to the State's soil survey and ecological site cooperators, Federal land management agencies, and soil survey regional offices.
- (vi) Ensure that existing soil surveys and ecological site descriptions in their State are evaluated effectively by having the SSO staff, technical team, cooperators, resource soil scientists, and other technical specialists identify needs to be addressed in the long-range plan (see part 610 of this handbook).
- (vii) Serve as a member of the management teams for the SSRs serving the State (the specific role is identified in the management team's operating procedures).
- (viii) Assist the soil survey regional director in monitoring progress to ensure that work schedules and timelines are being met according to the plan of operations.
- (ix) Coordinate with State office staff and regional soil survey office to develop schedules to meet soil and ecological site program objectives and to assist the State Conservationist in technical soil and ecological site service activities for conservation operations.
- (x) Provide legend certification for delivery of soil survey information to customers.
- (xi) Assist the State Conservationist and soil survey regional director in identifying needs for imagery, orthophotography, digital elevation models (DEMs), and other data layers.

- (xii) Host annual meeting of State NCSS cooperators to gather input for workload planning.
- (xiii) In general, assist all users of soil survey and ecological site information.

J. Area Offices and Field Offices

Resource soil scientists and other specialists—

- (i) Provide coordinated soil survey and ecological site information to all users.
- (ii) Respond to user needs for new interpretations and collect performance data.
- (iii) Evaluate the adequacy of soil survey and ecological site information.
- (iv) Provide soil survey support for USDA programs.
- (v) Provide technical soil and ecological site services within their assigned area.
- (vi) Update and maintain the field office technical guide (FOTG).
- (vii) Train field personnel in the use of soil survey and ecological site information.
- (viii) Participate as a member of appropriate soil survey technical teams.

K. Soil Survey Offices

The MLRA SSO leader—

- (i) Develops the SSO long-range plan based on findings from an MLRA-wide soil survey and ecological site inventory and assessment.
- (ii) Schedules routine work activities in plans of operations and monthly and weekly schedules, as appropriate, in consultation with the SSR.
- (iii) Supervises the SSO staff.
- (iv) Assesses training needs of the SSO staff and requests training through the SSR, State offices, and national technical support centers.
- (v) Provides leadership for the SSO technical team.
- (vi) Conducts activities on classification, correlation, interpretation, and joining of spatial and attribute data within and between soil survey areas.
- (vii) Provides management and support of soil survey and ecological site activities over a large geographic region (assigned MLRAs).
- (viii) Keeps soil survey maps and ecological site data throughout their assigned area current to meet the changing needs of users.
- (ix) Checks the quality of digital line work, ensuring lines conform to the landscape.
- (x) Performs investigations throughout their assigned area, maintaining soil survey and ecological site datasets and preparing and revising official series descriptions and ecological site descriptions.
- (xi) Conducts quality control of all soil survey activities in the MLRA soil survey area, including any initial soil surveys conducted from soil survey project offices.
- (xii) Coordinates quality control for ecological site description development and correlation.
- (xiii) Develops project plans and annual plans to address the goals and activities identified by the management team and board of advisors as priority work.
- (xiv) Provides and documents technical soil services to supplement State programs.
- (xv) Conducts work in a manner that follows NCSS standards, policy, and procedure.
- (xvi) Collects data in support of NCSS initiatives.

608.2 Soil Survey Area Designation

A. Definition

A soil survey area is a geographic area that has a size and shape defined for efficient field operations and timely release of products. A soil survey area is an administrative unit for project management (staffing and equipment), progress reporting, and delivery of products. Soil survey

area coverage includes all lands of the United States, Puerto Rico, the U.S. Virgin Islands, and the Pacific Basin Territories.

B. Purpose

- (1) National Soil Survey Center personnel follow the guidance set out in this section to identify soil survey areas in the NASIS database. Each soil survey area receives a unique area name and alphanumeric area symbol that are used in NASIS, the Soil Data Warehouse and Soil Data Access sites, cooperative agreements, memoranda of understanding, all survey area publications, correlation documents, and other official reports and correspondence. There are two types of soil survey areas recognized for managing soil surveys:
 - (i) MLRA soil survey area (MLRA SSA)
 - (ii) Non-MLRA soil survey area (non-MLRA SSA)
- (2) Refer to part 608, subpart B, section 608.12, for guidance on project administration and acreage management in the NASIS database.

C. MLRA Soil Survey Area (MLRA SSA)

- (1) In 2008, the NCSS Program was reorganized with soil survey areas based on MLRAs formally recognized across the Nation rather than on political boundaries, such as counties, and Federal land ownership. The MLRA soil survey areas follow physiographic boundaries reflecting natural features such as similar soils, geology, land use, and climate. They are the basis for the development of the soil survey legend used for interpretive needs and for all related classification, correlation, quality control, and quality assurance functions. The goal is to provide a seamless soil survey.
- (2) The boundaries of the MLRA SSA may encompass all or parts of one or more MLRAs. Changes in boundaries of the MLRA SSAs and office locations are approved by the director of the Soil Science Division.
- (3) MLRA SSAs are identified with an area symbol consisting of the SSR area number to which they are assigned, followed by the first three letters of the city in which the office is located. Examples are Asheville, North Carolina (6-ASH) and Elko, Nevada (2-ELK).

D. Non-MLRA Soil Survey Area (Non-MLRA SSA)

- (1) These areas are the county-based areas (or other similar areas based on political boundaries, such as a parish, national forest, or military base, or parts of a county subdivided or combined into more convenient-sized project areas) that have been traditionally used in the Soil Survey Program. They are used for exporting datasets from NASIS to the Soil Data Warehouse for product delivery to the Web Soil Survey. They are also used for completion of the initial soil survey. These areas are subsets of MLRA SSAs.
- (2) Boundary Designation
 - (i) Cooperating agencies of the NCSS designate the boundaries of non-MLRA soil survey areas in consultation with major users of soil information.
 - (ii) The boundaries may correspond to county boundaries, physiographic boundaries, Tribal boundaries, Federal agency management boundaries, or other land management areas.
 - Two or more small counties may be combined to form the survey area.
 - Large counties and physiographic areas may be subdivided for efficiency of field operations and publication of a final product.
 - (iii) The boundaries used for non-MLRA soil survey areas may be changed by the SSR director in consultation with NCSS cooperators, State soil scientists, and the National Soil Survey Center, as needed. Refer to section 608.2D.
 - (iv) Considerations for defining boundaries include—
 - Efficiency of managing legends and databases for different and overlapping spatial areas in the information system.
 - Timely and efficient delivery of the products.

- Other factors important to cooperators.
- (3) Naming and Symbolization
- (i) The RSS director coordinates with the NSSC and affected State soil scientists in creating area names and symbols for soil surveys designated non-MLRA soil survey areas for registration in NASIS. The area names should not exceed 135 characters.
 - (ii) For non-MLRA soil survey areas that correspond to a single county, parish, or independent city boundary, the symbol consists of the State abbreviation followed by the Federal Information Processing Standards (FIPS) code for the county, parish, or independent city. The FIPS codes are in the Federal Information Processing Standards Publication Series of the National Bureau of Standards, U.S. Department of Commerce.
 - (iii) For all other non-MLRA soil survey areas, the symbol consists of the State abbreviation and a unique 600-, 700-, or 800-series number that is assigned in lieu of the FIPS code.
 - (iv) Below are examples of names and symbols for non-MLRA soil survey areas that have differing boundary designations:
 - Soil Survey Area That Corresponds to a Single County Boundary
 - Baldwin County, Alabama (AL003)
 - Terrebonne Parish, Louisiana (LA109)
 - Soil Survey Area That Corresponds to Two or More County Boundaries
 - Beaver and Lawrence Counties, Pennsylvania (PA603)
 - James City and York Counties and the City of Williamsburg, Virginia (VA695)
 - Soil Survey Area That Includes Only Part of a Single County

Select a name that clearly distinguishes the survey area from other survey areas in the county or from adjoining counties. If a clear designation cannot be made, use the words “part” or “area” to indicate that the survey area boundary does not include the entire county.

- Washoe County, Nevada, South Part (NV628)
- Socorro County Area, New Mexico (NM664)
- Soil Survey Area That Includes Parts of Two or More Counties in One State

Use the name of a well-known place or geographic feature and list the counties.

 - Jicarilla Apache Area, New Mexico, Parts of Rio Arriba and Sandoval Counties (NM698)
 - Wenatchee National Forest, Naches Area, Washington, Parts of Kittitas and Yakima Counties (WA680)
- Soil Survey Area That Includes All of One or More Counties and Part of Another
 - Soil Survey of Curry County and Southwest Part of Quay County, New Mexico (NM669)
 - Menifee and Rowan Counties and Northwestern Morgan County, Kentucky (KY632)
- Soil Survey Area That Includes Parts of Two or More Counties in Adjoining States
 - Great Smoky Mountains National Park, Tennessee and North Carolina (TN640)
 - Great Smoky Mountains National Park, Tennessee and North Carolina (NC640)
 - Shiprock Area, Parts of San Juan County, New Mexico, and Apache County, Arizona (NM717)
 - Shiprock Area, Parts of San Juan County, New Mexico, and Apache County, Arizona (AZ717)

Note: In order to maintain acreage integrity for all States, separate project entries are made in NASIS for survey areas that cross State boundaries.

- Soil Survey Area That is in a Region With No Counties

Use the name of a well-known place or geographic feature in the area.

- San German Area, Southwestern Puerto Rico (PR787)
- North Star Area, Alaska (AK642)

E. Small Geographic Areas

- (1) Special management areas, such as small political subdivisions, areas of Tribal lands, and Federal management areas (e.g., National Park Service units, national forests, and Bureau of Land Management lands), are ordinarily handled as special projects or subsets (overlaps) of a larger soil survey area.
- (2) Soil survey regional directors in consultation with State soil scientists designate small geographic areas as soil survey areas. Legends for these areas are linked to the appropriate area types in NASIS, as needed.

608.3 Areas of Limited Access, Denied Access Areas, and Areas Not Completed

A. Definition

Many survey areas include parts that have difficult or limited access for personnel conducting field operations, and occasionally landowners deny access to their property. The goal of the NCSS is to survey all lands, and soil survey area coverage includes all lands (refer to section 608.2). Some survey areas that are only partially mapped may be posted to the Web Soil Survey.

B. Purpose

Land should not be excluded from a soil survey area based on difficult or limited access or because of difficulty in obtaining permission to gain access. All available resources should be used, such as old soil survey maps (if available), geology and topographic maps, aerial photography, and other available remote-sensing materials, to apply common field procedures and techniques in delineating map units. For relatively small areas, mapping surrounding lands and projecting soil lines across the area of denied access may be feasible. For relatively large areas, more broadly defined map units may be appropriate. In these cases, the reduced reliability in the map unit description should be described.

C. Surveying in Denied Access Areas

- (1) Soil survey regional directors, in consultation with the State Conservationist, State soil scientist, and local cooperators, determine the feasibility of mapping areas of denied access. Reliability of the mapping for anticipated use and interpretations should be the final determining factor.
- (2) Use judgment in deciding whether to attempt to gain permission to map areas of denied access. In some cases, such as when areas are restricted for national security purposes or where Native American officials desire that Tribal lands remain unmapped, the decision may be made to not pursue the issue further.
- (3) In situations other than those described in paragraph (1) above, use all reasonable means to obtain permission to map. Enlist the aid of community leaders, district cooperators and supervisors, county and State officials, and others, as appropriate.
- (4) If reasonable efforts to gain access are unsuccessful, apply techniques and resources discussed in section 608.3B to map the area.

D. Reporting Denied Access Areas (ANS)

- (1) Delineate the area with the map unit symbol “ANS” for a map unit with the name “Area not surveyed, access denied.” This is a national map unit that is queried in NASIS and added to the survey area through a linkage in the NASIS “Legend Mapunit” table. The map unit status

is identified as “correlated” because an attempt was made to map the area but access was denied.

- (2) In the map unit description, simply state “Area not surveyed, access denied.” Include the symbol and the acreage in the soil survey acreage table of the final report. Acreage for small or isolated areas of ANS is reported as mapping progress using standard progress reporting procedures. In rare cases where the area of denied access is very large, acreage of the unmapped area (ANS) is not reported as mapping progress.

E. Identifying Areas Not Completed (NOTCOM)

- (1) The purpose of identifying NOTCOM areas is to provide a consistently displayed map unit symbol for progressively correlated information published to the Web Soil Survey that identifies those areas yet to be completed.
- (2) The map unit designation “NOTCOM” is used to identify spatial areas that have not been surveyed. This designation does not include areas of limited access or denied access areas.
- (3) Delineate the area with the national map unit symbol “NOTCOM” and the map unit name “No digital data available.” This is a national map unit that is queried in NASIS and added to the survey area through a linkage in the NASIS “Legend Mapunit” table. The map unit status is identified as “approved” though the area has been neither mapped nor correlated.

F. General Soil Maps

The STATSGO2 map is the basis for the survey area general soil maps. Do not exclude any areas, even those areas excluded from detailed mapping, from the general soil map for the survey area and the U.S. General Soil Map (STATSGO2) database. Use standard procedures for delineating general soil map units and STATSGO2 map units.

608.4 Determining Workloads

A. Definition

Title 340, General Manual, describes agency policy for strategic workload planning and continuous process improvement. Other cooperating agencies have their own policy for workload planning.

B. Purpose

The workload planning process considers the work to be done, which is identified as projects. Estimates are made of the amount of time required to complete each project, and a timetable is made for completing the work. The workload process will vary slightly depending on the type of survey operation, either initial or update.

C. Initial Soil Survey

- (1) A long-range plan for initial soil survey projects details the activities needed to complete the project in a realistic amount of time (i.e., about 5 years or less). See part 608, subpart B, section 608.10.
- (2) An annual plan of operations for initial soil survey projects is used to guide and provide specific focus to staff as the long-range plan is being implemented. See part 608, subpart B, section 608.11.

D. Update Soil Survey

- (1) The SSO long-range plan considers all aspects of bringing all soil surveys in the area to a common standard to meet user needs. An inventory and assessment of the MLRA soil survey area is completed prior to development of a long-range plan (see part 610, subpart B, sections 610.10 to 610.12). In addition to the needs of the private lands in the area, it should include

- the needs identified by the cooperators responsible for the Federal lands within the area so that a coordinated effort is achieved in all soil survey work. The format and level of detail for the long-range plan may vary. The purpose is not to develop detailed plans to accomplish all of the needs but rather to identify the needs in enough detail to allow them to be prioritized effectively. Detailed planning to accomplish the highest priority needs then takes place through project plans.
- (2) Project plans for the SSO (see part 610, subpart A, section 610.4, of this handbook) are developed for one or more of the highest priority needs. The actual length of time needed to complete the project depends on the scope of the project and how it is defined. When possible, projects of very large extent should be redesigned as several smaller projects of shorter duration. Shorter-term projects are preferred because they can be managed and delivered more effectively. Some projects might be completed in weeks or months while others might require up to 2 years. Project plans are broken down into reportable milestones to identify annual progress. See part 610, subpart B, section 610.16, for an example.
 - (3) An SSO annual plan of operations (or business plan) is used to identify objectives, goals, responsibilities, and timelines during a fiscal year.

608.5 Priorities for Soil Survey Activities

A. Definition

State cooperative soil survey conferences, led by the State soil scientist, convene annually to discuss soil survey activities, consider cooperator priorities, and recommend action. Other interested user groups recommend priorities for such things as special or interim soil reports. Considerations for preparing the priority list are—

- (i) The status of initial soil surveys.
- (ii) NRCS needs for carrying out Farm Bill and technical or financial assistance programs and projects.
- (iii) Cooperating agency needs for meeting their program and project needs.
- (iv) Requests for soil surveys by local people.
- (v) Needs of Federal partners on Federal lands.
- (vi) Needs of State, Tribal, county, city or other local units of government for information that aids in land use planning and decisions.
- (vii) Rapid land use changes in areas where critical soil problems are expected.
- (viii) Contributions of funds or staffing.
- (ix) Needs for assessing land productivity value.
- (x) Other factors of specific local importance.

B. Purpose

- (1) The management team, in cooperation with the MLRA SSO leader, works with the above information to identify the needs for each SSO. Long-range plans are then refined to address the needs of the MLRA soil survey area (see part 610, subpart A, section 610.2, of this handbook). Where Federal lands are included within the MLRA soil survey area, it is important to coordinate with the appropriate representatives of those agencies.
- (2) The MLRA SSO leader, with input from the technical team, consolidates each State's needs for the SSO long-range plan.
- (3) The long-range plan is used by the management team and technical team to develop priorities. Priorities are then reviewed by the soil survey regional director for approval. The MLRA SSO leader incorporates the priorities into one or more individual MLRA project plans.

- (4) The SSO long-range plan is maintained as work progresses and new information or unforeseen circumstances arise. Additional issues to be addressed may come from a variety of sources, such as resource soil scientists, field offices, cooperators, customers, the SSR, and State soil scientists. Reports from Web Soil Survey or NASIS may also reveal issues and deficiencies that need to be prioritized and addressed in the future.

608.6 Planning Workflow

- A. MLRA project plans direct the use of resources to accomplish identified activities as described above. An SSO will typically have multiple plans in progress each year. The plans are managed in NASIS and identify the activities that need to be accomplished by the plan. Each plan includes the name of the person or staff responsible for each activity, projected completion dates, and goals.
- B. Part 608, subpart B, sections 608.10 and 608.11, provide sample formats for a long-range plan and annual plan of operations for initial soil surveys. In part 610, subpart B, sections 610.10 to 610.16, examples of documents used for planning MLRA update soil surveys are provided. These documents may be adapted to fit the needs identified for the soil survey area.

608.7 Goals and Progress

A. Definition

The establishment of performance goals and progress reporting is required by policy and outlined in the general manual (340-GM, Part 400, “Strategic Planning and Accountability”). NASIS includes a number of tables and data elements for planning, managing, and tracking status, milestone events, and progress of activities of the NCSS and Technical Soil Services (defined in part 600 of the Technical Soil Services Handbook). These data are stored in the “Project” object and in the “Technical Soil Services” object in NASIS. Projects for initial soil survey work are linked to “Non-MLRA Soil Survey Areas.” Projects for update work are defined by map units and are linked in NASIS through the data field “MLRA Soil Survey Office Area.” No entries are populated for update project work in the data field “Non-MLRA Soil Survey Area.”

B. Purpose

- (1) Managers use goals and progress information recorded in NASIS to assess workloads, develop activity schedules and budgets, and plan for resources needed to complete the national soil inventory and related databases. Included as projects in NASIS are all active initial mapping on non-MLRA soil survey areas, as defined in section 608.2, and all updating of survey information, as defined in part 610 of this handbook.
- (2) Initial projects that are linked in NASIS to each “Non-MLRA Soil Survey Area” contain administrative and other data that track the key business processes of the initial survey from field data collection through final publication.
- (3) Update projects are linked to the “MLRA Soil Survey Office Area” and contain administrative and other data that track the key business process for updating map units from the field data collection through final publication. The map units in an update project are listed in the “Project Mapunit” table.
- (4) A “milestone” is an item or task identified to be completed during the initial or update project. Milestones are process steps, such as the number of transects collected, number of pedon descriptions gathered, amount of spatial line work edited, number of OSDs revised, etc. The milestone information is entered into the NASIS “Project Milestone” table. Milestones allow the manager to divide the project into reportable items and track the progress. Progress towards completion of each milestone is entered into the NASIS “Project Milestone Progress” table.

- (5) The scheduled activities and progress of technical soil services are reported in NASIS. See section 608.8B for more information on scheduling.

C. Responsibilities

- (1) Data stewards for the various soil survey business areas are responsible for populating data elements and ensuring data quality in NASIS. Soil survey business areas perform all inventory-related activities at the field level and support and enable activities done in the generation of soil survey products.
- (2) The business area responsible for either initiating or completing a soil survey business process also is responsible for populating appropriate data elements and reporting progress associated with the process.
- (3) Part 608, subpart B, section 608.11, identifies broad soil survey business areas along with associated NASIS tables and data elements, and section 608.13 specifies the organizational office levels in NRCS that are responsible for populating the data. Some data elements in the exhibit indicate more than one responsible office level. For these situations, the appropriate business area program managers designate the responsible data steward. See section 608.1 for additional information.
- (4) Program managers may delegate the responsibility of populating some data elements to the SSO. For example, MLRA soil survey leaders may be designated to report mapping and compilation progress for their respective area.

D. Accessibility of the Data

Soil survey area legends and projects are accessible through the NASIS interface. The interface enables authorized users with full capability to create, edit, and report data. Extreme care should be taken to avoid populating or changing data that falls under the responsibility of another business unit. Various reports are available in NASIS to summarize the data.

E. Data Management

Part 608, subpart B, section 608.11, identifies soil survey business areas and related data elements, including key terminology and protocols, necessary for administration and maintenance of the data. Section 608.13 provides an overview of the data elements and responsible soil survey business areas.

F. Soil Survey and Ecological Site Performance Measurement

- (1) The NRCS Performance Results System (PRS) is the official progress reporting instrument used by the agency to prepare national-level reports. Agency-accountable items, such as soil mapping on initial acres and progress on updating data, are assembled from NASIS nightly and automatically uploaded to PRS. Acres of ecological sites inventoried are entered directly into PRS by staff in the States.
- (2) NASIS data is used to assess program performance and analyze budgets. Examples include signed MOUs, progress reviews and correlations completed, manuscripts edited, acres compiled and digitized, and the status of imagery and orthophotography acquisition. Both individual and business area performance can be analyzed.
- (3) Performance Goals
 - (i) At the beginning of the fiscal year, individual and team goals for soil survey business activities should be established.
 - (ii) In addition to initial and update soil surveys, mapping goals may be set for nonproject survey areas based on anticipated requests for conservation planning.
 - (iii) Supervisors—
 - Base performance goals on the individual's job description, experience, and training, on complexity, and on other factors.

- Monitor progress throughout the year.
 - Revise individual or team performance goals, as needed, in consultation with the employee.
- (iv) On initial soil survey projects, the soil survey office leader sets goals based on acres mapped (including data population in NASIS and geospatial components). In addition, goals for other aspects of soil survey can be established, especially for local project management.
- (v) In update soil survey work, the soil survey office leader sets goals based on completing milestones tracked in NASIS.
- (vi) The goals for technical soil services are assigned to resource soil scientists by supervisors at the State office or area office level.
- (vii) Performance goals may be set for—
- Technical soil services and soil survey support activities.
 - Mapping goals (although large water bodies, such as census water, should not be included, census water acres should be reported as a land category in the “Project Land Category Breakdown” table).
 - Gathering of field documentation.
 - Database development.
 - GIS analysis.
 - Correlations.
 - Manuscript development.
- (4) Progress and Progress Reporting
- (i) Soil survey progress records the inventory of the Nation’s soil resources, development of related databases, soil survey products, and interpretative materials.
- (ii) Soil survey regional directors are responsible for ensuring that progress is reported.
- (iii) Reportable items are all activities, including intermediate products (e.g., milestones) that lead to a final product that meets NCSS standards. These items are:
- Acres mapped
 - Correlations completed
 - Acres compiled and digitized
 - Ecological site description development and inventory
 - Documentation collected (e.g., pedon descriptions, transects, photographs, monitoring data, laboratory samples, vegetation data, and special studies)
- (iv) Progress should be reported in NASIS as it occurs. As a minimum, mapping progress should be reported quarterly and all other progress monthly.
- (5) Mapping Progress
- (i) Initial Projects
- Refer to part 608, subpart B, section 608.11, for further discussion on reporting mapping progress.
 - The regional soil survey director should discuss progress reporting issues with the associate director for soil survey programs and associate director of soil operations at Soil Science Division headquarters *before* significantly revising performance goals.
 - For each non-MLRA soil survey area, create, if not already created, a project in NASIS and enter mapping progress into the “Project Mapping Progress” table by land category (refer to acreage accountability below).
 - Enter the reporting date in the “Project Mapping Progress” table. This date determines the fiscal year for which progress is counted.
 - Report progress as initial mapping.
 - Distinguish NRCS personnel from cooperator personnel.
 - Enter each individual’s progress or the project team’s progress as a whole.

- Closely monitor initial soil surveys. Report initial mapping progress only one time and never delete it from the system once it is reported, except when data entry errors are immediately recognizable and easily corrected.
 - Upon completion of the initial soil survey, ensure that all initial acres reported as progress equal the land category acres and that the sum of all land category acres equals the area acres for the respective non-MLRA soil survey area.
- (ii) Update Projects (See part 610, subpart A, section 610.3, of this handbook)
- Report milestones upon completion of the task.
 - Distinguish NRCS personnel from cooperator personnel.
 - Enter each individual's progress or the project team's progress as a whole.
 - Report project acres upon publication of the project map units to the Soil Data Warehouse.

G. Project Administration and Acreage Management

- (1) NASIS provides a variety of ways in which data can be managed. Therefore, if the system is to function optimally, a uniform approach is required.
- (2) In NASIS, the data field "Non-MLRA Soil Survey Area" provides data about goals and progress for mapping and other milestone activities for initial soil survey work. A project is created for each initial soil survey project. Projects for soil survey update activities should be developed as needed (see part 610, subpart A, section 610.4, of this handbook).
- (3) Unique Spatial Areas
 - (i) All "Non-MLRA Soil Survey Areas" represent a unique geographical (spatial) area, such as an entire county, multiple counties, or parts of one or more counties. They receive a unique area symbol and area name (see section 608.2).
 - (ii) In NASIS 6.0, a project was created for each legend linked to a "Non-MLRA Soil Survey Area." The resulting project was named for the survey area and the status shown in the "Legend" table (e.g., Allen County, Kansas - Update needed). Data from the "Legend Data" object related to goals and progress in NASIS 5.4 were moved to this new project and related tables. Acreage data in the various tables for these specific, completed projects are not to be edited.
 - (iii) Section 608.12 provides additional information and examples of various project scenarios and protocols.
- (4) Acreage Accountability

NRCS, as Federal lead for the NCSS, maintains records of soil survey mapping for all lands of the Nation.

- Seven land categories distinguish non-Federal ownership from Federal ownership. Additionally, Federal lands are categorized according to the responsible Federal land management agency. The seven land categories are:
 - Native American land
 - Other non-Federal land
 - Bureau of Land Management
 - U.S. Forest Service
 - National Park Service
 - Other Federal land
 - Census water
 - Refer to part 608, subpart B, section 608.12, for definitions of the land categories and for additional information on acreage management and accountability.
- (5) Acreage Allocation

Federal and private land ownership and acreages constantly change. State soil scientists must periodically review land ownership for all soil survey areas. This information is maintained in the “Project Land Category Breakdown” table in NASIS.

- If ownership acres have changed in a soil survey area, the State soil scientist reports changes and discrepancies to the soil survey regional director. The soil survey regional director—
 - Reallocates acreage assigned to the seven land categories.
 - Reallocates progress assigned to each land category.
- The sum of all land category acres within a project for a “Non-MLRA Soil Survey Area” must equal the area acreage for the survey area.
- The sum of all land category acres within a project for a “Non-MLRA Soil Survey Area” must equal the State total acreage from the 1992 National Resource Inventory.
- To reallocate acres for soil surveys that have more than one project or that partially overlap another survey, refer to the discussion of acreage management and accountability in part 608, subpart B, section 608.12.

(6) Acreage Base

County-based 1992 National Resources Inventory (NRI) data for total surface area (land and water) is used within NRCS as the official acreage for non-MLRA soil survey areas that coincide with county or parish boundaries and for State totals. Acreages for non-MLRA soil survey areas that do not coincide with county or parish boundaries must be balanced with the respective State totals.

- Use the exact county-based figures or round to the nearest hundred.
- Coordinate acreage assigned to all survey areas with the national NASIS data steward at the National Soil Survey Center for inclusion in NASIS.

608.8 Developing Other Schedules for Soil Survey Operations

A. Soil Survey Operations

- (1) Schedules and timelines for soil survey activities are detailed in long-range plans, project plans, annual plans of operation, and monthly or weekly schedules. Part 608, subpart B, section 608.10, is an example of a long-range plan for initial soil surveys, and section 608.11 is an example of an annual plan of operations for initial soil surveys. Part 610, subpart A, section 610.6, of this handbook discusses how long-range plans address identified needs for MLRA soil survey areas.
- (2) MLRA SSO leaders schedule soil survey activities and coordinate routine work in consultation with the responsible soil survey regional director. Quality control activities are carried out and documented by the MLRA SSO leader per guidance in part 609 of this handbook.
- (3) SSR staff schedule quality assurance reviews and field assistance visits in consultation with the SSO, State offices, and NCSS partners per guidance in part 609 of this handbook.

B. Technical Soil Services

- (1) State, area, and field offices develop annual plans of operation and monthly or weekly schedules, as appropriate, for activities related to technical soil services.
- (2) Resource soil scientists and soil scientists assigned to nearby SSOs provide soil information as needed for conservation planning and other special local needs. These efforts ensure efficient use of soil scientist time and timely delivery of soil information. These activities should be reported in the “Technical Soil Service” table in NASIS. A choice list of activities is provided. New activities can be added to the list by coordinating with the national leader

for technical soil services and the NASIS data steward at the National Soil Survey Center. Scheduled start and end dates can be recorded for each service provided, as well as the actual start and end dates. The person providing the service, the geographic location where the service was provided, the name of the person or entity receiving the service, and the benefits realized should also be documented.

C. Individual Schedules

Individual soil scientists prepare monthly or weekly schedules, as required by supervisors. These schedules include—

- (i) Routine soil survey activities.
- (ii) Training to be given and received.
- (iii) Staff conferences.
- (iv) Information and public relations needs.
- (v) Planned leave.

608.9 Status Maps

A. Maps indicating the progress and status of soil surveys and soil survey products are important management and public relations tools. Maps may be on a national, regional, major land resource area, or State basis.

B. Source Data

- (1) The primary sources of attribute data are NASIS and the Soil Data Access. Sections 608.7D-F identifies the soil survey business areas that are responsible for populating and maintaining the data.
- (2) Base map cartography and spatial data for soil survey areas is maintained by the NSSC.

C. Responsibilities

- (1) The NSSC maintains a digital file of soil survey area boundaries for all non-MLRA soil survey areas listed in NASIS. Boundaries are taken from SSURGO data archived on the Soil Data Warehouse where SSURGO data is complete.
- (2) State soil scientists—
 - (i) Ensure the accuracy and completeness of non-MLRA soil survey area boundaries.
 - (ii) Initiate revisions and corrections to the boundaries, as needed.

D. Data Availability

- (1) Soil Data Availability Status Map
 - (i) The Soil Data Availability Status Map portrays the availability of SSURGO data in the Web Soil Survey. This map is updated at least annually by staff of the NSSC based on the contents of the Soil Data Warehouse. The map legend indicates the data available for each soil survey area. Partial surveys are also shown. The map can be accessed online at <http://websoilsurvey.sc.egov.usda.gov/DataAvailability/SoilDataAvailabilityMap.pdf>.
 - (ii) The standard map legend colors and categories are as follows:
 - Green – digital spatial and tabular data are available
 - Orange – only digital tabular data are available
 - White – no digital data are available
- (2) Other Status Maps

Program managers at the national, soil survey region, and State levels may determine other types of soil survey status maps useful for management and information purposes within their operational area.

Part 608 – Program Management

Subpart B – Exhibits

608.10 Long-Range Plan for Initial Soil Surveys

United States Department of Agriculture - Natural Resources Conservation Service	
_____ County, _____	
Date _____	Project staff _____

Narrative of Plan Items	FY- _____	FY- _____	FY- _____	FY- _____	FY- _____
1. Memo of understanding (optional with MLRA regionwide MOU on file)					
a. Meet with locals					
b. Prepare draft MOU					
c. Obtain review					
d. Obtain signatures					
2. Collection of references					
a. Geology					
b. Water resources					
c. Statistical reports					
1. Farm					
2. NRI					
3. SWCD					
4. Climate					
5. Other					
d. County roads					
e. Adjoining soil survey data					
f. Topo quad sheets, DEMs					
3. Preparation of field sheets (if used)					
a. Edging					
b. Identification					
c. Advance copy identification					
d. Acreage determination					
e. Other					
4. Preliminary field studies					

a.	Perform area reconnaissance					
b.	Develop landform map					
c.	Field test STATSGO2 for GSM use					
d.	Test map areas					
e.	Correlate studies and field observations					
5.	Preparation of descriptive legend (ensuring NASIS is populated)					
a.	Taxonomic descriptions					
b.	Map unit descriptions					
c.	Features and symbols legend					
d.	Identification legend					
e.	Classification of soils					
6.	Documentation and supporting data					
a.	Transect studies					
b.	Field notes					
c.	Identification of problem areas					
d.	Field descriptions					
e.	Pedon program					
f.	Transect program					
g.	Soil-ecosite correlation					
h.	Soil-landscape models					
i.	Other					
7.	Special studies					
a.	Crop yields					
b.	Forestland sites					
c.	Geomorphology					
d.	Characterization					
e.	Surficial geology					
f.	Other					
8.	Field mapping					
a.	Joining					
b.	Acreage goals					
c.	Sheet compilation (if needed)					
d.	Digitize					
e.	SSURGO AMLs					
9.	Sampling and lab data					
a.	Sampling for NSSC-KSSL					
b.	Sampling for university					

c. Sampling for highway dep.					
10. QA reviews & field visit assistance					
a. Pre-initial review					
b. Initial review					
c. Progress reviews					
d. Final review					
e. Preliminary correlation					
f. Final correlation					
g. Field assistance visit					
11. General soil map (STATSGO2) (revision and update)					
a. Adjust delineation of units					
b. Develop legend					
c. Describe units					
d. Develop diagrams					
12. Development of survey area soil handbook					
a. Introduction to area					
b. General nature					
c. Crops and pasture					
d. Forestland and windbreaks					
e. Rangeland					
f. Engineering					
g. Recreation					
h. Wildlife					
i. Factors of soil formation					
j. Classification of soils					
13. Interpretation tables					
a. Prepare & update data elements					
b. Generate tables for review					
c. Review tables with technical specialists					
14. Manuscript photos					
a. Select sites					
b. Review photos with editors					
c. Select final photos					
15. Preparation of soil survey manuscript					
a. Select from survey area soil					

Title 430 – National Soil Survey Handbook

handbook or generate from NASIS					
b. Obtain technical review					
c. Obtain English edit					

608.11 Annual Plan of Operations for Initial Soil Surveys

United States Department of Agriculture - Natural Resources Conservation Service

_____ County, _____
Date _____ Project staff _____

Narrative of Plan Items	Respon- sibility Total of	Number/ Amount	Hours Per Quarter				FY
			1	2	3	4	
Section A: Long-Range Plan of Operations							
1. Memo of understanding (optional)							
a. Meet with locals							
b. Review specifications							
c.							
d.							
2. Collection of references							
a. Geology reports							
b. Flood data							
c. Local history							
d. County road maps							
e. Land use							
f. Water quality info							
3. Preparation of field sheets (if used)							
a. Edging							
b. Identification							
c. Advance copy identification							
d. Designation of acreage							
4. Preliminary field studies							
a. Develop landforms map							
b. Draft initial STATSGO2 update							
c. Test map areas							
5. Descriptive legend (completion of data in NASIS)							
a. Prepare taxonomic							

unit descriptions _____							
b. Prepare map unit descriptions _____							
6. Documentation and supporting data							
a. Record transects _____							
b. Collect yield data _____							
c. Make forest transects _____							
d. Describe pedons _____							
e. Analyze transect data _____							
7. Field mapping							
a. Acreage goal by individual _____							
8. Field reviews							
a. Pre-initial review _____							
b. Progress review _____							
Section B: Soil Management and Interpretation Support Services							
a. Onsite investigations _____							
b. FOTG _____							
c. Special evaluation _____							
Section C: Information Activities							
a. Talk to service club _____							
b. Prepare news article _____							
c. Report to cooperators _____							
Section D: Leave and Holidays							
a. Annual leave _____							
b. Sick leave _____							
c. Holidays _____							

608.12 Goal and Progress Guidelines

This exhibit provides additional guidance for administering data in NASIS related to goals and progress reporting. It is primarily intended for Soil Survey Program managers and data stewards. It is divided into four major Soil Survey Program business areas for ease of reference. Data elements relevant to the business areas are listed and discussed. Also refer to section 608.13 for a quick-reference companion that provides a snapshot of business area responsibilities for NRCS offices. The four business areas are: (1) project administration and acreage management; (2) mapping goals and progress; (3) imagery, orthophotography, map compilation materials, and other data layers; and (4) initial and update survey operations. Definitions of data elements are in NASIS and therefore are *not* provided in this document. Additional explanations are provided for some data elements.

I. Project Administration and Acreage Management

Timely administration of projects and acreage accountability are critical functions in assuring the usefulness of the NASIS database as a management tool. Projects serve as “place holders” to plan future needs, identify progress, and track milestone events leading to completion of soil survey products.

Guiding Principles:

1. The tables and data elements related to goals and progress are imbedded in the NASIS database, which is a multiuser database. They serve as the official reporting instrument for production soil survey activities of the National Cooperative Soil Survey.
2. Administration is the responsibility of State offices; updating maps and data is the responsibility of data stewards of the soil survey business area.
3. For the initial soil survey, data are maintained in projects linked to the “Non-MLRA Soil Survey Areas” owned by the NASIS site “NSSC Pangaea.”
 - Each “Non-MLRA Soil Survey Area” is linked to a project in NASIS. All geographic areas of the Nation are covered in at least one such survey area.
 - With the data conversion to NASIS 6.0, a project was created for each legend linked to a non-MLRA soil survey area. The resulting project was named for the survey area and the status shown in the “Legend” table (e.g., Allen County, Kansas - Update needed). Data from the “Legend Data” object related to goals and progress in NASIS 5.4 were moved to this new project and related tables. Acreage data in the various tables for these specific, completed projects are not to be edited.
 - Mapping progress and milestones may be reported continuously but, as a minimum, are reported at the end of each quarter. Other data entries may be maintained continuously but, as a minimum, are current at the end of each month.
4. For update soil survey work, a project is created for each project plan developed for the “MLRA Soil Survey Office Area.”
 - Projects are linked to the appropriate “MLRA Soil Survey Office Area” in NASIS.
 - Mapping progress and milestones may be reported continuously but, as a minimum, are reported at the end of each quarter. Other data entries may be maintained continuously but, as a minimum, are current at the end of each month.

A. Administrative Data Elements

- Area Table

- Area Name (This data element applies to the “Area,” “Project,” “Legend,” and “Legend Area Overlap” tables.)
- Area Symbol (This data element applies to the “Area,” “Project,” “Legend,” and “Legend Area Overlap” tables.)
- Area Acres
- Legend Table
 - MLRA Office (This data element pertains to the 12 soil survey regional offices.)
 - MOU Agency Responsible
 - Legend Description
 - Geographic Applicability (This data element specifies the currency of soil survey information, including both attribute and spatial data.)
- Legend Certification History Table
 - Legend Certification Status
 - Certification Date
 - Certification Kind
- Legend Export Certification History Table
 - Export Certification Status
 - Export Certification Date
- Project Table
 - Project Name
 - Project Description
 - MLRA Soil Survey Office Area (This column header pertains to the MLRA soil survey offices and is composed of two underlying data elements labeled “MLRA SSO Area Symbol” and “MLRA SSO Area Name.”)
 - State Responsible
- Project Product Table
 - Product Availability Status
- Project Data Type Table
 - Product Data Type Name
 - Project Data Type Description
- Milestone Type Table
 - Milestone Type Name
 - Milestone Type Description
- Technical Soil Service Type Table
 - Tech Soil Service Type Name
 - Tech Soil Service Type Description

B. Acreage Management Protocols for Initial Soil Survey Projects Linked to Non-MLRA Soil Survey Areas

Seven land categories are used to identify the ownership of all lands of the United States and its trust territories. The land categories are: Native American land, other non-Federal land, Bureau of Land Management, U.S. Forest Service, National Park Service, other Federal land, and census water. Accordingly, acreage is assigned in each project linked in NASIS to a “Non-MLRA Soil Survey Area,” subject to the following conventions:

1. Land categories reflect the current land ownership in the survey area.
2. The sum of all land category acres from all projects linked to “Non-MLRA Soil Survey Areas” in a State equals the 1992 NRI acres for the State.

3. Land category acres are balanced across projects that cover the same geographic area so that each acre is recorded only once.
4. Survey areas that cover parts of two or more States will have a separate project for each State. Each project will have land categories, land category acres, goals, and progress for the respective State. A “Non-MLRA Soil Survey Area” will be needed for each State involved. The area symbol will be assigned for the respective State. The area name will be the same for both. Area acres will be for the whole survey area and will be recorded as the same in each State.
5. Acres are recorded to the actual acre or rounded to 100 acres.
6. Areas in Alaska identified as Alaska Native Lands or in Hawaii as Hawaiian Homelands are included in the meaning of Native American land.
7. Census water applies to all contiguous water polygons that are 40 acres in size or larger. If a water polygon is less than 40 acres in size in the survey area but extends into an adjoining survey area such that the total extent in both survey areas is more than 40 acres, then the water qualifies as census water. Census water acreage is *not* to be part of mapping goals; it is administratively managed in NASIS as a land category in the “Project Land Category Breakdown” table to account for total survey acres and progress.

Project Scenarios and Protocols:

1. Survey Areas With One Project. Only one project is linked to a “Non-MLRA Soil Survey Area” in NASIS and no other survey areas have been established that coincide geographically with any part of the survey area. The actual (or best estimate of) land category acres are recorded in the “Project Land Category Breakdown” table. The sum of all acres recorded in the table are to equal the survey area acreage.
2. Survey Areas With Two or More Projects. These areas typically have an older out-of-date legend and corresponding project and a newer update or published legend and project. Acres in the “Project Land Category Breakdown” table should be rebalanced so that the older project shows zero acres in each land category. The newer project should reflect the actual (or best estimate of) land category acres in the “Project Land Category Breakdown” table. Thus, land category acres will be recorded only once for the survey area. Mapping progress should be retained in both the older and newer projects as appropriate (see the section on mapping goals and progress).
3. Survey Areas That Partly Coincide With Another Survey Area. These areas typically consist of a newer survey area that covers part of an older survey area or a newer survey that covers all or parts of two or more previous survey areas. Acres in the “Project Land Category Breakdown” table should be rebalanced in all affected survey area projects so that current land category acres are recorded in the newest project and subtracted from older projects. The sum of land category acres in the newest project will equal the survey area acreage. The resulting sum of land category acres in each of the other affected projects will total less than their respective survey area acreage. Mapping progress should be retained in both older and newer projects as appropriate (see the section on mapping goals and progress).

C. Acreage Management Protocols for Update Soil Survey Projects Linked to MLRA Soil Survey Areas

Seven land categories are used to identify the ownership of all lands of the United States and its trust territories. The land categories are: Native American land, other non-Federal land, Bureau of Land Management, U.S. Forest Service, National Park Service, other Federal land, and census water. Accordingly, acreage is assigned in each project linked to a “Non-MLRA Soil Survey Area,” subject to the following conventions:

1. Land categories reflect the current land ownership in the survey area.
2. For each such project developed, the appropriate land categories and acres will be entered into the “Project Land Category Breakdown” table.
3. As these projects stand on their own and the same acre of land may be covered by more than one project, there is no need to balance land category acres across projects or within a State. The same acre may be reported as being updated more than once.
4. Acres are recorded to the actual acre or rounded to 100 acres.
5. Areas in Alaska identified as Alaska Native Lands or in Hawaii as Hawaiian Homelands are included in the meaning of Native American land.
6. Census water applies to all contiguous water polygons that are 40 acres in size or larger. If a water polygon is less than 40 acres in size in the survey area but extends into an adjoining survey area such that the total extent in both survey areas is more than 40 acres, then the water qualifies as census water. Census water acreage is *not* to be part of mapping goals; it is administratively managed in NASIS as a land category in the “Project Land Category Breakdown” table so that total survey acres and progress are accounted for.

II. Mapping Goals and Progress

Goals and progress are recorded in the “Project Mapping Goal” and “Project Mapping Progress” tables for each defined project. Goals and progress may be recorded for each individual project staff member or for the project staff as a whole. Use the following protocols:

1. Project Staff. First, enter individual project member names in the “Project Staff” table before entering goals or progress. A choice list is provided based on user names in the NASIS “User” table. If a name needs to be added to the list, contact the Soils Hotline (SoilsHotline@lin.usda.gov) to request a NASIS user account. For more information on requesting NASIS user accounts, see part 639, subpart A, section 639.2, of this handbook.
2. Goals. Enter fiscal year goals in the “Project Mapping Goal” table at the beginning of each fiscal year.
3. Progress:
 - a.) Enter mapping progress and show the effective progress reporting date in the “Project Mapping Progress” table under the appropriate land category. **Note:** The reporting date determines the fiscal year for progress reporting. Show initial and update mapping under NRCS or cooperator columns, as appropriate. Update acres may be reported in any project where update activity has occurred.
 - b.) Once initial soil survey mapping progress has been reported in a project, that progress should not be moved to another project, unless an error was made in data entry. In order to show the current progress for all land categories, however, progress may need to be reallocated among land categories within the same project to reflect any changes in land ownership. **Note:** For situations where land category acres have been rebalanced across projects, acres of mapping progress reported for a land category may be more than the land category acres shown for that project and, in some cases, the land category acres may even be zero.

A. Goal Setting.

- Project Staff Table
 - Project Staff Member
- Project Mapping Goal Table
 - Fiscal Year
 - Initial NRCS Acres Goal
 - Initial Cooperator Acres Goal

- Update NRCS Acres Goal
- Update Cooperator Acres Goal
- Project Staff Member

B. Reporting Mapping Progress

- Project Mapping Progress Table
 - Progress Reporting Date
 - Initial NRCS Acres
 - Initial Cooperator Acres
 - Update NRCS Acres
 - Update Cooperator Acres
 - Project Staff Member

Initial Acres. This item refers to mapping a soil survey area and reporting progress for the first time. The cumulative initial acres reported for a completed survey area always equals 100 percent of the survey area acres. The item applies to all lands of the Nation and mapping by both NRCS and cooperator personnel and to mapping at any order of detail or scale. Typically, initial acres are reported only for surveys having a nonproject or initial status but may apply to surveys with update status where areas that were not mapped during the initial survey are mapped and reported for the first time. Initial acres are reported only once for a given geographic area. All subsequent mapping on the same ground is reported as update acres.

Update Acres. This item refers to updating and reporting progress on acres previously reported for the Nation. All update acreage reported must be a part of a project plan entered in NASIS that was approved by the MLRA management team for the soil survey region. Acres are reported when revised data is posted to the Soil Data Warehouse.

Update projects consist of work that leads to significant changes in data or to work that confirms the quality of the existing attribute data. This work typically, but not always, results in the recorrelation of map units and their components. Update acres are reported even if the data and correlation are not changed. Update projects are based on an inventory and assessment of existing soil survey information and the deficiencies identified for correction. Refer to part 610 of this handbook for guidance on conducting the inventory and assessment. An update project is established after consideration of the work needed based on a project evaluation (described in part 610, subpart A, section 610.4). The project is designed to address, either all or a reasonable subset of, related needs that are identified for the area. One hundred percent of a map unit's acres are reported if update work was conducted on all components. Update acres are not reported for map units for which the edited component is used as a minor component. This situation pertains to map units that were not part of field investigation but for which revisions were extrapolated to the attribute data for the minor component.

Updates are based on field observations, which are either new observations or existing documentation. All documentation used as the basis for updating official soil survey information is populated in NASIS, either as recorded point data or as text notes indicating where the data is located. The documentation is used as the basis for a change or to confirm the accuracy of the official data.

III. Imagery, Orthophotography, Map Compilation Materials, and Other Data Layers

These data elements are primarily the responsibility of State offices in their administrative and liaison capacity between soil survey regional offices and National Cooperative Soil Survey partners within a

State. Field imagery, orthophotography, and map compilation materials may be needed for project survey operations or SSURGO initiatives.

Beginning with NASIS 6.0, these needs are recorded in the “Project Data Need” table. Each type of product or data needed should be recorded on a separate row in the “Project Data Type” column using the choice list provided. Applicable dates need to be recorded in the “Date” columns.

- Project Data Need Table
 - Project Data Type
 - Date Needed
 - Date Ordered
 - Date Received

IV. Initial and Update Survey Operations

These data elements relate most directly to production soil survey operations and therefore are the responsibility of the soil survey regional offices. Data elements relative to the memorandum of understanding for project areas and product types are jointly shared by State offices and soil survey regional offices.

A. Administrative and Field Activities

- Legend Table
 - MOU Signed
 - MOU Projected Completion
 - Project Scale.—Standard National map scales are 1:12,000 in quarter quad format or 1:24,000 in full quad format. Puerto Rico is approved for 1: 20,000 and Alaska is approved for 1: 25,000. Any other scale or format must be approved by the director of the Soil Science Division prior to development of the long-range plan for the survey area.
- Project Field Review Table
 - Correlation Event = “Initial Field Review”
 - Correlation Event = “Final Field Review”
 - Date = date of the respective correlation event report
- Project Table
 - English Edit Site
 - Digital Map Finishing Site

B. Map Finishing

- Project Table
 - Map Finish Method = either digital (preferred) or manual
- Project Milestone Table
 - Milestone Type Name = “Digital map finishing”
 - Milestone Date Started = date map finishing project was started
 - Milestone Date Completed = date map finishing project was completed
- Project Milestone Progress Table
 - Milestone Progress Amount
 - Milestone Progress Unit = “percent”
- Project Milestone Table
 - Milestone Type Name = “Maps to NGCE”
 - Milestone Date Started = date map finishing project was sent to NGCE

- Milestone Date Completed = date map finishing project was received at NGCE
- Milestone Type Name = “Maps to printer”
- Milestone Date Completed = date finished maps were sent to printer

C. SSURGO Digitizing, Certification, and Archiving

SSURGO Operations. As part of the National Cooperative Soil Survey, a SSURGO database is developed for all areas. The Soil Science Division coordinates with NGCE in SSURGO database development. Soil survey regional offices have soil business responsibilities for the correlation and quality assurance of SSURGO products. The dataset is archived in the Soil Data Warehouse and delivered via the Web Soil Survey and Geospatial Data Gateway.

SSURGO Progress Reporting. Progress and status for SSURGO development are tracked continuously in NASIS. Business areas with responsibilities for SSURGO development also have responsibility for populating the appropriate data elements in NASIS (refer to Section 608.13, “Business Area Responsibilities for Goals and Progress”). Data stewards are designated to ensure timely and accurate progress reporting.

SSURGO Certification. These data elements are the primary responsibility of the soil survey regional office. If actual digitizing is not done by the soil survey regional office, States have responsibility for populating “digitizing started,” “digitizing percent,” and “digitizing completed” prior to sending the job to the digitizing unit for certification review. Dates and progress for the following milestones are recorded in the “Project Milestone” and “Project Milestone Progress” tables as outlined in section 608.13.

- “Project Milestone” Table
 - Milestone Type Name = “Digitize maps”
 - Milestone Date Started = date the digitizing was started (The final correlation document, compilation certification, and attribute data are on file at the digitizing unit before the work is started. Correspondence that grants an exception is on file at the soil survey regional office.)
 - Milestone Date Completed = date the digitizing was completed (Quality control work by the State or the digitizing unit and quality assurance by the soil survey regional office are typically done after the digitizing is complete and before the SSURGO review is started.)
- “Project Milestone Progress” Table
 - Milestone Progress Amount
 - Milestone Progress Unit = “percent”
- “Project Milestone” Table
 - Milestone Type Name = “SSURGO Digital review”
 - Milestone Date Started = date the digital review was started
 - Milestone Type Name = “SSURGO Certification”
 - Milestone Date Completed = date the SSURGO dataset was certified
 - Milestone Type Name = “SSURGO Archived”
 - Milestone Date Completed = date the SSURGO dataset was archived

D. Manuscript and Product Development

1. Manuscript Technical Edit and Review

- “Project Milestone” Table
 - Milestone Type Name = “Technical Edit”

- Milestone Date Started = date the technical edit was started
- Milestone Date Completed = date the technical edit was completed
- Milestone Type Name = “Technical Review”
- Milestone Date Completed = date the technical review was completed

2. *English Edit*

- “Project Milestone” Table
 - Milestone Type Name = “English edit received”
 - Milestone Date Completed = date the manuscript was received by the editor
- “Project Milestone” Table
 - Milestone Type Name = “English Edit”
 - Milestone Date Started = date the English edit was started
 - Milestone Date Completed = date the English edit was completed
- “Project Milestone” Table
 - Milestone Type Name = “Text received at NGCE”
 - Milestone Date Completed = date the manuscript was received by NGCE
- “Project Milestone” Table
 - Milestone Type Name = “Text to printer”
 - Milestone Date Completed = date the manuscript was sent to the printer

3. *Products Data Elements*

- “Project Product” Table
 - Product Type.—Six final product types are available from a choice list. All that apply for a survey area are identified according to their publication date. Choices are:
 - Interim Report
 - Soil Attribute/Spatial on CD-ROM
 - Soil Survey Report on CD-ROM
 - Three Ring Bound Manuscript
 - Traditional Bound Manuscript
 - Web Publication
 - Product Description
 - Scheduled Delivery (date)
 - Actual Delivery (date)
 - Availability Status

608.13 Business Area Responsibilities for Goals and Progress

NASIS Table Name	Data Element	State Office	SSR	NSSC	NHQ	SSO	NGCE
I. PROJECT ADMINISTRATION and ACREAGE MANAGEMENT							
A. Administration							
Area	area name	X	X	X			
Area	area symbol	X	X	X			
Area	area acres	X	X	X			
Legend	MLRA office		X				
Legend	MOU agency responsible		X				
Legend	legend description		X				
Legend	geographic applicability						
Legend Mapunit	mapunit symbol						
Legend Mapunit	total acres						
Legend Certification History	legend certification status		X				
Legend Certification History	certification date		X				
Legend Certification History	certification kind		X				
Legend Export Certification History	export certification status						
Legend Export Certification History	export certification date						
Project	project name		X			X	
Project	project description		X			X	
Project	MLRA soil survey office area		X			X	
Project	State responsible		X			X	
Project Product	availability status						
Project Data Type	project data type name			X			
Project Data Type	project data type description			X			
Milestone Type	milestone type name			X			
Milestone Type	description			X			
Technical Soil Service Type	tech soil service type name			X	X		
Technical Soil Service Type	tech soil service type description			X	X		
B. Acreage Management							
Legend Area Overlap	area overlap acres		X				
Project Land Category Breakdown	land category acres		X				
Project Land Category Breakdown	land category		X				

NASIS Table Name	Data Element	State Office	SSR	NSSC	NHQ	SSO	NGCE
II. MAPPING GOALS and PROGRESS							
A. Goal Setting							
Project Staff	project staff member		X			X	
Project Mapping Goal	project staff member		X			X	
Project Mapping Goal	fiscal year		X			X	
Project Mapping Goal	initial NRCS acres goal		X			X	
Project Mapping Goal	initial cooperator acres goal		X			X	
Project Mapping Goal	update NRCS acres goal		X			X	
Project Mapping Goal	update cooperator acres goal		X			X	
B. Reporting Mapping Progress							
Project Mapping Progress	project staff member		X			X	
Project Mapping Progress	progress reporting date		X			X	
Project Mapping Progress	initial NRCS acres		X			X	
Project Mapping Progress	initial cooperator acres		X			X	
Project Mapping Progress	update NRCS acres		X			X	
Project Mapping Progress	update cooperator acres		X			X	
C. ESD Development Progress							
Project Milestone	ESI Quality Assurance – Field Assist		X			X	
Project Milestone	ESI Quality Assurance – Progress Review		X			X	
Project Milestone	ESD approval date		X			X	
Project Milestone	ESI Quality Control Review		X			X	
III. IMAGERY, ORTHOPHOTOGRAPHY, MAP COMPILATION MATERIALS, and OTHER DATA LAYERS							
A. Field Imagery							
Project Data Need	project data type = “field imagery”						
Project Data Need	date needed						
Project Data Need	date ordered						X
Project Data Need	date received						
B. Orthophotography							
Project Data Need	project data type = “digital orthophoto quads”						
Project Data Need	date needed						
Project Data Need	date ordered				X		
Project Data Need	date received						
C. Compilation Materials							
Project Data Need	project data type = “compilation materials”						

NASIS Table Name	Data Element	State Office	SSR	NSSC	NHQ	SSO	NGCE
Project Data Need	date needed						
Project Data Need	date ordered						
Project Data Need	date received						
IV. INITIAL and UPDATE SURVEY OPERATIONS							
A. Administrative and Field Activities							
Legend	MOU signed		X				
Legend	MOU projected completion		X				
Legend	project scale		X				
Project Field Review	correlation event = “initial field review”		X				
Project Field Review	date		X				
Project Field Review	correlation event = “final field review”		X				
Project Field Review	date		X				
Project	English edit site		X	X	X		
Project	digital map finishing site		X	X	X		
B. Map Finishing							
Project	map finish method		X				
Project Milestone	milestone type = “digital map finishing”		X				
Project Milestone	milestone date started		X				
Project Milestone Progress	milestone progress amount		X				
Project Milestone Progress	milestone progress unit = “percent”		X				
Project Milestone	milestone date completed		X				
Project Milestone	milestone type = “maps to NGCE”		X				
Project Milestone	milestone date started		X				
Project Milestone	milestone date completed		X				
Project Milestone	milestone type = “maps to printer”						X
Project Milestone	milestone date completed						X
D. SSURGO Digitizing, Certification, and Archiving							
Project Milestone	milestone type = “digitize maps”		X				
Project Milestone	milestone date started		X				
Project Milestone Progress	milestone progress amount		X				
Project Milestone Progress	milestone progress unit = “percent”		X				
Project Milestone	milestone date completed		X				
Project Milestone	milestone type = “SSURGO digital review”		X				
Project Milestone	milestone date started		X				
Project Milestone	milestone type =		X				

NASIS Table Name	Data Element	State Office	SSR	NSSC	NHQ	SSO	NGCE
	“SSURGO certification”						
Project Milestone	milestone date completed		X				
Project Milestone	milestone type = “SSURGO archived”						
Project Milestone	milestone date completed						
E. Manuscript and Product Development							
1. Technical Edit and Review							
Project Milestone	milestone type = “technical edit”		X				
Project Milestone	milestone date started		X				
Project Milestone	milestone date completed		X				
Project Milestone	milestone type = “technical review”		X				
Project Milestone	milestone date completed		X				
2. English Edit							
Project	English edit site		X	X			
Project Milestone	milestone type = “English edit received”		X				
Project Milestone	milestone date completed		X				
Project Milestone	milestone type = “English edit”		X				
Project Milestone	milestone date started		X				
Project Milestone	milestone date completed		X				
3. Products							
Project Product	product type		X				
Project Product	product description		X				
Project Product	scheduled delivery		X				
Project Product	actual delivery						
Project Product	availability status						

Part 609 – Quality Control, Quality Assurance, and Soil Correlation

Subpart A – General Information

609.0 Definition and Purpose of Quality Control and Quality Assurance

A. Soil Survey Quality Control

- (1) Soil survey quality control is the collective set of activities described in National Cooperative Soil Survey (NCSS) standards and procedures whose purpose is to achieve a high level of quality. Controlling quality involves providing direct review and inspection, direction, and coordination of soil survey production activities to ensure that soil survey products meet the defined standards for content, accuracy, and precision. The quality of soil survey products is controlled at the level where each of the soil survey process steps (from field-level work through publication) takes place.
- (2) Decisions made at the field level have a broad effect, and errors are not easily detected or corrected. Responsibility for quality control of soil survey products, such as maps, descriptions, point and component data, texts, photographs, etc., rests with the major land resource area (MLRA) soil survey leader.

B. Soil Survey Quality Assurance

Soil survey quality assurance is the process of providing technical standards and guidelines, oversight and review, and training to ensure that soil survey products meet NCSS standards. Responsibility for ensuring the quality of soil survey products such as maps, descriptions, data, texts, photographs, etc., rests with the soil survey regional office (SSR).

C. Purpose

Quality control and quality assurance are important at all levels in the preparation, publication, and update of a soil survey. Their purpose is to ensure that soil survey products are accurate and consistent, meet the objectives outlined in the memorandum of understanding or project plan, and satisfy the needs of the majority of soil survey users. Quality control and quality assurance activities also are carried out at other locations where soil survey products are developed, such as the National Soil Survey Center's Kellogg Soil Survey Laboratory (KSSL) and the National Geospatial Center of Excellence (NGCE).

609.1 Policy and Responsibilities for Quality Control and Quality Assurance

A. Policy

- (1) NRCS ensures the quality and integrity of soil surveys through a system of quality control and quality assurance at all levels of activity.
- (2) NRCS has leadership responsibility for nationwide soil correlation within the NCSS.
- (3) For soil surveys on Federal lands, NRCS works closely with partner agencies in carrying out these responsibilities.

B. Responsibilities

(1) Soil Survey Office (SSO)

The MLRA soil survey leader is responsible for—

- Controlling the quality of all soil survey products developed by the SSO within the MLRA soil survey area.

- Periodically conducting quality control reviews to ensure that all products meet NCSS standards.
- Ensuring that all soil survey products submitted for quality assurance review and certification have passed prior quality control inspections.
- Making initial correlation decisions for the survey area using NCSS standards and supplemental guidelines provided by the SSR.
- Conducting progressive soil correlation during the course of all soil survey activities.
- Coordinating ecological site description development and correlation.
- Ensuring that all changes to map unit names and legends, and the reasons for the changes, are recorded in the National Soils Information System (NASIS).
- Ensuring seamless soil survey products across political and physiographic boundaries in the survey area as defined in section 609.3.
- Timely preparation of agendas, soil descriptions, lab data, maps, and other information needed for quality assurance reviews conducted by the SSR.
- Ensuring that findings and recommendations identified in the SSR quality assurance reviews are addressed and implemented in a timely manner.
- Developing soil survey publications that meet NCSS standards as outlined in part 644 of this handbook.
- Developing digital spatial information that meets NCSS standards as outlined in part 647 of this handbook.
- Ensuring that draft or revised official soil series descriptions (OSDs) meet NCSS standards as outlined in part 614 of this handbook and have passed the validations of the OSD Check Program prior to being submitted to the SSR for a quality assurance review.

(2) MLRA SSR

The SSR is responsible for—

- Coordination of soil survey activities and quality assurance for soil survey information, including data collection, NASIS data population, interpretation, correlation, publications, and digital map development, to ensure that all soil survey products developed in the MLRA soil survey region meet NCSS standards.
- Making broad regional decisions to determine where to separate soils based on performance, classification, and other factors to ensure a seamless and scientifically credible soil survey for the Nation.
- Conducting quality assurance reviews to—
 - Ensure that information developed by the SSO has passed quality control inspections and meets NCSS standards,
 - Ensure that progressive correlation is being implemented and followed by the SSO staff, and
 - Identify training needs and management and performance issues.
- Providing States with findings, recommendations, and commendations from quality assurance reviews.
- Providing timely quality assurance review reports and followup from other assistance activities to soil survey offices and State offices.
- Providing or coordinating training for soil survey office staff in data collection and analysis, mapping techniques, map unit design and naming, soil classification, legend management, NASIS data population, interpretations, soil technologies,

quality control procedures, concepts and techniques of progressive soil correlations, and overall management of the soil survey.

- Conducting quality assurance of all attribute data residing in NASIS.
- Conducting quality assurance of all OSDs developed or revised in the MLRA region to ensure that they meet NCSS standards as outlined in part 614 of this handbook and have passed the validations of the SC/OSD Maintenance Tool prior to being uploaded to the OSD file share for public access.
- Quality assurance and maintenance of the OSD file share and soil classification (SC) database for the MLRA region.
- Conducting quality assurance of all spatial data developed in the MLRA soil survey region.
- Quality assurance of ecological site description development and correlation.
- Ensuring the development of seamless soil survey products across political and physiographic boundaries in the MLRA soil survey region as defined in section 609.3.
- Developing a regionwide memorandum of understanding for the entire MLRA soil survey region that outlines the responsibilities and specifications for conducting soil surveys in the region.
- Providing guidance to the SSOs in the region for implementing soil survey update policies as listed in part 610, subpart A, section 610.1, of this handbook.
- Providing MLRA-specific correlation guidelines on soil temperature and moisture regimes and their associated ecological zones, vegetative communities, and any other MLRA-specific information.
- Providing leadership for the coordinated collection of soil survey-related soil characterization data and investigations in the region.
- Approving final correlation documents for initial soil surveys.

(3) State Offices

(i) The state soil scientist is responsible for—

- Actively participating as a member of the SSO management team.
- Serving as liaison to NCSS cooperating agencies to coordinate soil survey program activities.
- Participating in quality assurance review activities sufficiently to support and concur with findings and recommendations.
- Providing leadership with NCSS partners in identifying the need for new soil survey information and interpretations within the State.

(ii) The State conservationist is responsible for—

- Participating as a member (or through a designated appointee) of the board of advisors (BOA) for the MLRA soil survey region.
- Certifying that the soil survey products (SSURGO) are the official soil survey data and maps for conservation planning and agricultural program implementation (e.g., the Farm Bill).

(4) National Soil Survey Center

The National Soil Survey Center is responsible for—

- Formulation and coordination of national guidelines, procedures, and criteria for producing soil survey information.
- Quality control of the criteria for classifying soils and of training in soil taxonomy.
- Quality control of the standards for making soil interpretations.

- Quality control of standards and criteria and of training for the soils portion of geographic and information systems.
- Quality control of analytical procedures used in both laboratory and field investigation of soils.

(5) National Geospatial Center of Excellence

NGCE is responsible for—

- Ensuring the cartographic quality of soil survey maps for archiving and distribution.
- Providing technical guidance specific to cartography and map production.
- Providing subsets of the U.S. General Soil Map (STATSGO2).
- Coordinating requests for cartographic products.
- Developing the techniques, standards, and specifications that ensure quality in spatial soil data capture.
- Providing training in SSURGO quality assurance activities.
- Assisting SSRs in the quality assurance of SSURGO, digital map finishing, and other cartographic soil survey products.
- Providing geospatial Web map services, image map services, feature map services, and the Geospatial Gateway for soil survey data distribution and application.

609.2 Soil Correlation

A. NRCS has leadership for soil correlation within the NCSS. Each SSR ensures the quality of soil surveys through a formal process of soil correlation within their assigned area. For soil surveys on Federal lands, NRCS works closely with partner agencies in carrying out these responsibilities. Soil correlation—

- (1) Addresses the natural geographic distribution and extent of specific soils to ensure consistent and accurate mapping, naming, classification, joining, database population, and interpretation within the MLRA.
- (2) Ensures that data entered into the NASIS database meets NCSS standards.
- (3) Ensures that all adjacent soil survey maps sharing the same purpose, scale, and order of survey exactly join.
- (4) Documents that soil properties and qualities of map unit component are populated using standards provided in part 618 of this handbook.
- (5) Ensures that each map unit is distinguished from all others and that proper interpretations are assigned to each map unit component.
- (6) Facilitates the effective transfer of technology.

B. Progressive Soil Correlation

Progressive soil correlation is a process that identifies and records all the issues and decisions surrounding information at the soil map unit level throughout the course of a soil survey. It is used in initial soil surveys as well as in MLRA soil surveys. It is practiced throughout the course of a soil survey, keeping pace with progress. Field reviews and field assistance visits are vehicles through which the SSO and the SSR promote progressive correlation, maintain quality control and quality assurance, and ensure that technical standards are met. Progressive correlation requires that during each review or field assistance visit, any changes, deletions, or additions to taxonomic units and map units recognized since the last review or assist are evaluated and, if appropriate, certified. For soils that extend beyond the project area, data and descriptions representing the soil on similar landforms and parent materials are used. Documentation, such as ranges for soil properties and map unit composition, is evaluated and

used for the survey in progress. All soil survey activities, including interpretation, legend development, joining, soil investigation, and report development, are concurrent with mapping.

C. Recording Progressive Soil Correlation Decisions

All progressive soil correlation decisions and their reasoning are recorded in NASIS. Any change or addition to legends, taxonomic units, or map units must be recorded. In addition, significant changes to soil property data and interpretive data, such as ecological site designation, farmland classification, land capability classification, or crop yields, should be recorded. The reasons for the decision should be recorded if they are relevant and important to future users of the information.

D. Final Correlation

- (1) Final correlation is a process that is used when an initial soil survey is near completion. If, during the course of an initial soil survey, effective progressive soil correlation has taken place, the final correlation is primarily a review of the progressive soil correlation decisions that have been previously made. The final correlation serves as a data check and also identifies any incomplete work that needs to be completed prior to the soil survey being certified.
- (2) After the final field review, the SSO and SSR schedule a time for a final correlation conference, the outcome of which is the draft correlation document. Although the final correlation is a joint effort between the SSO and SSR, it is the responsibility of the SSO to ensure that all data to be reviewed has passed prior quality control inspections. The SSO also is responsible for gathering and preparing all materials needed for the final correlation.
- (3) At the final correlation, the SSO and SSR—
 - (i) Review and confirm the classification of each pedon that has been analyzed in a soil survey laboratory or engineering laboratory and revise the classification as needed (also, if needed, update appropriate site and classification elements of soil laboratory data for all pedons sampled in the survey area).
 - (ii) Review taxadjuncts and taxons needing a correlation note and record the reason for the taxadjunct or correlation note in NASIS (e.g., unique or unusual information about a taxon that may prove useful to future users of the information).
 - (iii) Review and confirm taxonomic units and their classification and summarize and process final edits and changes to taxonomic unit descriptions.
 - (iv) Review and confirm the validity and classification of series and summarize and process final edits and changes to OSDs.
 - (v) Review and confirm map unit names and ensure their conformity with current naming conventions and consistency in the survey area, and summarize and process final edits and changes to map unit descriptions.
 - (vi) Review NASIS database entries for accuracy, completeness, and consistency.
 - (vii) Review interpretations for accuracy and consistency.
 - (viii) Review the draft report and identify any needed edits or changes.
 - (ix) Review and examine maps for joins, proper labeling, and line conformity with the landform imagery.
 - (x) Prepare a join statement that documents failures to join mapping units and polygons across survey boundaries, and identify how, where, and when field maps will be compiled, digitized, and map finished.
 - (xi) Prepare and review other supporting documents or information to be included in the correlation document (such as soil-vegetation-climate schema or models, special investigative studies, and lists of references used throughout the course of the survey).

- (xii) Record where all field documentation, field maps, and other supporting materials and information will be archived.
- (xiii) Prepare a draft correlation document. (The soil survey regional director approves the final correlation.)

E. Correlation Document

A correlation document, also referred to as a correlation memorandum, is a hardcopy product that is developed and distributed after the completion of an initial soil survey (see part 609, subpart B, section 609.10, for the format and content). The correlation document serves as a record of the final technical decisions made for a soil survey project. It provides—

- (i) The history and linkage from any previous survey information and to adjoining soil survey areas.
- (ii) List of all correlated map units, their components, and their taxonomic classifications.
- (iii) List of series that are established, dropped, or made inactive.
- (iv) Data on pedons sampled for laboratory analysis.
- (v) Specific instructions related to the publication of maps and the list of map and special symbols.
- (vi) If appropriate, the legend of the general soil map.

F. Development, Distribution, and Amendment Policy for the Correlation Document

- (1) All changes to legends, map units, or taxons for a soil survey area, either initial or update, are documented and recorded in NASIS. Recording changes to legends, map units, or taxons in NASIS will ensure that portions of the correlation document can be generated directly from NASIS.
- (2) For *initial soil surveys*, a correlation document will be produced by the SSR and distributed per the following guidelines:
 - (i) The soil survey regional director signs the final correlation document. The signature of the regional director certifies that the soil survey is complete and accurate.
 - (ii) The regional director distributes copies of the signed classification and correlation document and of any subsequent amendments to the document, as follows:
 - One copy to each SSR that has responsibility for soil series used in the survey area
 - One copy to the State in which the survey area resides
 - One copy to each State that adjoins the survey area
 - One copy to Director, NGCE
 - One copy to Director, National Soil Survey Center
 - One copy to NCSS cooperating agencies, as appropriate
 - Copies to NRCS staff within the State (at the discretion of the State Conservationist)
 - (iii) The final correlation document is archived in the “Project Correlation” table in NASIS.
 - (iv) Prior to SSURGO certification, the archived final correlation document can be amended and hard copies redistributed for an initial soil survey area. Amendments to the final correlation document receive the same signatures and distribution as the original document.
 - (v) Once a survey is SSURGO certified and deemed to be in update status, the correlation document and amendments are archived in NASIS. Subsequent correlation decisions are recorded in NASIS, and the original correlation document is no longer amended.
- (3) For *update soil surveys*—

- (i) All changes to legends, map units, or taxons must be documented and recorded in NASIS; however, the archived correlation document will not be amended and redistributed each time a change occurs as part of update activities.
- (ii) In lieu of amending and redistributing a hardcopy of the correlation document, a report will be generated from NASIS that lists and identifies all changes to legends, map units, and taxons. This report may be printed and distributed as the SSR deems necessary.
- (iii) A formal correlation document may be prepared and distributed for an MLRA soil survey area or a special project or to satisfy an agreement item with a cooperator.

609.3 Seamless Soil Survey

A. The goal of soil survey is a seamless product across political and physiographic boundaries. A seamless product entails an exact join of attribute and spatial data between soil survey areas. In some situations, an exact join may not be possible but an acceptable join can be achieved.

B. Exact Joins

An exact join between soil survey areas occurs when soil polygon lines and features are continuous across and along the common boundary and joined soil polygons share the same basic soil properties and selected soil qualities (see part 609, subpart B, section 609.11). Sharing basic properties and selected qualities includes major and minor component composition, basic property ranges (high, low, and representative values), and layer depths. An exact join should be achieved between two surveys with the same, or nearly the same, vintage, stated purpose, scale, and order of survey.

C. Acceptable Joins

- (1) When employing the acceptable join, the SSR must affect the best join possible and document the need for future improvement to the join as appropriate. Acceptable joins are employed primarily when joining previously correlated surveys that would require field investigations to resolve the join discrepancies.
- (2) An acceptable join between soil survey areas occurs when soil polygon lines and features are continuous across and along the common boundary and soil properties and selected soil qualities share the same basic soil properties and selected soil qualities (see part 609, subpart B, section 609.11) for most polygons.
- (3) Where map unit components do not match, they fit the concept of similar soils.
- (4) Rationale for the nonjoined polygons (map units) must be documented.

D. Joining Requirements

- (1) When completing a soil survey, map unit delineations along the boundary with each of the adjacent survey areas are to be joined. To achieve this goal, soil landscape features must be identified, mapped, and described consistently across political and physiographic boundaries. Data collection, analysis, and summary must represent these natural landscapes.
- (2) In most cases, an exact join should be achieved. An acceptable join may be the best join that can reasonably be achieved at the current time. If two soil surveys of different investigation intensities (orders) of mapping are adjacent, an exact join is in effect since the boundary between soil survey areas also serves as soil map unit boundaries. On hardcopy maps, a note is printed parallel to the boundaries that separate the areas of each survey order, such as “Limit of Order 3 Soil Survey.” Chapter 4 of the Soil Survey Manual provides more information. Each soil line in the survey of lower intensity must have a corresponding soil line in the adjacent survey of higher intensity, but the converse is not required.
- (3) If an ongoing soil survey borders a survey area that is out-of-date and therefore acknowledged as being obsolete, the SSR should effect the best join possible using

available knowledge and tools. It is not required to revise any part of the out-of-date survey until such time as an update project is initiated. The joining statement in the correlation document should state the situation.

- (4) The SSO prepares a statement regarding map unit joining with adjacent survey areas. The join statement document records all discrepancies from an exact join and any changes made to enact an exact or acceptable join between map unit polygons. Reasons for these changes should also be included in the join statement. This join statement documentation is included in the final correlation document and in NASIS.
- (5) Changes in map unit names or additions and deletions of map units or delineations to an existing soil survey as part of the SSURGO certification process are documented with an amendment to the final correlation document. Section 609.2E provides information on amending the final correlation document.
- (6) Minor adjustments to soil polygon lines are performed during SSURGO compilation and digitizing to facilitate a best possible join without benefit of field investigations. These adjustments generally involve moving lines slightly (so that they conform to new imagery and come together at the same point along the survey boundary) and coordinating the boundary between the two surveys. Changes in map unit names or additions and deletions of map units or delineations are documented with a correlation amendment. Digital soil surveys and discrepancy documentation and statements recorded in NASIS are tools for future update activities to implement MLRA legends and exact joins.

609.4 Quality Control Reviews

A. Each individual involved in soil survey operations, regardless of their role, has a great influence on the quality of the overall soil survey product. All are expected to perform their duties so that the resulting soil survey products meet NCSS standards and are of high quality.

B. The MLRA soil survey leader is the first-level manager responsible for ensuring that all work performed within their assigned geographic area (including any satellite offices) is of high quality and meets NCSS standards. Much of this quality control responsibility is carried out on a day-to-day basis through direct interaction with subordinate staff members, such as scheduling activities and making work assignments, reviewing completed work, providing on-the-job training, and other related activities. In addition to these routine management activities, systematic reviews are periodically conducted to document the success of the quality control procedures used. The specific details of the items to be reviewed will vary with the kind of activities being carried out as described in the project plan of operations.

C. Part 609, subpart B, section 609.12, contains a template to use for a quality control review for an initial soil survey. The SSRs are encouraged to use this template or a similar form that reflects the activities to be reviewed in a particular SSO. Activities reviewed may include the following:

- (1) Administrative activities and scheduling
- (2) Progress reporting
- (3) Review of mapping
- (4) Legend development and progressive correlation
- (5) Adequacy of field documentation
- (6) Field investigations and sampling
- (7) Database development
- (8) Digital map development
- (9) Publication development

D. The template (section 609.12) provides separate sections for various soil survey process steps and a set of specific items to be reviewed and certified for each. Each SSR should work with the SSO in their region to implement a quality control review process appropriate to their needs.

609.5 Quality Assurance Reviews

A. Quality assurance reviews are scheduled on a regular basis to ensure that technical standards of the NCSS are met. They also can evaluate and certify that progress is consistent with timelines agreed upon in the work plan. In addition, they can serve to help the SSO staff solve problems or provide on-the-job training for the project staff (however, these goals are best achieved through separate field assistance visits).

B. Title 340, General Manual, Part 404, Subpart E, “Internal Management Reviews,” contains NRCS policy for and content of other reviews. Access is through the NRCS eDirectives System at <http://policy.nrcs.usda.gov>. NRCS conducts five types of reviews: oversight and evaluation studies, leadership reviews, operations management reviews, program operations reviews, and functional reviews. Each type may include soil survey issues. Part 609, subpart B, section 609.13, lists potential items for these reviews.

C. Leadership and Participation

The SSR or the lead agency for quality assurance conducts the review. The soil survey regional director leads the quality assurance review. Other suggested participants are—

- (i) Soil scientists from other nearby areas.
- (ii) Members of the SSO.
- (iii) The local district conservationists.
- (iv) The representatives of cooperating agencies.
- (v) The State soil scientist or their designee.
- (vi) Resource soil scientists familiar with the area.
- (vii) Discipline specialists such as engineers, geomorphologists, plant scientists, and geologists.

D. Kinds of Reviews for Initial Soil Surveys

- (1) Each initial survey requires one initial and one final field review. Most initial surveys also require a yearly progress review. MLRA soil survey activities are reviewed for the status of progress toward meeting the goals and objectives set out in the project plan and annual plan of operation. The field review report is a record of such items as the current status of the fieldwork, observations and decisions, digital map and database development, and recommended actions. This working document guides future operations and certifies that completed work meets NCSS standards.
- (2) Initial Field Reviews
 - (i) The purpose of the initial field review is to guide the soil survey project at the start of mapping, to review the collection and recording of soil data, and to complete preparation of the first formal draft of the descriptive legend, based on the mapping completed and data collected. Part 609, subpart B, section 609.14, lists important items to check before and during the initial field review.
 - (ii) Preparation for an Initial Field Review.—An approved soil survey memorandum of understanding (MOU) must be available for the initial review. The MLRA regionwide MOU satisfies this requirement, but an MOU may also be developed for an individual project area. The long-range plan of operations must be available. The SSO assembles, reviews, and summarizes existing information about the MLRA and the subset survey area. The staff should be in place and have worked within the area long enough to

become familiar with the project area and the surrounding surveys. The SSO staff prepares—

- Preliminary concepts of the major soil-landscape models within the context of the larger MLRA region.
- Test mapping of sample areas for the provisional legend.
- Notes that support tentative judgments about the range of important soil properties within the most important kinds of mappable soil areas.
- Information on the kind and amount of mapping components.
- Information on geomorphology, surface features, and kinds of vegetation that provide clues to the kinds of soil and soil boundaries.
- A test of the initial interpretations.
- A first draft of the descriptive legend.
- Preliminary data to support judgments about the kinds and number of map units needed for the project area.
- Equipment, supplies, and base maps.

(iii) Conduct of the Review

- Initial Preparations.—The review team appraises all initial preparations to ensure that they are adequate and takes necessary action if they are not.
- Field Study.—The review team evaluates the draft descriptive legend against mappable bodies of soil in the field and reviews the collected soil data. It checks the accuracy of descriptions and the adequacy of map units for making soil interpretations. It evaluates and comments on the mapping done in sample areas in relation to the adjacent surveys. The team checks the joining of soil maps and selected soil properties or qualities within the soil survey area to adjoining survey areas to ensure they meet the joining specification in the memorandum of understanding. It makes decisions on soils for which the classification is doubtful.
- Descriptive Legend.—As a minimum, the descriptive legend consists of the taxonomic and map unit descriptions, the classification of the soils, the general soil map (U.S. General Soil Map – STATSGO2) and legend, the identification legend, and the features and symbol legend. After the field study, the review team evaluates the draft descriptive legend and makes necessary revisions. It examines the naming of the kinds of map units, the classification of the kinds of soil identified in the map units, the general soil map and legend, the list of features and symbols for the soil survey, and the definitions of ad hoc features. The team ensures that the design and description of map units meet the objectives of the survey. The descriptive legend includes only the map units and features that are actually identified and described before or during the initial field review.
- Scheduling.—The review team discusses and schedules long- and short-range activities necessary for completing the survey. Part 609, subpart B, section 609.14, identifies many of the items to check before and during the initial field review. The team discusses activities and schedules for—
 - Preparation of parts of the soil handbook for the survey area.
 - Plans for soil investigations and collection of samples for laboratory analysis.
 - Collection of data on yields and soil performance in all land uses.
 - Recording of field notes.
 - Preparation of the soil survey publication.

(iv) Preparation of the Report.—The leader of the initial field review prepares a report that is approved by the soil survey regional director. The report schedules subsequent progress field reviews and special studies. It includes arrangements for completing

laboratory work and a quality assurance worksheet (see part 609, subpart B, section 609.15). It also includes—

- The identification legend.
- A progress map.
- Draft descriptions of proposed new soil series.
- A statement on the accuracy of map unit composition and attribute data.
- Notes recording important observations made during the field study.
- Instructions and items agreed upon for the field soil scientists and others, which concern conduct of the survey and the assignment of responsibilities, priorities, and dates of accomplishment.
- A list of the classification of taxa in the survey area.
- A subset of the U.S. General Soil Map (STATSGO2) database for the survey area as a general soil map.
- A letter transmitting the report to the MLRA soil survey leader and others as appropriate, in which the soil survey regional director highlights significant issues and items that are agreed upon.

(3) Progress Field Reviews

- (i) The purpose of this review is to assess progress and ensure that NCSS standards are being met. Progress field reviews emphasize progressive correlation in a manner consistent with the larger MLRA soil survey area and certification of the work completed to date. Help also may be provided to the soil survey staff on problems of soil classification; field mapping; data collection, storage, and retrieval; and soil interpretation. However, these problems are generally best addressed during a separate field assistance visit.
- (ii) The frequency of progress reviews depends on the rate of progress, the complexity of the soil survey area, and the experience of the SSO staff. Part 609, subpart B, section 609.16, lists some important items to check before and during progress field reviews.
- (iii) Conduct of the Review
 - The review team spends at least some of the time in the field observing examples of mapping, field descriptions, and associated data and interpretations to ensure that the local quality control procedures are effective.
 - The review team examines maps for correct soil identification, proper placement of boundaries, legibility, and kinds and amounts of components in delineations.
 - The team checks the maps and databases for joins with adjacent surveys.
 - The team compares findings with statements in the descriptive legend. Where problems are noted, it assists the staff in avoiding similar future problems.
 - The progress field review team reviews the recommendations of the soil survey staff for progressively correlating completed mapping. They make a record of the reasons for any correlation decisions and any work needed to update field sheets.
 - The review includes a check of all interpretations. The review team cross-checks field data, such as forestry productivity, for use. It recommends changes and additions to soil property records.
 - The review includes the quality and status of the descriptive legend and the soil survey handbook. The review team recommends revisions for the descriptive legend as necessary to meet the objective of the survey.
 - The review team checks the adequacy of field notes and the rate and progress of mapping and other scheduled survey activities.
 - The review team determines if action has been taken to correct deficiencies and complete items agreed upon that were noted in previous field reviews.

- (iv) Preparation of the Report.—The leader of the progress field review prepares a report of the review. The report includes a quality assurance worksheet (see part 609, subpart B, section 609.15) that has been approved by the SSR. In addition to the worksheet, the report includes the following:
- A list of commendable activities of the soil scientists assigned to the survey area
 - A list of items agreed upon, persons assigned responsibility, and the dates for completion
 - A statement of the accuracy of map unit component and attribute data
 - A progress map
 - An updated list of the classification of taxa in the survey area
 - Notes recording important observations made during the field studies
 - A record of additions, deletions, or other changes to the descriptive legend
 - A complete updated identification legend
 - A letter transmitting the report to the MLRA soil survey leader and others as appropriate, in which the soil survey regional director highlights significant issues and items that are agreed upon
 - An evaluation and comments on the status of scheduled actions from earlier progress reviews
- (4) Final Field Reviews
- (i) The purpose of the final field review is to evaluate the entire survey to ensure that the work is of acceptable quality and to complete necessary modifications before field operations end. The final field review is held about 1 year before the completion of mapping in initial soil surveys. Part 609, subpart B, section 609.17, lists some important items to check before or during the final field review.
- (ii) Activities Completed Prior to the Final Field Review.—The activities include completing the mapping, checking the consistency and quality of mapping throughout the survey area, collecting soil sample and interpretation data for correlation, finishing the complete draft of the soil survey report and database entries, revising the U.S. General Soil Map (STATSGO2) database and (if one is to be prepared) the general soil map, completing laboratory analysis and soil investigations, providing correlated names and classifications for pedons in the laboratory database, taking photographs, and preparing illustrations.
- (iii) Conduct of the Review.—The major portion of the final field review occurs in the office. Field visits take place if needed. Those activities that were noted as needing corrective action during the last progress review receive special attention. Items scrutinized by the review team include the descriptive legend and supporting information; map unit names, composition, and associated data; the joining of the U.S. General Soil Map (STATSGO2) database; the draft soil survey report; and interpretative tables.
- (iv) Preparation of Report.—The leader of the final field review prepares a report. The report includes a quality assurance worksheet (see part 609, subpart B, section 609.15) that has been approved by the SSR. In addition to the worksheet, the report includes the following:
- An identification legend
 - A feature and symbol legend
 - A progress map
 - A record of soil characterization samples that were collected for laboratory analysis in the survey area
 - A record of soil samples that were collected for engineering tests

- A statement on the accuracy of map unit component and attribute data
 - An updated list of the classification of taxa in the survey area
 - An evaluation of the soil survey report
 - A list of commendable activities of the soil survey office staff
 - A list of actions agreed upon
 - A record of the decisions made during the review
 - A preliminary correlation memorandum
 - A letter transmitting the report to the MLRA soil survey leader and others as appropriate, in which the soil survey regional director highlights significant issues and items that are agreed upon
 - An evaluation and comments on the status of scheduled actions from any earlier progress reviews
- (v) Final Field Activities for Initial Soil Survey Projects.—The soil survey office schedules time between the final field review and the final correlation in order to complete the mapping, perform final checks, review the fieldwork and soil survey database, complete the final draft of the soil survey publication, and update all supporting records and data, such as map unit acreage data, map compilation, and statistical analysis for map unit composition information. Preparation of the final correlation memorandum requires completion of these activities. The final correlation memorandum is finalized upon signature by the soil survey regional director. Section 609.2 discusses preparing and distributing a correlation memorandum. Part 609, subpart B, section 609.10, discusses the format of the final correlation memorandum.

E. MLRA Soil Survey Quality Assurance Reviews

(1) MLRA Soil Survey Progress Reviews

- (i) Progress field reviews emphasize evaluation of activities of the field staff to ensure that the staff are carrying out soil survey update activities as described in the project plan of operations for the area, that NCSS policy and procedures are followed, and that the completed work meets NCSS standards. They may also provide help to the staff on problems such as soil classification; updating of maps; data collection and analysis, storage, and retrieval; and soil interpretation.
- (ii) The frequency of progress reviews depends on the rate of progress, the complexity of the project area, and the kinds of update activities being conducted. Part 609, subpart B, section 609.18, lists some important items to check before and during project reviews.
- (iii) Conduct of the Review.—Activities are tailored to reflect the nature of the work being performed. Commonly, the review team spends part of the time in the field reviewing the collected soil data. They also examine digital maps for correct soil identification, proper placement of boundaries with landforms and imagery, and validity of models used in revising the soil maps. As necessary, the team concentrates on solutions to problems brought to their attention by the field staff or discovered during the review process. It checks the adequacy of documentation and the rate and progress of scheduled survey activities. It determines if action has been taken to correct deficiencies and complete items agreed upon that were noted in any previous field reviews.
- (iv) Preparation of the Report.—The leader of the project review prepares a report of the review. The report includes a quality assurance worksheet (see part 609, subpart B, section 609.19) that has been approved by the SSR. In addition to the worksheet, the report includes the following:
 - A list of commendable activities of the soil scientists assigned to the survey area

- A list of items agreed upon, persons assigned responsibility, and the dates for completion
 - A statement of the accuracy of map unit component and attribute data
 - An updated list of the classification of taxa in the survey area
 - Notes recording important observations made during the field studies
 - A complete updated identification legend for the project area
 - A letter transmitting the report to the MLRA soil survey leader and others as appropriate, in which the soil survey regional director highlights significant issues and items that are agreed upon
 - An evaluation and comments on the status of scheduled actions from any earlier progress reviews
- (2) MLRA Soil Survey Completion Reviews
- (i) The purpose of the project completion review is to evaluate the activities to ensure that the work meets NCCS standards and to complete necessary modifications before individual project operations end. This review is held when activities described in the current plan of operations are nearing completion. Part 609, subpart B, section 609.18, lists some important items to check before or during the project review.
 - (ii) Activities Completed Prior to Project Completion Reviews.—Activities include completing the digital revisions, checking consistency and quality of previous mapping throughout the project area, collecting soil sample and interpretation data for correlation, completing laboratory analysis and soil investigations, and providing correlated names and classification for all applicable pedons in the laboratory database.
 - (iii) Conduct of the Review.—The major portion of the review occurs in the office. Field checks generally are covered under field assistance visits (see section 609.6). Those activities that were noted as needing corrective action during any project progress review receive special attention. Items scrutinized by the review team include supporting information, the validity of map units and their names, and the tabular database. A check is made to ensure that correlation decisions are recorded in NASIS.
 - (iv) Preparation of Report.—The leader of the project completion review prepares a report. The report includes a quality assurance worksheet (see part 609, subpart B, section 609.19) that has been approved by the SSR. In addition to the worksheet, the report includes the following:
 - An identification legend of revised map units
 - A feature and symbol legend
 - A record of soil characterization samples that were collected for laboratory analysis in the survey area
 - A record of soil samples that were collected for engineering tests
 - A statement on the accuracy of map unit component and attribute data
 - An updated list of the classification of taxa in the survey area
 - A list of commendable activities of the soil survey office staff
 - A record of the decisions made during the review
 - A letter transmitting the report to the MLRA soil survey leader and others as appropriate, in which the soil survey regional director highlights significant issues and items that are agreed upon
 - An evaluation and comments on the status of scheduled actions from any earlier progress reviews

F. Signature and Approval of Review Reports

- (1) Review Team Leader.—The SSR, or a cooperating agency, leads the review and is responsible for preparing and signing all review reports and transmitting copies of the

review report to the MLRA soil survey leader and others as appropriate. The soil survey regional director signs the transmittal letter.

- (2) Representatives of Cooperating Agencies.—The representatives may also sign all review reports, such as the quality assurance worksheet. When other partner agencies (for example, the U.S. Forest Service) lead the review, NRCS participates in a quality assurance role, which does not replace the responsibilities assigned to the partner agency. Field review reports and other documentation regarding survey quality on Federal land require the signature of a representative of the agency who participates in the review activity, or a designated representative of the agency, to document agreement or disagreement by signing the report.

G. Distribution and Review of Review Reports

The soil survey regional director distributes copies of all field reviews within 30 days after the final day of the review. The director sends at least one copy of the field review report and attachments and a letter of transmittal to the MLRA soil survey leader and others as appropriate, such as cooperating agencies and the State office in which the survey area resides.

609.6 Field Assistance Visits

- A. The soil survey office, State office, or a cooperating agency office may request help from the SSR. The SSR may also schedule field assistance visits.
- B. A written trip report is to be prepared documenting the activities from the field assistance visit and distributed to the participants, as well as the state soil scientist and any appropriate cooperating agencies. Decisions that affect the legend, data collection or recording, classification of soils, or interpretations become part of the permanent and formal record of the survey upon inclusion in the final field review or MLRA project completion report.

609.7 Final Soil Survey Field Activities for Initial Soil Survey Projects

- A. The soil survey office schedules time between the final field review and the final correlation to complete the mapping, perform final checks, review the fieldwork and soil survey database, complete the final draft of the soil survey report, and update all supporting records and data, such as map unit acreage data, map compilation, and statistical analysis for map unit composition information. Preparation of the final correlation memorandum requires completion of these activities.
- B. Final Correlation Memorandum.—The draft of the final correlation memorandum is prepared at the final correlation conference. The final correlation memorandum is finalized upon signature by the soil survey regional director. Section 609.2 discusses preparing and distributing a correlation memorandum. Part 609, subpart B, section 609.10, discusses the format of the final correlation memorandum.
- C. Final Draft of the U.S. General Soil Map (i.e., Digital General Soil Map of the United States).—The soil survey office prepares the general soil map for the final field review on its publication scale base map in final form. This map is from the Digital General Soil Map of the United States database. Inclusion of this map in the soil survey publication is optional. The general soil map unit names are revised as needed to agree with the general soil map legend in the correlation memorandum.

609.8 General Soil Maps, Index Maps, and Location Maps

A. The SSR ensures the technical quality of general soil maps, index maps, and location maps. The general soil maps are optional in soil survey publications, but index maps and location maps are required. If a general soil map (GSM) is not to be included, cooperators should agree with the decision. Also, an up-to-date U.S. General Soil Map (STATSGO2) database map of the survey area should be readily available to the public. The availability of the U.S. General Soil Map should be noted in the publication, such as in the section “How To Use This Soil Survey.”

B. General Soil Maps and Index Maps

- (1) Each soil survey publication includes an index to map sheets, which is available from the NGCE staff. By request, a soil survey area subset of the U.S. General Soil Map is provided by NGCE as one of the map sources for the GSM. The other source for GSM development is SSURGO. NGCE assists in determining format and the number of maps needed. A draft of the general soil map developed from the U.S. General Soil Map or SSURGO and the associated legend are completed to the extent possible after correlation decisions have been finalized. The soil data quality specialist reviews the GSM and legend to verify that—
 - (i) Soil map boundaries are accurate.
 - (ii) GSM map unit names conform to the correlated names on the detailed maps.
 - (iii) The map legend and manuscript are in agreement.
 - (iv) The general soil map legend matches adjoining survey areas (this ensures that all delineations are closed and symbolized, that the area of each map unit compares with the percentage given for the survey area, and that the organization and levels of generalization of the map and legend are appropriate).
 - (v) Map delineations and legends join the U.S. General Soil Map for adjacent surveys.
 - (vi) If the percentage of each component in the GSM is given, the total acreage of each is not more than that in the acreage table for the detailed map units.
- (2) Once the draft general soil map is approved, the detailed soil legend and feature and symbol legend can be ordered. To order:
 - (i) Go to NGCE online at <http://www.ftw.nrcs.usda.gov/ngcos/>.
 - (ii) Order the color check print of the general soil map, the index to map sheets, the feature and symbol legend, and the detailed soil legend. List the headnote to accompany the detailed soil legend if it is different from that shown in the final correlation memorandum. If the headnote is different, amend the final correlation memorandum to reflect the change.
 - (iii) Indicate additional instructions for completing the order. Include special instructions needed by the cartographic staff to prepare the symbol legend. Show suggestions for colors identifying soil groupings or levels of generalization on the supplement or on the edited legend. Attach a copy of the final correlation memorandum and any amendments, the electronic file of the U.S. General Soil Map, and a copy of the edited general soil map legend to the order.
- (3) NGCE completes the order and sends the general soil map color check print, the index to map sheets, and the legends to the SSR for final review and approval. The SSR checks—
 - (i) The GSM legend against the edited copy,
 - (ii) The detailed soil map legend against the final correlation memorandum and any amendments.
 - (iii) The names of cooperating agencies on maps and legends against the final correlation memorandum and any amendments.
 - (iv) The name of the survey area on maps and legends against the final correlation memorandum and any amendments.
 - (v) The conventional and special symbol legend for agreement with maps and the final correlation memorandum.

- (4) The SSR makes needed changes and corrections on the U.S. General Soil Map and returns them to NGCE. The NGCE staff makes the corrections identified.

C. Location Maps

Each soil survey publication requires a location map. This map shows the location of the survey area in the State. The SSR orders the location map at the time the soil survey manuscript is received for technical review. The NGCE staff prepares the location map.

Part 609 – Quality Control, Quality Assurance, and Soil Correlation

Subpart B – Exhibits

609.10 Format for Correlation Document

The following outline shows the order and character of items and data ordinarily contained in a correlation document. It does not preclude the inclusion of other information pertinent to the survey or the explanation of actions taken in the correlation. An example follows each item.

1. Heading

UNITED STATES DEPARTMENT OF AGRICULTURE
Natural Resources Conservation Service

Classification and Correlation
of the Soil Survey of
Any Area, Any MLRA, Any State

The United States Department of Agriculture (USDA) is an equal opportunity provider and employer.

2. Introductory Paragraph

In this paragraph cite persons participating in the correlation, the date, the location, data reviewed, the basis for the correlation, and other items if pertinent. For example: “John C. Smith, soil data quality specialist, and David G. White, MLRA soil survey leader, of the Natural Resources Conservation Service, and Joseph I. Black, associate professor, Anytown State University at Any Town, Any State, prepared this correlation the week of October 21-25, 2000. The soil survey database, soil survey publication, field notes, interpretations, laboratory data, correlation samples, field map sheets, and materials from the adjacent soil surveys provide the basis for this correlation.”

3. Headnote for Detailed Soil Survey Legend

This headnote is an explanation of the symbols on the detailed soil maps in the published survey. It appears on the SOIL LEGEND in the published report and precedes the list of map unit symbols and map unit names. For example: “Map unit symbols consist of numbers or a combination of numbers and letters. The initial numbers represent the kind of soil. A capital letter following these numbers indicates the class of slope. Map unit symbols without a slope letter indicate nearly level soils or miscellaneous areas.”

4. Field and Publication Names and Symbols

The correlation of soil map units is formatted into four columns. List map unit symbols for publication alphabetically or numerically in sequence. The heading and format are as follows:

<u>Field Map Unit Symbol</u>	<u>Field Map Unit Name</u>	<u>Publication Map Unit Symbol</u>	<u>Approved Map Unit Name</u>
DeB	Delta sandy loam,	AbB	Alpha sandy

	2 to 6 percent slopes		loam, 2 to 6 percent slopes
Bf	Beta mucky silt loam	Be	Beta silt loam
GaB, GhB	Gamma silt loam, 2 to 6 percent slopes	GaB	Gamma silt loam, 2 to 6 percent slopes

5. Series Established by This Correlation

List the soil series established by this correlation. List in parentheses, after the series name, the county, the parish, or survey area and the State in which the type location occurs if the type location is in a soil survey area other than the one being correlated. For example: “The Alpha series is established by this correlation, the Alpha type location in the adjoining Beta County soil survey area, Any State.” Enter “none” if no new series were established.

6. Series Dropped or Made Inactive by This Correlation

List the tentative soil series that were dropped or the established soil series that were made inactive by the correlation. For example: “The Beta series is inactivated by this correlation.” Enter “none” if no tentative series were dropped or no established soil series were made inactive.

7. Cooperators’ Names and Credits

List the following: The cooperators’ names and credits to be given in the published soil survey.

“United States Department of Agriculture
Natural Resources Conservation Service
In cooperation with
Anystate Agricultural Experiment Station
Anystate Conservation Commission
Anystate Cooperative Extension Service
Any Soil and Water Conservation District”

“This survey was made for Any Survey Area, Anystate, by the Natural Resources Conservation Service and the Anystate Agricultural Experiment Station, Anystate Conservation Commission, and the Anystate Cooperative Extension Service. It is part of the technical assistance furnished to the Any Survey Area Soil and Water Conservation District. The Any Survey Area Board of Commissioners provided financial assistance for the survey.”

8. Prior Soil Survey Publications

Indicate the reference to prior soil survey publications that will appear in the introduction of the published soil survey. A prior published soil survey is a literature citation in the soil survey publication. For example: “The first soil survey for Any Survey Area, Anystate, was published by the U.S. Department of Agriculture in 1903. Maps were printed in 1905. This soil survey is on an aerial photography base and contains more interpretative information.” Enter “none” if there is no prior soil survey publication.

9. Miscellaneous Items

Use the appropriate headings and include items pertinent to the correlation or publication of the survey. For example, the soil-vegetation-climate schema, or model, used to guide correlation for the

survey area should be included. Other examples include a summary of soil temperature or moisture studies or special investigative reports that provided guidance for the survey area.

10. Instructions for Map Development

These brief instructions should include:

- Who is responsible for the development of digital spatial data
- The date and projection of the orthophoto imagery being used for the base map
- Who is responsible for digitizing the maps and when it is scheduled
- Who is responsible for finishing the digital maps and when it is scheduled
- Whether or not a layer for point and linear map units will be compiled and digitized
- Any other instructions that may be relevant to the achieving a digital soils layers

Detailed instructions for soil map data capture are found in part 647 of this handbook.

11. Feature and Symbol Legend

Include a copy of form NRCS-SOI-37A and indicate the features and symbols that are used in the survey area by highlighting or underlining in red. For example: “Only those symbols indicated on the NRCS-SOI-37A will be shown on the legend.” Complete the descriptions for standard landform and miscellaneous surface features and descriptions for ad hoc features on the back of the form for those features indicated.

12. General Soil Map Unit Legend

List the general soil map units that will be shown on the legend of the general soil map of the survey area. For example:

“The following map units will be used on the general soil map legend:

Alpha-Beta to Alpha-Beta association

Beta-Gamma-Zeta to Beta-Gamma-Zeta association.”

13. Conversion Legend

List all field symbols and their approved publication symbols. A conversion legend is not needed if field symbols and publication symbols are identical. For example:

CONVERSION LEGEND, ANY SURVEY AREA, ANY STATE

Field Symbol	Publication Symbol	Field Symbol	Publication Symbol
7A	7A	20B	20B
7B	7B	21C	21D
7C	7C	21E	21E

14. Legend of Map Units in Alphabetical Sequence

This legend is used only where numeric symbols will be published to assist publication crosschecking. For example:

LEGEND OF MAP UNITS IN ALPHABETICAL SEQUENCE, ANY SURVEY AREA, ANY STATE

Publication Symbol	Approved Map Unit Name
43	Alpha clay
37	Beta clay loam, 5 to 9 percent slopes, eroded
39	Beta clay loam, 9 to 14 percent slopes, eroded

15. Classification of Pedons Sampled for Laboratory Analysis

This table lists pedons that have laboratory data or engineering test data. Give the source of the data and other pertinent information. In the table “Publication Symbols,” refer to the map symbol that identifies the area from which the sample was taken. Additional columns can be added if needed.

CLASSIFICATION OF PEDONS SAMPLED FOR LABORATORY ANALYSIS

Sampled as	Soil Survey Sample No.	Publication Symbol	Approved Series Name or Class Identification
1. Laboratory Data from the NSSC Kellogg Soil Survey Laboratory			
Alpha	S79AS-047-003	AbB	Alpha
Beta	S79AS-047-004	GbB	Gamma
2. Laboratory Data from the Anystate Agricultural Experiment Station Laboratory			
Beta	S79AS-047-005	BgB	Beta
Gamma	S79AS-047-006	AaA	Alpha
3. Laboratory Data from the Anystate Highway Department Laboratory			
Alpha	S79AS-047-007	AaA	Alpha
Beta	S79AS-047-008	BbC	Beta

16. Sampled Pedons in Published Soil Survey Report

This table lists the pedons and laboratory data that will be included in the published soil survey report. These pedons should represent the typical pedon for the series in the survey area. If the pedon is not the typical pedon for the series in the survey area, place a tabular or semi-tabular description in the soil survey report.

<u>Series</u>	<u>Sample No.</u>	<u>Status</u>
Alpha	S79AS-047-003	Typical pedon for the Alpha in the survey area.
Alpha	S79AS-047-011	Typical pedon from map unit Aa.

17. Notes to Accompany the Classification and Correlation of the Soils in the Survey Area

Notes of general explanation that contribute to the understanding of the correlation can be included as an introductory paragraph. For example: “This survey area is in a transitional zone of soil temperature regimes. Soils with mesic and thermic temperature regimes have been correlated.”

In the notes, include items such as:

(a) Pertinent information about series being established. For example: “Alpha Series. The Alpha series is established by this correlation for soils that were formerly mapped as Beta but that have mixed mineralogy rather than siliceous mineralogy as defined for Beta.”

(b) How taxadjuncts differ from the series concept. For example: “Gamma Taxadjunct. This soil is a taxadjunct to the Gamma series because it contains less than 15 percent sand that is coarser than very fine. The soil classifies as coarse-silty.”

(c) A correlation note for soils that are slightly outside the official series range, but are not taxadjuncts. For example: “Beta soils in this survey have a redder subsoil and are slightly more acid

throughout than those defined in the OSDs. These differences do not affect taxonomic placement or use and management. The OSD was not revised because the color and reaction differences are due to the inherent characteristics of the Theta geologic formation in which these soils formed and which is not the typical formation in which the Beta series formed.”

18. Classification of the Soils

This table lists the classification of the taxonomic units that are used in the survey area. Classify taxonomic units that are named at a level above the series as precisely as the data permits. Designate taxadjuncts with an asterisk only if the representative pedon is a taxadjunct. Address map units with major components that are taxadjuncts in the “notes.” Do not list miscellaneous area names in the classification table. For example:

CLASSIFICATION OF THE SOILS OF ANY SURVEY AREA, ANYSTATE

Soil Name	Family or Higher Taxonomic Class
Alpha	Coarse-loamy, mixed, active, frigid Aridic Haploxerolls
Beta	Fine-silty, mixed, active, frigid Cumulic Epiaquolls
Gamma*	Coarse-loamy, mixed, active, frigid Dystric Eutrudepts
Udorthents	Udorthents

*Taxadjunct. See “Notes to Accompany Classification and Correlation of the Soils of Any Survey Area, Anystate” for details.

19. Join Statement

The join statement prepared at the final field review is included. It explains where an exact join was not achieved and identifies what map units need review and their joins resolved.

20. Certifications

The correlation document is to contain certification of the following:

- (a) Mapping is complete. For example: “Mapping completed in June 1999.”
- (b) General soil maps and detailed maps join exactly with those of adjacent survey areas, and detailed maps join within the survey area. Discrepancies in the join of maps with those of adjacent areas are documented, and a detailed statement of join differences is referenced and included in the correlation document. The reason the maps cannot be joined is given in the join statement.
- (c) Databases and interpretations are coordinated and complete. For example: “Databases and interpretations are coordinated, map unit lines of adjoining surveys are continuous across and along the shared borders, and the joined map units share basic soil properties and selected soil qualities. All data elements are populated and no obsolete terms are used.”
- (d) Type locations are in soil areas that have the referenced names, and location descriptions are correct. For example: “The locations of all typical pedons used in this survey are within the major land resource area, are correct, and are within delineations that have the referenced name.”
- (e) Forestland and rangeland site plots were taken in soil areas that have the referenced series names, the series names have been correlated in the forestland and rangeland databases, and all data is certified.

(f) All typical pedons are classified according to *Soil Taxonomy*, 2nd edition and the latest edition of the *Keys to Soil Taxonomy*. For example: “All typical pedons are correctly classified according to *Soil Taxonomy*, 2nd edition and the latest edition of the *Keys to Soil Taxonomy*.”

(g) Only approved names for miscellaneous areas have been used as component names, as specified in Part 627, Exhibit 627-1, of this handbook.

(h) The soil maps have been reviewed for completeness, accuracy, and consistency. For example: “The soil maps are complete, accurate, and consistent.”

21. Approval Signatures and Date

Soil Survey Regional Director

Date

609.11 List of Soil Property or Quality Attributes for Joining

The following list provides basic soil properties and selected soil qualities that are to be joined between soil surveys to achieve an “exact” join. NASIS data element names are used for convenience, but their usage is not intended to suggest a database solution.

National Attributes *

Soil Property or Quality Name	
aashto_group_classification	geomorph_feat_modifier
aashto_group_index	geomorph_micro_relief
albedo_dry	geomorphic_feat_id
aluminum_oxalate	geomorphic_position_flats
available_water_capacity	geomorphic_position_hills
bulk_density_fifteen_bar	geomorphic_position_mountains
bulk_density_one_tenth_bar	geomorphic_position_terraces
bulk_density_one_third_bar	gypsum
bulk_density_oven_dry	hillslope_profile
calcium_carbonate_equivalent	horizon_depth_to_bottom
cation_exch_capcty_nh4oacph7	horizon_depth_to_top
clay_sized_carbonate	horizon_designation
clay_total_separate	horizon_thickness
component_kind	horz_desgn_discontinuity
component_name	horz_desgn_letter_suffix
component_percent	horz_desgn_master
corrosion_concrete	horz_desgn_master_prime
corrosion_uncoated_steel	horz_desgn_vertical_subdvn
diag_horz_feat_depth_to_botm	hydrologic_group
diag_horz_feat_depth_to_top	iron_oxalate
diag_horz_feat_kind	linear_extensibility_percent
diag_horz_feat_thickness	liquid_limit
earth_cover_kind_level_one	local_phase
earth_cover_kind_level_two	major_component_flag
effective_cation_exch_capcty	manner_of_failure
electrical_conductivity	mean_distance_between_rocks
Elevation	month
erosion_accelerated_kind	organic_matter_percent
erosion_class	parent_material_general_mod
excavation_difficulty_class	parent_material_group_name
excavation_difficulty_moist_st	parent_material_kind
exists_on_feature	parent_material_modifier
extractable_acidity	parent_material_order
extractable_aluminum	parent_material_origin
flooding_duration_class	particle_density
flooding_frequency_class	ph_01m_cacl2
fragment_hardness	ph_1_1_water
fragment_kind	phosphorous_bray1
fragment_roundness	phosphorous_oxalate
fragment_shape	phosphorous_total
fragment_size	phosphorous_water_soluble
fragment_volume	plasticity
free_iron_oxides	plasticity_index
	ponding_depth

ponding_duration_class
ponding_frequency_class
pore_continuity_vertical
pore_quantity
pore_shape
pore_size
potential_frost_action
restriction_depth_to_bottom
restriction_depth_to_top
restriction_hardness
restriction_kind
restriction_thickness
rock_frag_3_to_10_in
rock_frag_greater_than_10_in
rupture_resist_block_cem
rupture_resist_block_dry
rupture_resist_block_moist
rupture_resist_plate
rv_indicator
sand_coarse_separate
sand_fine_separate
sand_medium_separate
sand_total_separate
sand_very_coarse_separate
sand_very_fine_separate
sat_hydraulic_conductivity
shape_across
shape_down
sieve_number_10
sieve_number_200
sieve_number_4
sieve_number_40
silt_coarse_separate
silt_fine_separate
silt_total_separate
slope_aspect_clockwise
slope_aspect_counterclockwise
slope_aspect_representative
slope_gradient

slope_length_usle
sodium_adsorption_ratio
soil_erodibility_factor_rf
soil_erodibility_factor_whole
soil_moist_depth_to_bottom
soil_moist_depth_to_top
soil_moisture_status
soil_temp_depth_to_bottom
soil_temp_depth_to_top
soil_temperature_mean_monthly
stickiness
stratified_textures_flag
structure_grade
structure_group_name
structure_id
structure_parts_to
structure_size
structure_type
sum_of_bases_nh4oacph7
surface_frag_cover_percent
surface_frag_hardness
surface_frag_kind
surface_frag_roundness
surface_frag_shape
surface_frag_size
t_factor
terms_used_in_lieu_of_texture
texture_class
texture_modifier
texture_modifier_and_class
total_subsidence
unified_soil_classification
water_fifteen_bar
water_one_tenth_bar
water_one_third_bar
water_satiated
wind_erodibility_group
wind_erodibility_index

* Soil performance elements (range and forest production, etc.) and linkage to data related to ecological sites are not included as being required to be joined but should at least be coordinated between surveys.

609.12 Quality Control Template for Initial Soil Surveys (subject to change to reflect local conditions)

**INITIAL SOIL SURVEY
QUALITY CONTROL REVIEW**

Date:

Area name:

State Soil Survey Area Identification:
Major Land Resource Area(s):

This quality control report is to ensure this soil survey is science-based, the legend and correlation use the MLRA concept, and the survey meets the standards and specifications of the NCSS. This report consists of several soil survey functions. Each function (legend, soil mapping, database, etc.) can be completed at different times of the year depending on the flow of work during the year. However, after 1 year, each function should be reviewed. As a function is reviewed, the document should be signed and sent to the SSR for a quality assurance check.

GENERAL INFORMATION AND SCHEDULING

Agency in charge of survey:

Cooperating agencies:

Total acres from NASIS (see legend/legend land category): land _____; census water

Status of memorandum of understanding:

Scheduled date - mapping completion:

Scheduled date - final correlation:

Scheduled date - manuscript to the technical team for technical review:

- manuscript to the MLRA SSR for technical review:

Scheduled date - map digitizing completion:

Has a long range plan been developed? _____

Does the soil survey office have an official electronic soil survey area boundary? _____

What soil surveys does the project survey match to and what is the status of each survey:

1) _____

2) _____

3) _____

4) _____

For each adjoining soil survey, attach a list of map units requiring a join by soil survey area

NASIS: Provide location where NASIS tabular data is stored and edited:

Area Symbol _____

Area Name _____

Survey Status _____

Is soil mapping being compiled and digitized to the imagery to be used for publication?

Data and source of imagery _____

Will the survey have a general soil map? _____

Will the survey have a published soil survey report? _____

If yes, list the manuscript sections and NASIS generated reports/tables to be included (this may change as reports are updated or revised)

Comments:

PROGRESS AND LEGEND

Date

- 1) Cumulative total of acres reported as mapped in NASIS (see Legend / Legend Mapping Progress):
- 2) Are ALL map symbols on the official soil maps for the survey in the legend:
 - Attach a legend from NASIS by map unit status
 - Attach a legend from NASIS by map unit name and include the additional symbols
 - Attach the SOI-37A indicating miscellaneous features and ad hoc features
 - Attach a list of map units added to the legend since the last quality control review
 - Attach a list of map units correlated or dropped since the last quality control review and include a correlation note report from NASIS identifying reason for decisions
- 3) Does the legend contain all map units from adjacent surveys in order to have an exact join? _____ If no, list the map units that are matching but not in the legend:

Comments:

Action or Recommended Items:

TYPICAL PEDONS

Date _____

- For each series or higher taxa in the legend, is the typical or representative pedon entered into NASIS pedon? _____ If no, list the series or taxa not in NASIS pedon:

- Are all new series names used in approved map units reserved? _____ If no, what names are not reserved?

- Are all series and higher taxa properly classified using Soil Taxonomy?

Attach a classification table from NASIS

- Provide a list of all soil series (OSDs) having their type location in the survey area :

- Are all typical pedons for series and higher taxa located within the survey area?
If no, list the series or higher taxa and the survey area in which it occurs:

- List the typical pedons (and its range of characteristics) reviewed and compared to the OSD:

- List the OSDs to be submitted to the SSR for revision with a proposed date for submission:

Comments:

Action or Recommended Items:

DATABASE

Date _____

- Are all map units in the legend table linked to a data map unit (DMU) thru the correlation table?

If no, list the map units that are not linked to a DMU.

- Are all components (major and minor) to be fully populated? _____
- SSRO-X Technical Note ZZ provides guidance on reviewing Soil Survey Data Quality in NASIS.

List the map units and associated data map units reviewed:

- List the Standard Reports as identified in Tech. Note 38 that were used to review data quality, for example:
 - * UTIL – Comparison of LL and PI, stored vs. calculated (National)
 - * UTIL – T. Factor Validation (National)
 - * CORR – Slopes and Climate Data (SSRO-X)
- List the NASIS Validations as identified in SSRO Tech. Note XX that were used to review data quality, for example:
 - * Component / Horizon
 - percent passing sieves
 - particle-size distribution
 - * Horizon Texture Group

Comments:

Action or Recommended Items:

MAP UNIT DESCRIPTIONS

Date _____

- List the NASIS MUG report to be used for the soil survey:

- List the map unit descriptions reviewed for quality and quantity of data populated:

- For each map unit description reviewed, identify data voids or data elements needing review (see SSRO-X Tech. Note XX for data population guides):

Map Unit Symbol

Database element needing review

Comments:

Action or Recommended Items:

SOIL MAPPING

Date _____

- What are the official soil maps for the survey (field sheets, compilation sheets, digital files/plots)?
- What is the minimum size polygon (acres) to be delineated?
- Attach a small scale soil mapping progress map for the survey area.
- List the field sheets reviewed along with date reviewed:

Review

- Are all symbols on the maps in the NASIS legend? _____ If no, which symbols are missing?
- Do map unit polygons conform to landforms/landscapes and are their segments visible on the photo base?
- Are all miscellaneous or ad hoc features on the maps identified on the NRCS SOI-37A? _____ If no, which features are on the maps but not on the 37A?
- Is the use of the feature symbol(s) consistent across the soil survey extent?
- Are size of polygons consistent with specifications in the MOU?

Comments:

Action or Recommended Items:

DOCUMENTATION

Date _____

- List the map units in which transects were made since the last quality control review to determine map unit kind and composition:

- Are the transect locations georeferenced with a GPS unit?

- Has a spatial documentation layer in GIS been created? This layer would document by polygon, how the map unit was determined. Each polygon would be coded using a legend. For example: 1. transect made in polygon, 2. polygon was visited to confirm map unit, 3. polygon was observed with “high” degree of confidence, 4. polygon was observed with “low” degree of confidence, 5. polygon was remotely sensed.

- For each new series proposed how many complete pedon descriptions are available? List the series name and number of descriptions:

Comments:

Action or Recommended Items:

COMPILATION AND DIGITIZING

Date _____

- Describe the map compilation and digitizing process being used for the soil survey:

- Provide the following information for off-site security of soil maps:

Location of site _____

Date of last security update _____

Type of security material: paper or electronic _____

- List the compilation sheets (quads) reviewed and digital sheets reviewed, along with date reviewed:

- For each sheet reviewed, list issues or concerns:

Map Sheet (Quad)

Issues/Concerns

Comments:

Action or Recommended Items:

INVESTIGATIONS

Date: _____

- Are there plans to have a project investigation within the survey area? _____ If yes, when is the projected date for sampling?

- List all pedons sampled within the survey area. This list will consist of all pedons sampled for laboratory analysis (reference and complete characterization), and will be a running list from year to year. For example:

<u>Sampled as</u> <u>Name</u>	<u>Map Unit</u> <u>Symbol</u>	<u>Pedon ID</u>	<u>Laboratory</u>	<u>Site ID</u>
Cosbie	2017	050R035003	KSSL	99-JFD-04

Comments:

Action or Recommended Items:

609.13 Outline of Items Considered in an Operations Management Review or Program Operations Review for Soil Survey

A. Objectives and Plans

1. Long-range plan and priorities
 - a. Soil survey evaluations
 - b. Soil survey maintenance
 - c. Soil survey areas
2. State soil survey conference
3. Memorandum of understanding for soil survey areas
4. Cooperative and contribution agreements for soil survey activities
5. Annual, monthly, and weekly plans of operation

B. Personnel and Schedules

1. Previous soil survey appraisals
2. Staffing and assignments
3. Workload analysis and scheduling
4. State and local contributions to the National Cooperative Soil Survey (NCSS)
5. Cooperative relations
 - a. Other Federal agencies
 - b. State agencies and representatives
 - c. Local agencies and representatives
6. Training given and received
7. Adherence to Equal Employment Opportunities/Civil Rights policies and procedures

C. Field Operations and Quality Control

1. Soil survey automation at all levels
2. Status of digitizing soil maps
3. Status of imagery
4. Interdisciplinary needs and inputs to soil survey
5. Quality control procedures used
6. Soil survey appeals and disposition
7. Archival of soil survey records
8. Adherence to policies in the National Soil Survey Handbook (NSSH)
9. Application of technology, such as computers, field equipment, ground-penetrating radar, global positioning systems, and remotely sensed data, to increase efficiency

D. Soil Interpretations

1. Maintenance of database
2. Maintenance of field office database
3. Guidelines and criteria used for developing national, State, and local interpretations
4. Updating and coordinating interpretations in State by major land resource areas
5. Status of automated soil survey interpretation development and application (GIS, Pedon-PC, and other)
6. Status of special lists, such as prime farmlands, hydric soils, and highly erodible land
7. Technical guides
8. Training given and received

E. Field and Laboratory Investigations

1. Plan for soil survey investigations
2. Existing laboratory data availability
3. Coordination of field and laboratory studies
4. Benchmark soil data
5. Special projects and interagency coordination
6. Reference sampling for interpretations, classification, and correlation

F. Preparation and Processing of Maps and Text for Publication

1. SSURGO review
2. Publication development

G. Soil Survey Use

1. Effectiveness and use of soil surveys, whether or not they meet objectives
2. Inventory of published soil surveys
3. Information activities
4. Procedures for distributing published soil surveys
5. Advance information
6. Special and interim reports
7. Supplemental reports

609.14 Initial Field Review Checklist for Initial Soil Surveys

(Completed by the review leader)

- 1) Review completed mapping (digital or field sheets) for completeness
- 2) Review acreage for completed mapping and map units
- 3) Inspect mapping in the field
- 4) Review taxonomic and map unit descriptions
- 5) Review progressive correlation of map units
- 6) Review U.S. General Soil Map update and map unit descriptions
- 7) Review U.S. General Soil Map join
- 8) Check join to adjacent surveys and among field sheets
- 9) Review photographs and other figures for soil survey publication
- 10) Review soil interpretations
- 11) Review lab data
- 12) Review classification of all pedons with lab data
- 13) Review classification of all described pedons
- 14) Compare typical pedon to the OSD
- 15) Review transect/random sampling data
- 16) Review statistical data
- 17) Check documentation distribution and content
- 18) Update databases
- 19) Update long-range plan as needed
- 20) Review memorandum of understanding
- 21) Discuss development of annual plan for coming year
- 22) Complete quality assurance worksheet
- 23) Complete comments, correlation notes, things-to-do, agreed-to-items, and commendable items
- 24) Provide completed report to SSR
- 25) Review proposed new soil series and assign dates to submit OSDs to the SSR
- 26) Circulate proposed new soil series for peer review
- 27) Update soil data in Field Office Technical Guide (FOTG)
- 28) Update existing OSDs as needed
- 29) Review and revise scheduling dates

609.15 Quality Assurance Worksheet for Initial Soil Surveys (subject to change by the SSRs to reflect local conditions)

U.S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

QUALITY ASSURANCE WORKSHEET

MLRA _____

_____ County, State

_____ (stssaid)

(Date)

This quality assurance report is to ensure that the soil survey is science-based, the legend and correlation use the MLRA concept, and the survey meets the standards and specifications of the NCSS.

CONTENTS

GENERAL INFORMATION and SCHEDULING.....

MANAGEMENT ISSUES.....

CORRELATION and DESCRIPTIVE LEGEND.....

SOIL INVESTIGATIONS.....

SOIL MAPPING.....

MAP COMPILATION and DIGITIZING.....

PUBLICATION.....

NASIS and DATABASES.....

INTERPRETATIONS.....

MISCELLANEOUS ISSUES.....

ATTACHMENTS and NARRATIVES.....

SIGNATURE PAGE.....

CERTIFICATION PAGE.....

All negative responses identified in this report must be adequately addressed in a narrative.

QUALITY ASSURANCE REVIEW

_____ County, State - a subset of MLRA(s) _____
(Date)

GENERAL INFORMATION and SCHEDULING

Agency in charge of survey:

Cooperating agencies:

Survey team (name and agency):

Total acres (land, census water):

Acres updated/mapped and percent of survey:

Status of memorandum of understanding (e.g., current, signed)

List quality assurance reviews (type and date):

Scheduled date - next quality assurance review:

Scheduled date - mapping completion:

Scheduled date - final correlation:

Scheduled date - publication to the SSR for technical review:

Scheduled date - map compilation completion:

Participants at this review:

MANAGEMENT ISSUES

_____ Are deficiencies and agreed-to items stated in previous quality assurance reviews satisfied?

_____ Are management documents, such as long-range plan, project plans, annual plan of operations, and standards of performance, current?

_____ Are there management problems associated with this survey?

_____ Is the survey party accessing and using the latest versions of the NSSH, *Keys to Soil Taxonomy*, SSR technical notes and other guidance documents, past quality assurance reports, and other relevant documents?

_____ Is the scheduling information for the soil survey correct in NASIS?

List in the narrative the specific technical training needs of soil survey staff not already identified by the local staff as part of their development plans.

CORRELATION and DESCRIPTIVE LEGEND

All map units correlated must have data to support the correlation—if not from the subset, then from the MLRA. The MLRA concept must be used for developing the legend.

One legend is maintained for the survey containing the provisional and the approved map units for the MLRA. The legend is the official, progressively correlated subset legend of the MLRA. The map units in the legend have been approved by the SSR. The legend contains “provisional” map units that are being mapped but have insufficient acreage or documentation. The type and amount of documentation required for the map units to become approved depends on the complexity of the map unit, existing documentation for the map unit within the MLRA, and previous correlation decisions.

Attach the legend. Include a list of map units added, dropped, or changed since the last review. Summarize the documentation gathered and provide a narrative of the field stops seen on this review.

_____ Is documentation sufficient for approved data map units on the legend?

_____ Do all new series components of map units to be added to the legend classify properly in accordance with the current edition of the *Keys to Soil Taxonomy*?

_____ Are the properties (representative values) of all new components of map units as mapped in the survey area within the range of the named series?

_____ Are the OSDs up-to-date and contain current data for all series used in the survey area (e.g., typical pedon georeferenced, taxonomic classification, metric units of measure, horizon designations, competing series section, diagnostic horizons and features listed)?

_____ Have names for new series been reserved in the Soil Classification Database (SC Database) accompanied by an OSD uploaded to the OSD file share?

_____ Are the map unit names and design consistent with the MLRA soil survey area for this initial soil survey?

_____ Are all proposed changes in the legend recorded and reported in the appropriate NASIS tables?

_____ Are notes recorded in NASIS detailing the location and acreage of provisional map units until they are approved for the ID legend?

_____ Is a strategy in place for gathering documentation and are there instructions as to kind and quality of field notes needed?

_____ Does each project member have an up-to-date copy of the descriptive legend?

_____ Is the descriptive legend adequate to ensure consistency of the mapping by all project members and to ensure a timely completion of the publication?

_____ Are the pedon descriptions stored in NASIS?

_____ Are field notes, transect data, and laboratory data summarized regularly? Is the descriptive legend brought up to date?

_____ Is a conversion legend generated? Is it up-to-date?

The project leader is responsible for updating the section “Notes to Accompany Classification and Correlation of the Soils.” Refer to section 609.10, item 17 for an example. Attach the notes or the plans for developing this document.

SOIL INVESTIGATIONS

_____ Is a soil investigation work plan prepared and approved by the SSR?

_____ Are the taxonomic classification of NCSS lab pedons current with the latest edition of the *Keys to Soil Taxonomy*?

_____ Is the disposition of the laboratory pedon data given and provisions made to update the NCSS soil characterization database?

The project leader is responsible for updating the section “Classification of Pedons Sampled for Laboratory Analysis.” Refer to section 609.10, item 15 for an example. Attach the document or the plans for developing this document.

SOIL MAPPING

Describe in a narrative the process used by the soil survey office to ensure:

- quality control of mapping and approval by the soil survey project leader;
- an exact join as described in NSSH 609.3; or an acceptable join
- join statements to allow an exact join in the future (consider metadata)

_____ Is there a process for ensuring security of the original maps, compiled maps, and data files (e.g., fire-safe copies, back-up disks at a secure location, etc.)?

Attach a list of field sheets (or quadrangles) reviewed: _____

_____ Is recent and/or update mapping consistent throughout the subset and MLRA?

_____ Does the map unit design represent the landscape/landform position and other information in the data map unit?

_____ Do map unit boundaries generally conform to landscape features and other features visible on the photo base?

_____ Is the level of detail in mapping consistent and does the level of detail conform to the specifications in the memorandum of understanding?

_____ Do map sheets join?

_____ Is a Feature and Symbol Legend for Soil Survey, NRCS-SOI-37A (NSSH Part 627, Exhibit 627-5) applied properly and consistently?

_____ Is the NRCS-SOI-37A current and are major/minor codes completed?

_____ Are typical pedons located in a delineation with the component named?

_____ Is there a system in place to track, for each field sheet, the surveyor's name, dates, acreage mapped, acreage reported, and date of completion of the field sheet?

_____ Do completed maps show: survey name and State, date of survey, name of soil scientist, "advance copy"?

_____ Are legible and oriented symbols in all delineations?

_____ Are typifying pedons accurately georeferenced?

_____ Are all ad hoc features clearly defined?

_____ Where appropriate, are section corners marked?

_____ Is a progress map maintained?

_____ Is the general soil map concurrent with mapping?

MAP DEVELOPMENT and DIGITIZING

If applicable, describe the process to ensure quality control of soil map development activities (100 percent check).

_____ Was the digitizing performed according to the NRCS data capture specifications as described in the NSSH, part 647?

_____ Is the soil survey spatial data captured to NRCS approved base maps?

_____ Do map unit delineations and their symbols match across map boundaries? Has an exact or acceptable (choose one for each adjacent survey) join been achieved with adjacent surveys?

_____ Do plans ensure a 100 percent edit of the digital spatial data prior to sending the map files to the SSR for quality assurance and geographic data certification?

Attach plans to digitize the survey, including plans for preparing the maps for publication.

PUBLICATION PREPARATION

Date the following publication items that are complete. Address incomplete items in the narrative.

Note: Not all of the items listed below are required for a publication (see NSSH Part 644, Exhibit 644-1).

- _____ Map unit descriptions
- _____ Taxonomic unit descriptions
- _____ General soil map
- _____ General soil map unit descriptions
- _____ Edited prewritten material
- _____ “General Nature of the County” section
- _____ Climate tables and narrative
- _____ Interpretive tables
- _____ Database populated for generation of interpretations and map unit descriptions
- _____ Pictures and captions
- _____ Block diagrams or other graphics
- _____ Input from appropriate partners
- _____ Input from other disciplines
- _____ Soil formation section
- _____ Use and management narratives
- _____ Draft publication for technical review

NASIS and DATABASES

- _____ Is NASIS being populated by the soil survey office staff?
- _____ Are data elements for all map unit components (including miscellaneous areas, as appropriate) being populated sufficiently with data to meet nationally mandated requirements, as well as State and local needs?

Attach plans to populate the database. Include NASIS training received and training needed for all project members, along with the staff member(s) who have responsibility for editing.

INTERPRETATIONS

_____ Are existing interpretations adequate for the purposes of the survey as described in the memorandum of understanding?

_____ Are interpretive ratings being reviewed and tested?

In a narrative, describe:

What special interpretations or interpretive tables are needed?

What assistance have other disciplines provided or scheduled for making, testing, and coordinating interpretations?

What soil performance data (e.g., crop yields, site indices) are collected and how?

MISCELLANEOUS ISSUES

Attach responses to these in a narrative:

Have resource soil scientists participated in this survey? If yes, in what capacity and has work been reviewed for quality control?

What input and involvement is there from soil survey partners?

Describe the survey party's involvement with technical soil services (i.e., Conservation Reserve Program (CRP), soil quality, global climate change, FOTG, etc.).

1) What are the plans for certifying and updating the FOTG?

What are the plans to provide advanced information and support to users?

How is the survey being publicized?

What are the plans to update the U.S. General Soil Map (STATSGO2) database when the survey is completed?

Other issues

ATTACHMENTS and NARRATIVES

All negative responses are to be addressed. In addition, include the following with this report:

Identification legend

Provisional legend

List of the map units added, dropped, or changed

Conversion legend

Summary of documentation

Field stops report

Notes to accompany classification and correlation of the soils

Title 430 – National Soil Survey Handbook

Classification of pedons sampled for laboratory analysis
Field sheets reviewed
Plans to digitize the survey, including plans for preparing the maps for publication
How publication items planned but not completed are being addressed
Technical training needs
Response to miscellaneous issues
Quality control process of soil maps
Quality control process of soil compilation (if applicable)
Plans to populate the database
Commendable items
Recommended or significant items
Action items (agreed-to items)

SIGNATURE PAGE

We, the undersigned, have reviewed this report and concur with its findings.

MLRA Soil Survey Leader Date

Soil Data Quality Specialist Date

NCSS Partner(s) Date

State Soil Scientist Date

CERTIFICATION

As of _____, this soil survey meets the standards and specifications of the NCSS. The survey is science-based and joins adjacent survey areas using the MLRA concept.

Director of _____ (city, State)
Soil Survey Regional Office

609.16 Progress Field Review Checklist for Initial Soil Surveys

(Completed by the review leader)

- 1) Review SSURGO spatial and attribute data for completeness
- 2) Review acreage for completed mapping and map units
- 3) Review previous agreed-to-items and prepare response(s)
- 4) Review field sheets in the office
- 5) Inspect field mapping
- 6) Review classification of all new lab data pedons
- 7) Review classification of all described pedons
- 8) Review comparison of all typical pedons to the OSD
- 9) Review all taxonomic and map unit descriptions
- 10) Continue progressive correlation approval
- 11) Review U.S. General Soil Map legend and descriptions
- 12) Review U.S. General Soil Map join
- 13) Check join to adjacent surveys and among field sheets
- 14) Review spot check of map digitizing
- 15) Review photographs for the soil survey publication
- 16) Review database entries and interpretations
- 17) Order or review set of interpretation tables
- 18) Review lab data
- 19) Review transect/random sampling data
- 20) Review statistical data
- 21) Check documentation distribution and content
- 22) Update long-range plan as needed
- 23) Review memorandum of understanding
- 24) Discuss development of annual plan for coming year
- 25) Complete quality assurance worksheet
- 26) Complete comments, correlation notes, things-to-do, agreed-to-items, and commendable items
- 27) Provide completed report to SSR
- 28) Review proposed new soil series and assign dates to submit OSDs to the SSR
- 29) Circulate proposed new series for peer review
- 30) Update soil data in the FOTG
- 31) Update existing OSDs as needed
- 32) Provide OSDs and checklist tables to soil survey office
- 33) Review and revise scheduling dates
- 34) Review special studies data, such as yield or water table data
- 35) Review or schedule assistance from other disciplines
- 36) Review soil survey information program and activities
- 37) Review check plots of digitized quads

609.17 Final Field Review Checklist for Initial Soil Surveys

(Completed by the review leader)

- 1) Review SSURGO spatial and attribute data for completeness
- 2) Review previous agreed-to-items and prepare response(s)
- 3) Review field sheets in the office
- 4) Review acreage for completed mapping and map units
- 5) Review classification and geo-reference of all described pedons
- 6) Review comparison of all typical pedons to OSD
- 7) Review classification of all new lab data pedons
- 8) Review all taxonomic and map unit descriptions
- 9) Review documentation distribution and content
- 10) Review legend and descriptions for U.S. General Soil Map
- 11) Check join for U.S. General Soil Map update
- 12) Check join among field sheets
- 13) Review cartographic spot check of map digitizing
- 14) Review photographs for the soil survey publication
- 15) Check line work and database for the join with adjacent surveys
- 16) Review soil interpretations and all NASIS entries
- 17) Review lab data
- 18) Review transect/random sampled data
- 19) Review statistical data
- 20) Complete correlation approval
- 21) Review completed legend
- 22) Update laboratory database for correlated names and classifications
- 23) Review memorandum of understanding
- 24) Discuss development of annual plan for completion
- 25) Complete quality assurance worksheet
- 26) Review preliminary correlation if prepared
- 27) Complete correlation notes, things-to-do, agreed-to-items, and commendable items
- 28) Prepare final field review report
- 29) Prepare preliminary correlation memorandum without certifications to attach to final field report
- 30) Update OSDs, the Soil Classification Database (SC Database), and NASIS
- 31) Provide OSDs, soil interpretations information, and checklist tables to soil survey office
- 32) Review and revise scheduling dates
- 33) Review check plots of digitized quads
- 34) Review complete report draft

609.18 Project Review Checklist for MLRA Soil Surveys

_____ MLRA Soil Survey Area, _____

(Completed by the review leader)

- 1) Review previous agreed-to-items and prepare response(s)
- 2) Review SSURGO spatial and attribute data for completeness
- 3) Review spatial and attribute revisions in the office
- 4) Review classification and geo-reference of all described pedons
- 5) Review changes or proposed revisions to OSDs
- 6) Review classification of all new lab data pedons
- 7) Review documentation distribution and content
- 8) Review legend and descriptions for U.S. General Soil Map
- 9) Check join for U.S. General Soil Map update
- 10) Review photographs and other figures for the soil survey publication
- 11) Check line work and database for the join with adjacent areas
- 12) Review soil interpretations and all NASIS entries
- 13) Review lab data
- 14) Review transect/random sampled data
- 15) Review statistical data
- 16) Complete correlation approval of map units
- 17) Review completed legend
- 18) Update laboratory database for correlated names and classifications
- 19) Discuss development of annual plan (if needed) for completion
- 20) Complete quality assurance worksheet
- 21) Complete correlation notes, things-to-do, agreed-to-items, and commendable items
- 22) Prepare project review report
- 23) Review correlation documentation in NASIS for completeness.
- 24) Submit updated OSDs and soil classification data
- 25) Review and revise scheduling dates
- 26) Review check plots of digitized quads

609.19 Quality Assurance Worksheet for MLRA Soil Surveys (subject to change by the SSRs to reflect local conditions)

U.S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

QUALITY ASSURANCE WORKSHEET

MLRA _____

_____ MLRA SSA
_____ (MLRA ssaid)

(Date)

This quality assurance report is to ensure that the soil survey is science-based, that the legend and correlation use the MLRA concept, and that the survey meets the standards and specifications of NCSS.

CONTENTS

GENERAL INFORMATION and SCHEDULING.....

MANAGEMENT ISSUES.....

CORRELATION.....

SOIL INVESTIGATIONS.....

SUPPLEMENTARY SOIL MAPPING.....

MAP DIGITIZING and SPATIAL REVISIONS.....

NASIS and DATABASES.....

INTERPRETATIONS.....

MISCELLANEOUS ISSUES.....

ATTACHMENTS and NARRATIVES.....

SIGNATURE PAGE.....

CERTIFICATION PAGE.....

All negative responses identified in this report must be adequately addressed in a narrative.

QUALITY ASSURANCE REVIEW

_____ MLRA project area – a subset of MLRA(s) _____
(Date)

GENERAL INFORMATION and SCHEDULING

Agency in charge of survey:

Cooperating agencies:

Survey team (name and agency):

Total acres (land, census water):

Acres updated/remapped and percent of survey:

List of quality assurance reviews (type and date):

Scheduled date - next quality assurance review:

Scheduled date - project completion:

Participants at this review:

MANAGEMENT ISSUES

_____ Are the deficiencies and agreed-to items stated in previous quality assurance reviews satisfied?

_____ Are management documents such as long-range plan, project plans, annual plan of operations, standards of performance, and individual development plans current?

_____ Are there management problems associated with this survey?

_____ Is the survey party accessing and using the latest versions of the NSSH, *Keys to Soil Taxonomy*, SSR technical notes and other guidance documents, past quality assurance reports, and other relevant documents?

_____ Is the scheduling information for the soil survey correct in NASIS?

List in the narrative the specific technical training needs of soil survey staff not already identified by the local staff as part of their development plans.

CORRELATION

One legend is maintained for the survey containing the provisional and the approved map units for the MLRA. The legend is the official, progressively correlated subset legend of the MLRA. The map units in the legend have been approved by the SSR. The legend contains “provisional” map units that are being mapped but that have insufficient acreage or documentation. The type and amount of documentation required for the map units to become approved depends on the complexity of the map unit, existing documentation for the map unit within the MLRA, and previous correlation decisions.

Attach the legend. Include a list of map units added, dropped, or changed since the last review. Summarize the documentation gathered and provide a narrative of the field stops seen on this review.

_____ Do all project members and participants understand the concept of map units, data mapunits, and the MLRA process?

_____ Is documentation sufficient for approved data map units on the legend?

_____ Do all new series components of map units to be added to the legend classify properly in accordance with the current edition of the *Keys to Soil Taxonomy*?

_____ Are the properties (at least the representative values) of all new components of map units as mapped in the survey area within the range of the named series?

_____ Are the OSDs up-to-date and contain current data for all series used in the survey area (e.g., typical pedon georeferenced, taxonomic classification, metric units of measure, horizon designations, competing series section, diagnostic horizons and features listed)?

_____ Have names for new series been reserved in the Soil Classification Database (SC Database) accompanied by an OSD uploaded to the OSD file share?

_____ Are the map unit names and design consistent with purposes and scale of the MLRA soil survey area?

_____ Are all proposed changes in the legend recorded and reported in an accepted systematic procedure in the appropriate NASIS tables?

_____ Is a strategy for gathering documentation in place and are there instructions as to kind and quality of field notes needed?

_____ Are the pedon descriptions stored in NASIS?

_____ Are field notes, transect data, and laboratory data summarized regularly?

_____ Is a conversion legend generated? Is it up-to-date?

SOIL INVESTIGATIONS

_____ Is a soil investigation work plan prepared and approved by the SSR?

_____ Are the taxonomic classification of NCSS lab pedons current with the latest edition of the *Keys to Soil Taxonomy*?

_____ Is the disposition of the laboratory pedon data given and are provisions made to update the NCSS soil characterization database?

SUPPLEMENTAL SOIL MAPPING

Describe in a narrative the process used by the soil survey office to ensure:

Quality control of supplemental mapping and approval by the soil survey leader

An exact join as described in NSSH section 609.3

Attach a list of spatial data reviewed

_____ Is supplemental mapping consistent throughout the subset and MLRA?

_____ Does the map unit design represent the landscape/landform position and other information in the data map unit?

_____ Do map unit boundaries generally conform to landscape features and other features visible on the imagery?

_____ Is the level of detail in mapping consistent and does the level of detail conform to the objectives of the project plan?

_____ Is a Feature and Symbol Legend for Soil Survey, NRCS-SOI-37A (NSSH Part 627, Exhibit 627-5) applied properly and consistently?

_____ Is the NRCS-SOI-37A current and are major/minor codes completed?

_____ Are typical pedons located in a delineation with the component named?

_____ Are typifying pedons accurately georeferenced?

_____ Are all ad hoc features clearly defined?

_____ Is a progress map maintained?

_____ Is the provisional U.S. General Soil Map (STATSGO2) map concurrent with mapping?

SSURGO DEVELOPMENT and REVISIONS

_____ Do digitized map unit delineations and their symbols match across project boundaries? Has an exact join been achieved with adjacent MLRA soil survey areas?

_____ Do plans ensure a 100 percent edit of the digital spatial data prior to sending the map files to the SSR for quality assurance and geographic data certification?

NASIS and DATABASES

_____ Are all data elements for all map unit components including miscellaneous areas populated with data?

Attach plans to populate the database. Include NASIS training received and training needed for all project members, along with the staff member(s) who have responsibility for editing.

INTERPRETATIONS

_____ Are interpretations consistent with the purposes of the survey as described in the project plan?

_____ Are interpretive ratings being reviewed and tested?

In a narrative, describe:

What special interpretations or interpretive tables are needed?

What assistance have other disciplines provided or scheduled for making, testing, and coordinating interpretations?

What soil performance data (e.g., crop yields, site indices) are collected and how?

MISCELLANEOUS ISSUES

Attach responses to these in a narrative:

What are the roles and responsibilities of the resource soil scientist(s) with this project? Conversely, what are the roles and responsibilities of the survey party with the resource soil scientist(s)?

What input and involvement is there from soil survey partners?

Describe the survey party's involvement with technical soil services (i.e., CRP, soil quality, FOTG, onsite investigations, etc.).

1) What are the plans for the State certifying and updating the FOTG?

What are the plans to update the U.S. General Soil Map (STATSGO2) database when the survey is completed?

Other issues

ATTACHMENTS and NARRATIVES

All negative responses are to be addressed. In addition, include the following with this report:

- Identification legend
- Provisional legend
- List of the map units added, dropped, or changed
- Conversion legend
- Summary of documentation
- Field stops report
- Notes to accompany classification and correlation of the soils
- Classification of pedons sampled for laboratory analysis
- SSURGO data reviewed
- Web Soil Survey reviewed
- Technical training needs
- Response to miscellaneous issues
- Quality control process of soil maps
- Plans to populate the database
- Commendable items
- Recommended or significant items
- Action items (agreed-to items)

Title 430 – National Soil Survey Handbook

SIGNATURE PAGE

We, the undersigned, have reviewed this report and concur with its findings.

MLRA Soil Survey Leader Date

Soil Data Quality Specialist date

NCSS Partner(s) Date

State Soil Scientist Date

State Soil Scientist Date

CERTIFICATION

As of _____, this soil survey meets the standards and specifications of the NCSS.
The survey is science-based and joins adjacent MLRA survey areas.

Director of _____ (city, State)
Soil Survey Regional Office

Part 610 – Updating Soil Surveys

Subpart A – General Information

610.0 Definition and Purpose

A. **Definition.** The update of soil survey is a systematic process designed to improve official soil survey information (see General Manual, Title 430, Part 402, Section 402.5(A)) with consideration of the full extent of soils and ecological sites across a major land resource area (MLRA) (see Part 649, Subpart A, Section 649.2 of this handbook). Updating by MLRA is a continuous activity of inventory and assessment, data collection, synthesis, review, and recertification of existing soil survey and ecological site information that brings all information to a common standard. The MLRA soil survey update is planned and organized using scheduled projects that systematically focus on specific groups of soils or landforms and the associated support data, interpretations, and maps.

B. **Purpose.** The MLRA process will develop a seamless coverage of consistent soil survey and ecological site information across the Nation. Updating soil survey and ecological site information by MLRA ensures that appropriately detailed information which meets user needs is developed and delivered in a timely manner. Project plans are created and coordinated across the existing (i.e., traditional or non-MLRA) soil survey area boundaries and follow natural landforms. The MLRA process facilitates mapping, interpreting, and delivering seamless soil survey and ecological site information across broad geographical areas of common resource values, land uses, and management concerns.

610.1 Policy and Responsibilities

A. Policy

- (1) MLRA soil survey update activities are conducted as a series of projects developed to address prioritized update needs (refer to Part 608, Section 608.05 of this handbook and Part 630, Section 630.16 of the National Ecological Site Handbook). Projects are developed in the context of the entire MLRA with the goal of developing a seamless soil survey product across political lines.
- (2) Inventories and assessments are conducted on existing soil survey products to identify deficiencies and are used to make recommendations for improvement of the official soil survey and ecological site information (see Section 610.2(C)). The inventories and assessments are completed by the soil survey office (SSO) prior to commencing update activities for the MLRA soil survey area (see General Manual, Title 430, Part 402, Section 402.5(C)).
- (3) Project plans are developed by the SSO staff with assistance from the SSO technical team (see Part 608 of this handbook). NASIS is used to manage project plans. All project plans are reviewed and concurred by the management team and approved by the soil survey regional director. The Board of Advisors is kept informed of project activities and progress.
- (4) Projects are based on the map units occurring on natural landforms over a broad physiographic area. Maps and data are standardized to create seamless soil delineations

- that follow natural landforms and flow across county, parish, or State lines and land management boundaries.
- (5) The scale and intensity of mapping as well as map unit design and naming are standardized to provide consistent soil survey and ecological site information that addresses resource management needs appropriate to land uses and the majority of users needs.
 - (6) Project milestones are used to identify, document, and manage project activities.
 - (7) Project concerns are used to identify the agency resource concern(s) (see Part 610, Subpart B, Exhibits, Section 610.10).
 - (8) Correlation decisions are recorded in the appropriate NASIS tables.
 - (9) A long-range plan is developed based upon the results of the inventory and assessment and reviewed annually by the management team and technical team.
 - (10) Annual plans of operation are developed to guide activities and provide specific focus to the SSO staff.
 - (11) Project quality control review is completed by the MLRA soil survey leader with input provided by the technical team (see Part 609, Subpart A, Section 609.4 of this handbook and Exhibit A, National Instruction 430-305).
 - (12) Project quality assurance review of revised spatial and attribute data is completed by the soil survey regional office (SSR) prior to publication (see Part 609, Subpart A, Section 609.5 of this handbook).
 - (13) Projects are considered complete once issues identified by quality control and quality assurance reviews have been resolved and correlation activities have been accomplished.
 - (14) Projects are published as official soil survey information to the Soil Data Mart and made available through the Web Soil Survey (see General Manual, Title 430, Part 402, Section 402.5) by the state soil scientist.
 - (15) Project progress (in acres) is reported in the Project Mapping Progress table when the SSR staff certifies the project as completed after populating the Milestone Date Completed column for the milestone “Project completed date.”

B. Responsibilities. Responsibility for the aspects of updating soil surveys is held jointly by various organizational levels within NRCS and, for some Federal lands, other NCSS partner agency representatives. The NRCS General Manual (Title 430, Part 402, Section 402.10) outlines the responsibilities of staff leaders in these offices. Refer to Part 608, Section 608.01 and Part 609, Subpart A, Section 609.1 of this handbook for an overview of additional responsibilities.

(1) MLRA Soil Survey Regional Office (SSR)

The directors of the SSRs:

- (i) Coordinate activities of the management teams;
- (ii) Approve SSO project plans and review long-range plan reports and annual plans of operation;
- (iii) Provide SSO guidance on initiating and updating soil survey and ecological site information;
- (iv) Conduct quality assurance reviews as specified in Part 609, Subpart A, Section 609.5 of this handbook;
- (v) Provide training to survey staff in soil survey procedures and database management;
- (vi) Approve changes to soil survey legends and assignment of ecological sites; and
- (vii) Coordinate the updating of soil survey information between SSOs, MLRAs, and soil survey regions.

(2) State Office

The state soil scientists:

- (i) Serve as a member of the management team(s) for the soil survey offices servicing their State (specific roles are identified in the management team operating procedures);
 - (ii) Develop priorities for soil survey update projects with the management team members (refer to Part 608, Section 608.05(d) of this handbook);
 - (iii) Serve as the primary contact (liaison) to the NCSS cooperators and partners in the State;
 - (iv) Inform and obtain project priority concurrence from the state conservationists and NCSS partners; and
 - (v) Provide legend certification and publication of soil survey information.
- (3) **Soil Survey Office (SSO)**
The MLRA soil survey leaders:
- (i) Inventory and assess all correlated map units and consistency of soil survey mapping within the MLRA soil survey area (see Part 610, Subpart B, Exhibits, Section 610.11);
 - (ii) Manage and update attribute and spatial data within the MLRA soil survey area;
 - (iii) Coordinate update activities with other SSOs (imperative for those MLRAs that are assigned to multiple SSOs);
 - (iv) Lead the SSO technical team and carry out its functions;
 - (v) Develop project plans that address prioritized and approved update needs;
 - (vi) Review the benchmark soils and propose changes;
 - (vii) Populate data and manage update projects in NASIS;
 - (viii) Develop the long-range plan and annual plan of operations;
 - (ix) Inform the SSR, States, and NCSS cooperators of activities and progress;
 - (x) Maintain the correlation history in the NASIS Mapunit History Text table;
 - (xi) Maintain the component correlation decisions in the NASIS Component Text table;
 - (xii) Conduct quality control as specified in Part 609, Subpart A, Section 609.4 of this handbook; and
 - (xiii) Review and concur with soils information for ecological site projects.

610.2 Inventory and Assessment

A. Definition. An inventory and assessment is an analysis of the SSURGO-certified map units (see Part 647, Section 647.03 of this handbook) within an MLRA. The existing soil survey and ecological site data is inventoried and analyzed to determine completeness, accuracy, continuity, and appropriateness for current land management decisions within the MLRA. This information will be used to prioritize work on map units and document the need for future MLRA update projects.

B. Purpose. The inventory and assessment identifies deficiencies and improvements needed in the official soil survey information, including ecological site information. This inventory is necessary to develop the long-range plan report.

C. Procedure. Information is gleaned from a variety of sources (see Part 610, Subpart B, Exhibits, Section 610.12). Information may come from those who actively participated in developing the initial soil survey or from NCSS partners and users of the information. Major information items to be considered in the inventory and assessment are listed in Part 610, Subpart B, Exhibits, Section

610.11. The inventory and assessment may be repeated as needed to address emerging user needs and land use changes.

D. Documentation. All documentation is managed in NASIS. The information gathered is compiled for each map unit. The taxa used in the map unit name and individual delineations of the map unit are evaluated. The results of the inventory and assessment are entered into the NASIS database (see Part 638 of this handbook) in the Mapunit Text table under the specific map unit(s). All notes entered into the Mapunit Text table should be populated with—

- Kind set to “miscellaneous notes,”
- Category set to “evaluation notes,” and
- Subcategory set to “spatial,” “attribute,” or “interpretation.”

Part 610, Subpart B, Exhibits, Section 610.13 provides a sample evaluation worksheet and an example of evaluation notes.

610.3 Update Strategies

A. Definition. Strategies to update existing soil survey and ecological site information are designed to make efficient use of staff resources and their time. They address the deficiency(ies) identified by the inventory and assessment. They can address updating soil survey and ecological site information individually or concurrently or integrate multiple projects to address data issues for a geographic area.

B. Purpose. Strategies provide the tactical framework from which to initiate, conduct, and deliver updated soil survey and ecological site information to users under the auspices of the National Cooperative Soil Survey program. Key projects, milestones, and resource concerns are identified in the long-range plan and annual plan of operations.

C. Policy. There are four soil survey update strategies. These strategies allow for a mixture of concurrent projects in order to achieve efficient operation and timely reporting of updated soil survey information. All soil survey update activity will encompass the map unit or landform as it occurs in the MLRA. The NASIS Project object is used to manage MLRA updates. The update strategy selected for a project should be identified in the project description. Project milestones are used to manage tasks and document progress. Project concern types are used to identify the agency resource concerns (see Part 610, Subpart B, Exhibits, Section 610.10). For detailed information on population of the NASIS project, see Chapter 14 of the NASIS User Guide (available on the NASIS webpage).

(1) MLRA assessment and correlation

This strategy compiles historical documentation and uses limited field time to reconcile map unit names, map unit composition, and component and horizon properties for developing a seamless coverage of soil survey and ecological site information. It will be applied to all map units. The process focuses on reducing the number of duplicative map unit information for soil map units that have the same map unit concept. It reconciles map units that represent a continuation of mapping concepts across non-MLRA soil survey area boundaries. A single MLRA map unit is created with fully populated properties, qualities, and interpretations for components and horizons. This process is the underpinning of MLRA correlation. Reportable acres are 20 percent of the total project map unit acres. Projects are goaled and reported within the assigned fiscal year.

The MLRA assessment and correlation strategy:

- (i) Bridges the inventory and assessment and the MLRA field project using information obtained from the map unit inventory and assessment to readily accomplish MLRA correlation and database population;

- (ii) Uses existing soil survey information and correlation documents in conjunction with limited field visits;
- (iii) Relies on the experience and knowledge of technical team members;
- (iv) Ensures that same-named and similarly named map units are reviewed and that duplicate map units with the same map unit concept are correlated into a single map unit that extends seamlessly across political boundaries;
- (v) Requires map unit names to be correlated to common MLRA phase criteria;
- (vi) Contains a project name beginning with the prefix “SDJR – MLRA XXX - <project name>”; and
- (vii) Assists staff in identifying additional MLRA field projects.

(2) MLRA field projects

MLRA field projects collect additional data necessary to re-correlate map units; document and populate soil properties, qualities, and interpretations; and update the spatial data to bring all soil survey information on a specific map unit or landform to a common and current standard. A “map unit” approach is effective when the update need is to collect data to fill voids in the data mapunit or to determine map unit composition. A “landform” approach is effective in areas where current mapping concepts or soil survey maps are inconsistent. The result is a seamless coverage of attribute and spatial data across political boundaries within the MLRA.

MLRA field projects involve the field collection of data or spatial revision that is beyond the scope of MLRA assessment and correlation, as described in Section 610.3(C)(1).

MLRA field projects are intended to address most, if not all, of the prioritized update needs identified during the inventory and assessment. Reportable acres are 100 percent of the total project map unit acres.

An MLRA field project requires, and is focused on, the results of an inventory and assessment. It identifies the project concern and collects the necessary documentation to address the agency resource concerns. It focuses on a single map unit concept or landform or on multiple map unit concepts and a catena or landform. Timeframes range from weeks to as much as 2 years, depending on the project size and extent.

Extensive update needs are to be addressed on a map unit or landform basis. Key update issues must be identified in the inventory and assessment. The work is then prioritized and ranked. Proposed project plans are developed and included in the long-range plan report. These projects are addressed within the confines of an approved MLRA project and contained within its timelines. Assistance from National Cooperative Soil Survey partners may be necessary or desired for extensive updates. Extensive updates must be reviewed and prioritized by the management team and board of advisors based on the overall needs of the entire MLRA soil survey area. Updated soil survey information is supported by the documentation requirements as given in Part 627, Section 627.08 of this handbook. Approval to conduct any extensive revision must be obtained from the Director of the Soil Science Division (refer to General Manual, Title 430, Part 402, Subpart A, Section 402.5(C)). The project evaluation is submitted as supporting documentation.

(3) Special investigations and/or monitoring

Special investigations or monitoring programs are designed to answer specific questions about a particular soil, a catena of soils across the landscape, or regional questions regarding geology, climate, or plant communities. They are undertaken in order to clarify or augment existing soil survey or ecological site information used in update projects. These studies may address hydric soils, saturated soil layers, saturated hydraulic conductivity, chemistry or mineralogy, climate, dynamic soil properties, and other site-specific soil conditions.

Consideration should be given to involving NCSS partners, adjoining soil survey offices, and staff of the National Soil Survey Center (NSSC) and Kellogg Soil Survey Laboratory (KSSL). Such involvement should be designed to reduce the local workload, shorten the time required to complete, or bring expertise to support the project.

Special investigations are a milestone activity within a MLRA field project. An investigation plan is developed by the soil survey leader in consultation with the regional office, NSSC liaison, and partner agencies. Investigation plans are written in the Project Text table (see Section 610.4(C)). Progress and reportable acres are managed in the associated MLRA field project.

Most special investigations should focus upon soils or conditions occurring extensively within the MLRA, so that findings can be applied to similar adjacent soils and ecological sites. Those for soils with limited extent should address issues critical to interpretation or management of these areas.

The milestone “Scheduled Completion Date” for some special investigations and monitoring activities may extend beyond the “Scheduled Completion Date” for the associated MLRA field project. In these cases, the MLRA field project can still be completed and acres reported if all other milestone activities are accomplished. Once the special investigation or monitoring activity is complete, the information gained can be used to refine the map unit data. The project acres, however, are not reported a second time.

(4) Supplemental mapping

Supplemental mapping provides a more detailed order of soil survey (order 1 or 2), including the soil map and attribute data, and requires more intensive onsite investigations.

- (i) *Mapping that provides order 1 detail within a higher order soil survey.*—This produces a separate soil map for specific planning needs of limited extent. It is maintained as improved documentation and attribute data but is not considered a change to the official soil survey information (see General Manual, Title 430, Subpart A, Section 402.5(F)). This method of supplemental mapping is conducted, and reported, as a Technical Soil Service activity for a specific customer and managed as a site-specific investigation (see Part 629 of the Technical Soil Services Handbook for more information). Results can be referenced in the long-range plan and captured as pedon information in the NASIS database to serve as additional documentation to support future update projects. Progress is reported through the NASIS Technical Soil Service table.
- (ii) *Mapping that provides order 2 detail within a higher order survey.*— This is managed within the confines of an approved MLRA field project to address the prioritized update need. For example, an area within the MLRA previously mapped at order 3 detail could be mapped to order 2 detail utilizing mapping concepts from surrounding areas and field visits to ground truth decisions. Supplemental mapping is often performed at the request of partners and land management agencies requiring more detailed information to address management needs. The resulting information is official soil survey data and is delivered to the Web Soil Survey. Progress and reportable acres are managed in the associated MLRA field project.

610.4 Project Plan

A. Definition. The project plan details work activities necessary to address deficiencies and improve soil survey and ecological site information on an MLRA-wide basis. All projects are managed in the NASIS database. Projects are developed from the information gathered during the inventory and assessment. The project milestones and goals are used to manage project completion with available resources in a timely manner.

B. Purpose. The project identifies specific soil map units, geographic areas, landforms, soil catena, or soil properties to be investigated for improving the official soil survey information. It manages the timeframe and coordinates strategies to be employed, resources required, investigations needed, and quality control and quality assurance activities. Project plans may take on various forms depending on the update strategy (see Section 610.3). The project objective is the publication of seamless soil survey information that is accurate, complete, and consistent to meet user needs across the MLRA. The updated information is correlated into soil survey legends and published to the Web Soil Survey via the Soil Data Mart.

C. Development.

- (1) Project plans are developed for the approved and prioritized update needs identified in the long-range plan. The Project object is populated using the Project Plan Checklist (see Part 610, Subpart B, Exhibits, Section 610.14) and the process steps found in Chapter 14 of the NASIS User Guide (available on the NASIS webpage). The Project Plan is a NASIS report extracting data entered in the Project object and requires:
 - (i) A project description containing an initial summary paragraph followed by project details, including objective, procedures, project extent, timeframe, benefits, outcome, deliverables, and travel budget;
 - (ii) Map units that will be updated;
 - (iii) Staff, including all field, regional, State, and national personnel who will provide time and resources;
 - (iv) A project mapping goal based on the sum of the project map unit acres;
 - (v) Concerns that address agency resource concerns (see Part 610, Subpart B, Exhibits, Section 610.10); and
 - (vi) Project milestones necessary to manage a project.
- (2) Soil survey investigations may be needed as part of the MLRA field project plan. The investigation plan is developed by the soil survey leader in consultation with the regional office, NSSC liaison, and/or partner agencies. Investigation plans are included in the Project object:
 - (i) The NSSC liaison is added as a project staff member.
 - (ii) The investigation plan is written in the Project Text table:
 - The Kind column is populated as “project plan.”
 - The Category column is populated as “KSSL.”
 - The Text column stores the investigation plan. (See Part 631 of this handbook for more information on soil survey investigations.)
 - (iii) The milestone “KSSL Investigation Plan” is included in the Project Milestone table. “Scheduled Start Date” and “Scheduled Completion Date” are populated to assist staff in scheduling.

D. Managing Spatial Data. Spatial adjustments (e.g., map unit polygon line adjustments, adjustments to delineations so they coincide better with landforms, map unit symbol changes, spot

symbol changes) can be made during the normal course of work for a project. Spatial updates that contribute to updating the soil survey on a MLRA basis are handled within the confines of MLRA field projects. The spatial update needs are identified in the MLRA inventory and assessment, prioritized and ranked, developed into proposed project plans along with attribute update needs, included in the long-range plan, and addressed within the confines of approved projects and their timelines. Adjustments to lines in areas beyond the boundaries of project map units are not considered. Analysis of map unit delineations is made at publication scale. Digital line editing will follow digital soil mapping standards as addressed in Part 647 of this handbook.

E. **Approval Process.** The SSO submits proposed project plans to the regional office for preliminary review. Next, they go to the management team for review, comment, and concurrence. The soil survey regional director approves project plans based on management team recommendations and informs the SSO to mark accepted plans as approved in NASIS. The SSO then begins conducting the approved projects.

610.5 Prioritizing and Ranking

A. **Definition.** Future projects (update needs), including those identified during the SDJR Initiative, are prioritized and ranked in order to help balance local needs with those of the Nation, State(s), NCSS partners, and agency. Input from technical team members is used in determining local priorities. The local issues are merged with the priorities of the Nation, State(s), NCSS partners, and agency that were identified during work planning conferences.

B. **Purpose.** The purpose of prioritizing and ranking is to efficiently utilize SSO staff and permit timely reporting of progress. Agency resource concerns, project cost and benefit, ease or difficulty of project effort, acres impacted, staff capabilities, and equitable assistance to users are among the various factors considered in prioritizing projects. Prioritizing and ranking focuses agency resources on highest priority update needs.

C. **Prioritizing and ranking considerations.** Priority status for update needs is evaluated annually. The scientific merit, external merit, internal merit, financial/partnership inputs, and efficiency are used in the ranking process. Part 610, Subpart B, Exhibits, Section 610.15 (Example of a Project Evaluation Ranking Procedure) can be used to create a soil survey office area ranking and prioritizing formula. A ranking procedure that evaluates the need and importance of individual projects, especially projects that require substantial resources, aids in prioritization of staff and resources. Soil survey offices should periodically review their ranking procedures to ensure that they are addressing important issues and are consistent across the soil survey office area. Ranking criteria are created to defend ranking decisions. Each soil survey office will have unique issues to consider when developing ranking criteria. Items to consider when ranking projects include:

- Status of initial soil surveys and the specific map units requiring re-correlation
- Age of the survey and soil series and issues with the series concept or classification
- Agency resource concerns for addressing Farm Bill and technical or financial assistance (see Part 610, Subpart B, Exhibits, Section 610.10)
- Program and project needs of cooperating agencies
- Requests by local constituents and frequency of complaints or appeals
- Needs of Federal partners regarding Federal lands
- Information that aids in land use planning and decisions, such as tax evaluation consistency
- Rapid land use changes in areas where critical soil problems are expected

- Cost share contributions of funds or staffing
- Other factors of specific local importance
- Survey boundary join status
- Consistency in map unit kind (phases, taxadjuncts, miscellaneous units)
- Consistency of the soil property data
- Interpretive issues
- Number of acres affected
- Spatial line placement and conflicts with the landscape model
- Amount of KSSL lab data
- Benchmark status of the series

D. **Process.** After the technical team and soil survey office have prioritized and ranked all future projects, the soil survey office leader populates the priority in the “user project identification” column. The SSO then proceeds with developing the long-range plan.

610.6 Long-Range Plan

A. **Definition.** A long-range plan presents future update activities based upon a continuation of current trends and needs. In an MLRA soil survey update, the long-range plan report is used to document the status of current soil survey and ecological site projects and identify emerging information needs.

B. **Purpose.** The long-range plan report is a succinct document presenting the prioritized projects from the NASIS Project object. It is designed to maintain effective and efficient soil survey area resource workload and is available to the management team and board of advisors using the Soil Science Division Management Reports webpage. The long-range plan provides the framework for the MLRA update process and SSO operations. It assists in the logical creation of shorter term MLRA field projects and ecological site projects with specific objectives, goals, strategies, and milestones.

C. **Development.** The SSO staff, with input from the technical team, uses the results of the inventory and assessment to populate the NASIS Project object with information necessary to prepare a long-range plan report. The report is used to assist stakeholders in understanding the value and condition of the soil survey and ecological site information. It presents the work necessary to improve existing soil survey and ecological site information and maps. The NASIS national report

“PROJECT - Soil Survey Office Long Range Plan” extracts specific project information from survey office projects. Major data fields used in building the long-range plan report are:

(1) Project table

- (iv) User Project Identification column.—This is populated with the proposed SSO and technical team priority. The priority (see Section 610.5(d)) is populated based on region guidance, such as the four-digit fiscal year and the priority number (e.g., 2018-1).
- (v) Project name.—This is populated with the type of project, the MLRA, and the project name (e.g., MLRA 133B – Cahaba fine sandy loam, 1 to 3 percent slopes). Specific population guidance is found in Chapter 14 of the NASIS User Guide.
- (vi) Project Description column.—This includes an initial summary paragraph, limited to 1000 characters, that provides managers with an overview of the project. Additional

Title 430 – National Soil Survey Handbook
project information is populated after the summary paragraph. Part 610, Subpart B,

Exhibits, Section 610.14 provides guidance for preparing the project description. Section 610.16 offers examples of the project summary.

- (vii) Project Approved? box.—This is left unchecked unless the project has received prior approval from the management team.
- (viii) MLRA Soil Survey Office Area.—This is populated with the MLRA SSO area responsible for the project.
- (2) Project Mapunit table.—This is populated with the map units associated with the project.
- (3) Project Mapping Goal table.—This can be populated with the proposed year in which the project will begin but it is not required. If populated, the information will appear on the Long Range Plan report.
- (4) Project Concern Need table.—The Project Concern Type column is populated with the agency resource concern that the project is designed to address (see Part 610, Subpart B, Exhibits, Section 610.10).
- (5) Project Milestone table.—The Milestone Type Name column is populated with the “Future Project” milestone and the proposed “Scheduled Start Date” date.
- (6) Project Land Category Breakdown table.—“Land Category Acres” is populated with the sum of map unit acres associated by land category for the project.

D. Publication. The NASIS long-range plan report is accessed as a NASIS report or from the Soil Science Division Management Reports webpage. The long-range plan is used by national managers, management teams, and technical teams to review the prioritized update needs (refer to Part 608, Section 608.05(d) of this handbook).

E. Approval of project priorities. The SSO notifies the soil survey regional director that the project plans have been populated and available for review in the long-range plan report. The soil survey regional director distributes the report to the management teams for their review, comments, recommendations, and concurrence. The comments from the management team are returned to the soil survey regional director. After review, the soil survey regional director notifies the SSO to finish developing the approved project plans.

This process is repeated when update needs change or when work is scheduled for a different work period. The scheduled start date and scheduled completion date are updated to reflect SSR approval. The long-range plan is a dynamic document that is reviewed annually by the SSO and maintained as work progresses or concludes, needs emerge, agency priorities shift, or special initiatives are undertaken that impact workload planning. The technical team and management team remain involved in the development and adjustment of the long-range plan.

610.7 Annual Plan of Operation (APO)

A. Definition. Annual plans of operation (aka business plans) are developed to guide and provide specific focus to staff as projects are being implemented in accordance with the long-range plan. An APO is developed by the SSO each fiscal year and designed to identify staff, projects, goals, milestones, objectives, timelines, and responsibilities to guide the staff in planning day-to-day operations to complete the targeted work. See Part 608 of this handbook for more information.

B. Purpose. APOs are developed, managed, and implemented by SSO staff. The APO incorporates the variety of MLRA project plans being managed during the course of the fiscal year. The list of needs and priorities may change with time (according to Farm Bill priorities, cost share opportunities, etc.), and flexibility should be maintained for possible adjustments within

this process.

- (1) The APO should account for all projects and staff activities, including field mapping and investigations, database maintenance, formal and informal training, technical soil services, technical and management team meetings, staff meetings, and personnel management (leave) and supervision.
- (2) The APO is maintained and adjusted for the gains or losses in staffing at the SSO.
- (3) NASIS reports are available to assist in the development of the APO.

610.8 Certification of Soils Data

A. Definition. Data certification is a three-step process for ensuring that project attribute and spatial information are accurate, complete, and meet NCSS standards. The soil survey office leader begins the certification process with a quality control review (see Part 609, Subpart A, Section 609.4 of this handbook and Exhibit A, National Instruction 430-305) of new or edited attribute and spatial data. The second certification step is a project quality assurance review by the SSR (Part 609, Subpart A, Section 609.5) where the project information is reviewed and ultimately correlated into the appropriate legends. Quality control and quality assurance reviews are described in Part 609 of this handbook. The final certification step is the state office review of the attribute and spatial information and the SSURGO (Part 647, Section 647.01(B)(6) of this handbook) and legend certification (Part 609, Subpart A, Section 609.1) by the state soil scientist.

B. Purpose. The data certification process ensures that all significant changes to any previously certified database are reviewed, documented, and recorded. By exporting the data (attribute and spatial), the State is certifying that the information posted to the Soil Data Warehouse has passed SSO quality control and SSR quality assurance inspections, meets National Cooperative Soil Survey standards, and is suitable for use by the general public. Progressive soil correlation, quality control, and quality assurance are essential and integral tools in data certification. These processes are used throughout the progression of a soil survey update project.

C. Data Documentation. The certification of attribute data is documented in NASIS. This documentation includes quality control and quality assurance reviews of changes made to the previously certified survey. Changes to an attribute dataset and what was actually changed are documented in export metadata. Procedures for certifying and documenting changes to a spatial dataset are discussed in Part 647 of this handbook. The certification level is assigned to the data mapunit, legend, and export for the particular soil survey area. It indicates the degree of confidence with which the new information may be used. As new records are created, the previous records are retained in order to maintain a certification history. The following NASIS tables are used for recording certification:

- (1) *Data Mapunit Certification History table.*—This records information about the review and certification of data in the Data Mapunit object. The completion of quality control reviews is recorded by the MLRA soil survey leader. The completion of quality assurance reviews is recorded by the SSR staff. A level of certification is assigned to the data mapunit. This level indicates whether or not the data mapunit should be used and the degree of confidence with which it may be used. This certification relates to the whole data mapunit, including all of its components, horizons, etc.
- (2) *Legend Certification History table.*—This records information about the review and certification of data in the Legend object. The SSR certifies completion of quality assurance reviews, and a level of certification is assigned to the legend. This level indicates whether or not the legend should be used and the degree of confidence with which it may be used. The state soil scientist certifies legends by populating the Legend

Export Certification History table identifying the modification to the legend by the project.

- (3) *Legend Export Certification History table.*—This records information about the export of all data associated with a legend, including map units, soil property data, and interpretations. A level of certification is assigned by the state soil scientist to the export package for a particular soil survey area. Information on the reason for changes to a dataset and what was actually changed are documented in narrative text notes (export metadata). The export metadata explains to customers the changes made in the survey area.

610.9 Publication of Soils Data

Following certification of attribute and spatial data, the final step is the export of the soil survey legends to the staging server by the state soil scientist and the export of the soil survey spatial databases by the regional office to the staging server. The state soil scientist verifies the spatial and attribute databases on the staging server. After verification, the databases are then committed to the Soil Data Warehouse. The version with the most recent time stamped is forwarded to the Soil Data Mart. The databases are committed to the Soil Data Warehouse as frequently as needed to meet NRCS or cooperator needs. The annual publication to the Web Soil Survey refresh (see Part 644 of this handbook) occurs in the first week of October.

Part 610 – Updating Soil Surveys

Subpart B – Exhibits

610.10 Agency Resources Concerns

Project Concern Type Name	Project Concern Description
Air Quality	Particulate matter less than 2.5 and/or 10 micrometers in diameter is suspended in the air, causing potential health hazards to humans and animals.
Fish and/or Wildlife	Habitat has insufficient structure, extent, and connectivity to provide ecological functions and/or achieve management objectives.
Land Use	Implementing the conservation practices may cause an increased change from one land use to another.
Plant Condition	Plants do not produce the yields, quality, and soil cover to meet client objectives or do not have adequate nutritive value or palatability for the intended use.
Soil Condition	The capacity to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water.
Water Erosion	Detachment and transport of soil particles caused by rainfall splash and runoff degrade soil quality.
Water Quality	Excessive nutrients and organics in surface water pollution from natural or human-induced nutrients such as N, P, and S (including animal and other wastes) degrades surface water quality.
Water Quantity	The capacity to capture, store, and safely release water from rainfall, run-on, and snowmelt (where relevant).
Wind Erosion	Detachment and transport of soil particles caused by wind degrade soil quality and/or damage plants.

610.11 Information Items for the Inventory and Assessment

The following outline presents the major information items to be considered in updating soil surveys for an MLRA SSO area.

- (1) A general review of existing soil surveys and an identification of deficiencies (needed as part of the long-range plan)
 - a. Review of legends
 - b. Examination of the geographic distribution of soils using GIS tools
 - c. Examination of spatial data for join problems
 - d. Collection of known information about the quality of existing soil surveys from resource soil scientists, conservationists, other discipline specialists, and other knowledgeable sources
- (2) Inventory and review of benchmark soils
 - a. Benchmark soil status and documentation
 - b. Current status and need for revision
 - c. Inventory of existing data
 - d. Identification of data gaps
- (3) Review and update of Official Soil Series Descriptions (OSD)
 - a. Georeferences
 - b. Metric units of measure
 - c. Use of current taxonomy and horizon designations
 - d. Competing series
 - e. Distribution and extent
 - f. Diagnostic horizons and features
 - g. Other items needing attention
- (4) Taxonomic classification of soil components
 - a. Application of latest edition of *Keys to Soil Taxonomy*
 - b. Series with obsolete classification
 - c. Typical pedon selection
- (5) Attribute data review
 - a. Integrity and management of the NASIS site, pedon, map unit, data mapunit, and legend objects
 - b. Names and acres of unique map units within the MLRA SSO area
 - c. Traditional map unit concepts from published map unit and taxonomic unit descriptions, mapping concepts, and existing database population.
 - d. Number of data mapunits by unique component name
 - e. Data populated in non-MLRA data map units compared to soil information in published manuscripts
 - f. Map units meeting current naming convention standards
 - g. Inactive series or components out-of-place for a particular MLRA
 - h. Consistent use of map unit phase criteria for the MLRA, including but not limited to standardized slope phases; consistent use of erosion, surface stoniness, rockiness, flooding, local phases, or other appropriate map unit phases.
 - i. Consistency of surface horizon textures populated in the database in relation to the correlated map unit phase
 - j. Map unit composition, including major and important minor components

- k. Consistency of map unit correlations across the MLRA for a particular landform or map unit setting
 - l. Current soil temperature regime and possible adjustment to assist with map unit correlation on a MLRA basis
 - m. Map units with incomplete or inconsistent data population
 - n. Map units of obsolete or unofficial miscellaneous areas
 - o. Component or map unit concepts compared to OSD concepts, particularly for soils where the OSD concept has evolved
 - p. Soil morphology or other properties of series versus taxadjuncts
 - q. Soil morphology of typical and representative pedons
 - r. Component interpretation inconsistencies or errors
 - s. Areas impacted by land use changes
 - t. Consistent use of data population guides and calculations
 - u. Other items needing attention
- (6) Spatial database review
- a. Spatial extent of map units—
 - i. Do map units extend to appropriate parts of the MLRA?
 - ii. Do map units need to be extended and correlated into new areas, or removed and recorrelated out of certain areas?
 - iii. Is mapping density consistent across the MLRA?
 - b. Consistency in level of mapping detail within and among individual survey areas for particular groups of landforms, parent materials, or map units (For example, are flood plains and adjacent stream terraces combined in mapping or separated; are soils formed in residual and colluvial materials combined in mapping or separated; are key landforms delineated, such as aspect differences in mountainous areas?)
 - c. Consistency of mapping concepts within and between individual survey areas
 - d. Consistency between how the map units are delineated and the concept described in the manuscripts
 - e. Consistency in map unit design (kind) in mapping same or similar landforms (For example, did some non-MLRA soil surveys use complexes while others used consociations to map the same or similar landforms?)
 - f. Identification of areas where the existing mapping is too broad or inadequate for current needs
 - g. Consistency in mapping scale or mapping order
 - h. Correction of symbol errors due to recompilation
 - i. Adjustment of line placement errors, i.e., map unit delineations adhering to correct landforms or fitting the base image correctly
 - j. Series or map units mapped over too broad an extent
 - k. Joins issues at soil survey area boundaries
 - l. Areas impacted by land use changes
 - m. Geographic areas with spatial problems
 - n. Other items needing attention
- (7) Review and update of ecological site descriptions (ESD)
- a. Correlation of ESDs across MLRA/LRU and State lines
 - b. Creation and addition of needed ESDs to cover minor components and unique habitats
 - c. Completeness of existing ESDs (including S&T models)
 - d. Comparisons to check for redundant sites

610.12 Resources for the Inventory and Assessment

(1) Items to compile

- a. All available historical documentation
- b. Personal interviews with retired soil scientists
- c. Published soil survey manuscripts
- d. Laboratory investigations by the Kellogg Soil Survey Laboratory (KSSL) and university labs (lab data will be used in the review of a component's properties)
- e. University research findings (experiment station bulletins, theses, dissertations, etc.) and other published materials
- f. Official soil survey records (correlation documents, progress field reports, etc.) and trip reports of field assistance visits
- g. Official SSDs and accompanying or historical notes
- h. Pedon descriptions, transects, and field notes
- i. Electronic, i.e. database and paper file notes
- j. Expert knowledge from soil scientists familiar with the area

(2) Map unit descriptions

- a. Review previously completed soil surveys
- b. Review soil surveys for conservation planning
- c. Review soil survey quality control data, including field notes and documentation
- d. Review soil survey photographs, block diagrams, and other figures
- e. Review soil survey quality assurance documents
- f. Review soil correlation memoranda and amendments.
- g. Review the map unit names and phase criteria within the MLRA based on guidance in Part 627 of this handbook and the *Soil Survey Manual* (SSM). Reconcile the map unit name phase criteria for similarly named map units to a standard developed for the MLRA.
- h. Compare the map unit concept for the similarly named map units within the MLRA. Identify and reconcile the map unit compositions (major and minor components) from the various soil surveys.
- i. Identify minor components worthy of populating within the MLRA map unit. Verify those minor components contrasting to the named major components. Development of a MLRA similar/dissimilar model provides consistency.
- j. Evaluate the validity and regional consistency of map unit concepts.
- k. Ensure that standard landform and miscellaneous surface features and ad hoc features have been reviewed to identify additional minor components not written into the map unit description.
- l. Review the manuscript reports and compare the soil properties and interpretations assigned to the map unit components.
- m. Gather all characterization data on the major components for the given project. Analyze the data to verify proper correlated name and correlated classification. Manuscript information and lab data will be used as the foundation for populating the estimated soil properties for the components in the MLRA map unit.

(3) Other items

- a. Review correlation records for all surveys to identify final correlation issues.
- b. Review ESD and other plant community information for completeness and appropriateness for development of ESDs and state-and-transition models.

- c. Review any special investigation and laboratory data collected for the map units.
- d. Review available historical transect and pedon descriptions, including the manuscript taxonomic unit descriptions.
- e. Review and evaluate the accuracy and consistency of that data in NASIS.
- f. Create a map unit geographic distribution map to identify soil delineations and landform positions.
- g. Determine if map units are mapped too extensively.
- h. Determine if map unit spatial extent is artificially interrupted within the MLRA.
- i. Look for variability of soil delineations that may result from individual mapping styles, inconsistent quality control, or differences in detail within and among soil survey areas and for the consistent use of standard landform and miscellaneous surface features and ad hoc features (i.e., spot symbols).
- j. Analyze the soil-landscape model, ensuring that the same map units occur in areas with the same or similar geology, landforms, and parent materials.
- k. Evaluate map unit delineations that fall outside of the predicted landform(s).
- l. Examine line placement for conformance to landforms and crisp landscape boundaries, such as for escarpments, upland and flood plain interfaces, and the edges of water features. The analysis is made at publication scale.
- m. Examine line work for join issues between adjacent soil survey areas.
- n. Examine line placement and spot symbol placement for conformance to the official base map. The analysis is made at publication scale.
- o. Determine the extent and impacts of change in land use within the survey area.
- p. Investigate catastrophic natural events or human activities that have altered the land and, consequently, interpretive ratings.
- q. Review the kind and accuracy of the soil interpretations and consider interpretive results and the relation of data entries to criteria.
- r. Evaluate needs for new or additional interpretations not included in the survey.
- s. Evaluate needs for new interpretations, such as dynamic soil properties or soil quality.
- t. Review State soil survey conference reports and recommendations.

(4) Reference maps (use in digital format if available)

- a. Original field sheets
- b. Major land resource area maps
- c. General soil map
- d. All available aerial photography and other remote-sensing coverage
- e. USGS topographic and slope maps
- f. Public lands survey
- g. Maps and text on geology, geomorphology, geography, and water resources
- h. Maps and text on vegetation and land use
- i. Climatic maps and data
- j. Flood plain maps
- k. Maps and text on air resources
- l. U.S. Fish and Wildlife Service wetland maps

(5) Reports and Inventories

- a. Census reports
- b. Crop-reporting service reports
- c. Multi-spectral data
- d. River basin reports
- e. State, regional, or county land use plans and regulations

- f. Resource Conservation and Development work plans
 - g. Public lands management reports and inventories
 - h. Bulletins and reports of State Agricultural Experiment Stations
 - i. National Food Security Act Manual and similar manuals
 - j. National resource inventory data
 - k. Field office technical guides
 - l. Soil laboratory data
- (6) Scientific and research reports and data**
- a. Theses and dissertations of college or university students
 - b. International committee (ICOM) reports, such as those for wet soils, Vertisols, Aridisols, and Andisols
 - c. Articles in scientific and technical journals
 - d. Well logs from local or State agencies
 - e. NRCS drainage, irrigation, and erosion-control guides and maps
 - f. Percolation test results from local agencies
 - g. Highway soil test data
 - h. Climate data
 - i. Geomorphology studies
- (7) Ecological site descriptions (ESD)**
- a. Existing ESDs
 - b. ESDs developed in other States and adjoining MLRAs
 - c. Ecoregion descriptions
 - d. Life zone descriptions
 - e. Other plant community inventories
- (8) Forestry, range, and wildlife inventories and studies**
- a. Forest inventories
 - b. Range inventories
 - c. Studies and reports on wildlife habitat recreational sites
- (9) Official Soil Series**
- a. Current version of Official Soil Series Descriptions (OSD)
 - b. Archived copies of previous versions of OSDs (if available)
- (10) Databases**
- a. National Soil Information System (NASIS) database
 - b. Ecological Site Inventory System (ESIS) database
 - c. U.S. General Soil Map (STATSGO2) database
 - d. Soil Survey Geographic (SSURGO) database
 - e. Soil characterization databases (NRCS and universities)
- (11) Digital data**
- a. Digital orthophotography LiDAR
 - b. Digital raster graphic
 - c. Digital elevation model
 - d. Common land units
 - e. Common resource areas
 - f. Digital hydrography, transportation, etc.

610.13 Sample Project Evaluation Worksheet

This worksheet should be tailored for the MLRA soil survey area. An effective worksheet identifies key items for evaluation and assists with an organized and consistent review of map units. The information gathered on this worksheet should be used for the evaluation of each map unit, the evaluation of the taxa used in the map unit name, and the evaluation of individual delineations of the map unit. This information should be collected and analyzed and a summarized paragraph entered into the NASIS database (see part 638 of this handbook) in the Mapunit Text table under the appropriate map unit(s).

All notes entered into the Mapunit Text table should be populated with Kind set to “miscellaneous notes,” Category set to “evaluation notes,” and Subcategory set to “spatial,” “attribute,” or “interpretation.” A variety of national NASIS reports named “MLRA – mgmt – XXX” can be used to create the evaluation report.

Part A. Evaluation of the survey area

Summarize the information from the non-MLRA survey areas occurring within the update project:

- How were the soil maps digitized?
- What is the new base map for the update?
- What is the new map scale?
- What additional soil data have users requested?
- What additional interpretations have users requested?

Briefly describe the investigative and laboratory support needed to provide the new data and interpretations.

Briefly describe how this survey will be improved by the update.

Briefly describe any publication plans in addition to the Web Soil Survey.

Part B. Evaluation of the map unit (subcategory “attribute”)

- Give the probable map unit name if re-correlated.
- Do map unit names correspond with current NCSS and editorial standards?
- Is the unit adequately described? If not, what is inadequate?
- Does the map unit design meet current user needs within the MLRA?
- Are limiting dissimilar soils named as minor map unit components in NASIS?
- Is the amount and type of minor components consistent with NSSH guidelines?
- What were the major interpretive uses of the map unit at the time it was correlated?
- What is the major interpretive use of the map unit at the time of evaluation?
- Are soil properties consistent with the needs of the current land use?
- Are soil property entries in the NASIS database complete?

Part C. Evaluation of the map unit components used to name the map unit (subcategory “attribute”)

- Is the proper component kind value entered for the component?
- Does the component name and/or taxonomic classification need to be updated? If so, what is the proposed new name or taxonomic classification?
- Do miscellaneous area names correspond to the approved list of miscellaneous areas?
- Are component names properly entered with only the component name and in title case (e.g., Jonus)?
- Are phase criteria properly entered in the local phase column?
- Can the soil component be classified as presently described? If no, why not?
- Does the depth of the typifying pedon meet current needs?
- Does the series (taxa), as described, overlap with other series (taxa)? If yes, how?

Does the typical pedon represent the map unit component?
 Is there lab data for the series (taxa)? If yes, how many locations were tested and is the data adequate?
 Do the component properties concur with characterization data?
 Is the representative pedon within the RIC of the OSD? If not, why?
 Is the series consistent with parent material?
 Is the series consistent with geomorphic landform?
 Is the series consistent with geographic setting and the MLRA?

Part D. Evaluation of the map unit delineations (subcategory “spatial”)

Do soil lines fit major landform breaks?
 Do lines correctly separate map units in the soil landform?
 Is there a need to create new map units to delineate dissimilar soils?
 Are dissimilar soils consistent with the map unit description?
 Is the intensity of mapping suitable for the land use?
 Does the series concept, as correlated, fit the map unit concept?
 How was the mapping evaluated?
 Are there user comments?
 What are the number of:
 transects _____
 field notes _____
 descriptions _____
 areas that need remapping _____
 areas that need road checking for line placement _____
 Is there an exact join with surrounding surveys?
 Is soil mapping consistently applied to landscapes across the major land resource area?
 Does the use of features and symbols reflect current definitions and follow standards on the Feature and Symbol Legend for Soil Survey, NRCS-SOI-37A?
 Will this map unit require extensive revision (remapping)?

Part E. Evaluation of map unit interpretations (subcategory “interpretation”)

Address the interpretation issues within the survey manuscript.
 Identify interpretation join issues of similar map units across survey boundaries.

Example report:

Area Symbol	Area Name	Mapunit Symbol	Mapunit Name	Kind	Category	Subcategory	Text Entry
AL007	Bibb County, Alabama	FuD	Fullerton gravelly silt loam, 6 to 15 percent slopes	Miscellaneous notes	evaluation notes	attribute	The manuscript identifies several dissimilar soils and states that they occupy 20 total percent; however, no information is provided in the database. The population of soil properties are not complete to NI305 Exhibit A population standards. The component name and taxonomic

Area Symbol	Area Name	Mapunit Symbol	Mapunit Name	Kind	Category	Subcategory	Text Entry
							classification need to be updated to current standards. Five KSSL sites exist but none from this survey area. One (Madison Co, AL) fits the Fullerton OSD very well. Three others deviate from the OSD slightly in fragment and/or clay content, but are within acceptable margins of error to use as reference data. One is a Kandiodult. Fullerton is a benchmark soil and additional characterization sampling is needed. The component properties do concur with characterization data.
AL007	Bibb County, Alabama	FuD	Fullerton gravelly silt loam, 6 to 15 percent slopes	Miscellaneous notes	evaluation notes	interpretation	The interpretive focus on this map unit is agriculture, woodland, and residential and low-density urban development. In review of the interpretations during SDJR with similar named map units, the major interpretation discrepancy is slope phases that must be reconciled for the MLRA. Once a decision on slope phase is made, the interpretations should be more uniform.
AL007	Bibb County, Alabama	FuD	Fullerton gravelly silt loam, 6 to 15 percent slopes	Miscellaneous notes	evaluation notes	spatial	During the SDJR review, no spatial issues were noted. The lines all fit the landform boundaries and seem to fit the map unit concept. There were polygons outside the major areas that will require field visits to verify map unit concept.

610.14 Project Plan Checklist

The Project Plan is a NASIS report that presents the data entered into the NASIS Project object. For proposed projects, the following data fields in the Project table data are populated:

- User Project Identification
- Project Name
- Project Description
- MLRA Soil Survey Office
- Project Map units
- Project Land Category Breakdown
- Project Concern Need
- Milestone “Future Project”

Once approved, the remaining fields are then populated.

This exhibit provides a checklist of NASIS populated fields to be managed by the SSO.

User Project Identification: This column identifies the priority of the project and is populated based on region guidance. An example is “2018-1,” which identifies the top priority for fiscal year (FY) 2018.

Project Name: The project name begins with the MLRA followed by a space, a dash, and another space, map unit or landform indicator (e.g., MLRA 133B – Cahaba fine sandy loam, 1 to 3 percent slopes; MLRA 128 – Great Limestone Valley Summits).

Project Description

The project description discusses the key issues of project map units identified during the inventory and assessment and describes specific work activities necessary to address those key issues. Time needed to complete the project, where work will occur, expected outcome, and benefits gained from completing the project are described. The project description provides managers with appropriate information to review and approve the project while providing project staff with information sufficient to carry out the project. Section 610.16 shows examples of project descriptions. Including items in the project description that are also populated elsewhere in project object may produce redundancy in the Project Plan. For example, the Project Plan may extract project map units from the Project Map Unit table; therefore, consideration should be given to how the map units, or components are described in the project description.

The project description is subdivided into two required sections. The first section is a single paragraph summary while the second section expounds specific project details. Each section describes the what, how, where, when, why, and who of the project.

First Section - Summary Paragraph

The first paragraph is an executive summary, or abstract, of the project. The primary audience are managers, e.g., State Conservationists, State soil scientists, and soil survey regional directors. The summary provides the managers with an overview to assist them in reviewing the project. The paragraph is limited to 1,000 characters. The paragraph is written without headers, bulleted items, or lists. See section 610.16 for examples. The summary paragraph discusses the following six items:

1. *What* map units (or components) are being investigated AND what are the key issues.

2. *Where* will the project be focused or the areas impacted by the project. Identify individual survey areas, specific landforms, geographic areas, States or sections of States, or MLRAs or sections of MLRAs.
3. *How* will the issues be addressed or resolved, AND what is the expected outcome:
 - a. List field and/or office work necessary to address the issues listed in item 1,
 - b. Summarize how the current soil survey information will change.
4. *When* is the project timeframe and how many staff years to complete the project?
5. *Who* requested the project and/or is the main beneficiary?
6. *Why* is the project important by identifying the major resource concern to benefit from project completion?

Second Section – Project Details

This section follows the executive summary (above) and begins with the major heading “Project Details.” It should be as concise as possible while remaining informative enough to provide current or future soil scientists with the information necessary to continue the project. The primary target audience is the field soil scientist. Include background history only to the extent necessary to guide the project leader. The following outline will be followed; however, the list is not all inclusive and other issues can be included. A comment on the implemented update strategy is interwoven into this section (see section 610.3(C)). The project details are organized by: Objectives and Procedures, ‘Areas Included in the Project, Timeframe, Benefits, Outcome and Deliverables, and Travel Budget.

Objectives and Procedures (what and how)

Discuss the map units and/or components to be investigated, the issues needing to be addressed, and the specific work activities necessary to address those issues in relation to map unit correlation, spatial adjustment, and database population.

Map unit correlation

- Discuss correlation issues of project map units and any re-correlation plans.

Spatial adjustment

- Discuss the join condition of project map units along SSA boundaries and how deficiencies will be corrected.
- Discuss adjusting the map unit extent to produce consistent geographical distribution of project map units where map units correctly follow natural landforms.
- Discuss how spatial adjustments will be managed for those map unit delineations that do not conform to the base image or correct landform.
- Discuss adjustments to map unit symbols, spot symbols, or line features.
- Discuss supplement mapping to provide more detail within a higher order survey.

Data

- List specific lab data needs and purpose. Include number of pedons to sample.
- List and discuss other field data needs, such as number of field transects and purpose, or other needs as appropriate.
- Discuss transect and sampling locations to the extent necessary to guide the project leader.

Areas Included in the Project (where)

- Explain the project extent by listing:
 - The SSAs or portions of the SSAs impacted, or
 - Particular landforms, geology, and/or geographic areas.

Timeframe (when)

- List project length (see section 610.3(C)(2)). This should coordinate with project milestone dates.

Benefits (why and who)

Discuss the major benefit(s) gained from the project completion, and who requested the project and/or who benefits. Benefits to the soil survey program include, but are not limited to:

- Scientific: updating and improving attribute and spatial soil survey information, where issues identified in the inventory and assessment have been addressed
- External: better interpretations to meet user needs; support for partners or other disciplines
- Internal: complete population of attribute information used in Farm Bill programs, conservation planning, and other agency needs or concerns or cooperator needs
- Synergy: wider application of data to support other projects or for multiple soil survey areas
- Efficiency: improvement in the ratio of acreage affected to time required to complete project

Outcome and Deliverables

List the expected outcome of the project, i.e., how will the legend, maps, NASIS data, and interpretations be influenced or impacted as a result of this project.

List deliverable products, i.e., data updated to the WSS, reports and maps deliverable to cooperators, etc.

Travel Budget Needs

List the proposed travel nights needed for SSO staff for the duration of the project.

Project Approval: The “Approved?” column is checked if approved and unchecked if not approved.

MLRA Soil Survey Office: This column is used to assign the project to a specific office.

State Responsible: Choose the State where the regional office is located.

Project Mapunit table: Identify the correlated map units that will be investigated within the project. Include the provisional map unit(s) that will be created during the project. All editing is completed on the new map unit(s); original map units remain untouched.

Project Staff table: Identify all personnel whose time and/or resources will be required to complete the project. Include any SSR staff, the NSSC liaison, State soil scientists, vegetation specialists, etc. The individual SSO staff that is responsible for completing the project is assigned as the project leader.

Project Mapping Goal table: Populate the acre mapping goal for the project. Typically, this figure is the sum of all correlated map unit acres. The goal is assigned to appropriate SSO staff with fiscal year identified.

Project Land Category Breakdown table: Populate the acre assignment to the various land categories.

Project Milestone table: Identify the tasks and their scheduled start and completion dates. This table is used to manage the time table for the project. NASIS Pangaea Query “! PROJECT Templates National ES, SDJR, MLRA” retrieves project templates to assist with developing MLRA field projects. The project named “MLRA XXX - enter mapunit name(s) (National Template)” provides the applicable milestones for MLRA field projects.

The projected scheduled completion date for the Milestone Type “Project completed date” includes time needed for SSO work and quality control and regional office quality assurance and correlation activities.

Project Text table: Include any additional project plans or investigation plans.

Project Data Need table: Include assistance from NSSC staff, lab data, equipment, materials and supplies, technology, training, and other staff or administrative support.

Project Mapping Progress table: Report progress once the SSR staff certifies the project as completed.

Project Concern Need: Each MLRA field project identifies the project concern to address the agency resource concerns as listed in section 610.10. The Seq column is populated to identify the priority concern where multiple concerns exist.

610.15 Example of a Project Evaluation Ranking Procedure

Rank each factor from 1 to 3, with 1 being low and 3 being high. Determine the overall priority ranking from the key at the end.

A. Scientific Merit. How important is the project for soil science and the soil resource inventory?

Examples: updating or investigating taxonomic classifications, revising series concepts, updating or correcting pedon descriptions, sampling to fill data voids for series.

Score	Criteria
1	Little or no scientific merit
2	Some merit: minor changes to benchmark soils; changes to soils of small extent, etc.
3	High merit: major advances in scientific knowledge about benchmark soils

B. Agency Merit. Does the project address agency resource concerns, or how important is the project for programs of NRCS and their partners? Included are all of the agency concern types (see section 610.10), Farm Bill programs, conservation planning, State cost-share, etc. Examples: K factors (affecting HEL and CRP), hydric soils (wetlands), prime farmland issues, suitability groups.

Score	Criteria
1	Little or no agency merit
2	Minor or incidental effects on some properties or areas of concern; affects one or more programs in a minor way
3	Significant revision to properties of benchmark soils used in programs or areas of significant concern to conservation efforts; affects several programs or has a major impact on one or more programs

C. External Merit. How important is the project for external customers, either government or private?

Score	Criteria
1	Little or no interest from external customers
2	Some effect on soil survey users or agencies; one user group impacted
3	Major impact on land use planning, interpretations, or agency programs or lands; more than one user group impacted

D. Financial/Partnership Inputs. Are there inputs from other sources or partners, such as funding, staffing, equipment, or technical support?

Score	Criteria
1	Little or no partnership involvement
2	Some commitment of staff time, equipment, and/or technical support; one partner involved
3	Major commitment of staff time and equipment and/or financial support; more than one partner involved; strong support or guidance needed from NRCS or partner administration

E. Synergy. Does the project serve or support another project or proposal?

Score	Criteria
1	Not at all
2	Some advantage to another project
3	Closely related to another project; significantly improves the efficiency of both projects

F. Deficiencies in Soil Survey Information. Does the project address deficiencies identified in the inventory and assessment and/or digital flags?

Score	Criteria
1	No deficiencies previously noted
2	Minor deficiencies are addressed
3	Significant deficiencies in the existing soil survey information are addressed

G. Efficiency. How much “bang for the buck” is in this project? Evaluate, in part, on the ratio of acreage affected to time required to complete.

Score	Criteria
1	Low: lots of work for a few acres (e.g., < 300 acres / person-day, few and minor NASIS changes per person-day)
2	Moderate: reasonable return for the labor (e.g., 300 to 1000 acres / person-day, numerous NASIS changes per person-day, etc.)
3	High: big changes with little effort (e.g., >1000 acres / person-day, major NASIS revisions per person-day, etc.)

Key:

- 1) If G = 3 and D = 3 and two or more of A or B or C or F = 3 or if score = 3 on three of A, B, C, or F, then Priority = High
- 2) If D = 1 and G = 1 and none = 3 and composite score < 11, then Priority = Low
- 3) All other, Priority = Medium

610.16 Project Description Examples

Examples of Summary Opening Paragraphs

Example 1.

The northern portion of the Chehalis River flood plain is experiencing heavy urban development. This development is causing land use concerns about the accuracy and consistency of the current soil lines and water-related soil properties. This area occurs in MLRA 2 and includes portions of WA627, WA667, and WA641. This 2-year project will result in updated order 2 tabular and spatial data for 41,861 acres. Chehalis, Cloquato, and Newberg are the major soils that will be investigated. New map units will be generated and line work will be recompiled to current imagery using LIDAR. Data will be updated, including new field observations and KSSL samples; however, information from existing KSSL data, archived manuscripts, original SSURGO data, and tacit knowledge will be reviewed and incorporated. No ESD work will be included in this project.

Example 2.

The Jaucus series is mapped throughout the Hawaiian Islands of Oahu, Molokai, Lanai, and Maui—on beaches of all islands and on relatively upland soils in the isthmus valley of Maui on sugar cane lands (MLRAs 158, 163, 164, 166, and 167). This series was established in the U.S. Virgin Islands; documentation needs to be obtained to establish a new series to reflect Hawaiian Island characteristics. Preliminary investigation of soil mapping in sugar cane fields indicates that the soil condition has extensive surface anthropogenic modification affecting soil morphology. Basic requirements for establishing series, including transects to determine map unit composition, will be met. New map units will be developed, some map line work will be modified, and all data associated with the data mapunits will be updated. The project will encompass the 2016 and possibly 2017 fiscal years. It will require an estimated 250 staff hours (0.12 staff years) to complete. Travel costs are anticipated.

Example 3.

Hydric ratings, as well as forestland suitability, are very important water quality/quantity issues with Pelham soils. This map unit is correlated in 9 counties along with other Pelham map units mapped along the GA-FL line. Determining and populating the exact water table associated properties for this ponded phase will erase an issue where hydric ratings differ along State lines. As a result, more consistent interpretations will be available for farmers, as well as State and Federal agencies that utilize this data for suitability and compliance determinations. This project will focus on MLRA 153A/B in Florida/Georgia within transition areas between non-ponded Pelham units as well as along drain heads and flat, sluggish drains without well-defined channels. This is a substantial project, requiring transects, sample collection for base saturation, as well as ponding frequency observations. With one staff person, this project will take 1 year.

Example 4.

Huckleberry is a benchmark series in MLRA 43A and has been mapped in a cryic temperature regime in 4 surveys (ID606, ID670, WA065, WA651). Currently, the associated forest canopy is western red cedar, subalpine fir, and mountain hemlock. Current research supports a cryic temperature regime for soils occurring under a subalpine fir or mountain hemlock canopy and a frigid temperature regime for soils under a western red cedar canopy. Huckleberry components will be evaluated against vegetative models and then field verified to refine plant condition mapping. The Huckleberry series concept will be updated and a frigid counterpart developed for areas with a western red cedar canopy. This project encompasses 181,400 acres. It will take two field seasons by one staff person to complete due to short seasons and remote travel locations.

Example 5.

Soil wind erosion of the Ulysses eroded map units has significantly changed the soil condition in 7 counties in MLRA 72 as identified by farmers in the area. Transects will be run on these map units to verify map unit composition and identify soil condition characteristics. Significant KSSL samples are available; however, additional samples will be collected to compare surface soil properties between non-eroded and eroded phases of these map units. Soil classification may change due to erosion. The evaluation of these map units found a potential difference in soil properties impacting the Kf value interpretation. This study is significant with almost 150,000 acres. Fieldwork should be completed in one field season by one staff year.

Example 6.

The map unit “Frederick silt loam, 8 to 15 percent slopes” occurs in the large limestone valley in the mesic part of MLRA 128. The map unit is in four counties, but is absent in two adjacent counties (VA155 and VA121). Past correlation concepts varied, and similar soils, such as Groseclose or Lodi, were preferred in VA155 and VA121 in place of Frederick. New field transect data from the similar map units in VA155 and VA121, combined with existing data, will confirm or disprove that the Frederick map unit can be extended and correlated into these two counties. Spot checks where Frederick is currently mapped will verify those correlations. Soil delineations will be joined between counties, and attribute data will be updated. The result will be consistent map unit correlation on this particular hillslope in the MLRA. The project will benefit land use and conservation decisions by providing consistent and improved data. The fieldwork will be completed in 1/3 of a field season by 2 staff.

Example 7.

Atmore soils occupy water collection positions on the landscape, receiving and filtering both surface runoff and subsurface flow downslope above a restrictive layer. They occur in ecological sites commonly referred to as pitcher plant bogs and host vegetative communities dominated by hydrophytic vegetation of a jurisdictional wetland. These map units include a variety of carnivorous plants and some endangered species, and are well represented in an ecological system known as the longleaf pine savannah. Atmore is mapped in MLRA 133A and 152A in 13 counties, occupying 164,442 acres. Evaluations suggest potential differences in soil properties (such as texture, silt content, and plinthite amount) related to differences in parent material age and depositional environment, topography, hydrology, and landform position across the extent of this map unit. Additional characterization data is needed for these ecologically sensitive areas. This project will be completed by four staff members within 2 years.

Example 8.

Severe dust storms are reducing air quality and visibility along the I-10 corridor where playa systems occur. Several cooperators have requested updated soil and ecological site information for these playa areas. The scope of MLRA 41 – Update of the Animas Valley Playas and Adjoining Map Units is to update all playa areas that exist throughout MLRA 41, LRU 41.2. All geographically associated landforms, such as basin floor, play dune, piedmont, and drainageway, will be assessed and updated accordingly. This effort will develop new map units, modify existing map units, evaluate ecological sites, and update all data associated with the data map units. This effort will be accomplished by gathering all current documentation, collecting additional documentation as needed, and sampling map unit components for characterization data. The project consists of private, BLM, and State lands for a total of 105,027 acres. It will be completed with two personnel in 1 year.

Example 9

Wind erosion impacts the Optima loamy sand, 10 to 25 percent slopes found in the Dust Bowl area of Oklahoma and Kansas. The evaluation identified soil composition and spatial join deficiencies.

Documented deficiencies include pedons that are not spatially representative of the map unit extent and a lack of transects to estimate map unit composition. KSSL data is available for the OSD type location and supports soil properties and classification. Local laboratory data will be collected to improve identification of physical and chemical properties and refine soil interpretations. Soil polygon boundaries, through field investigation, will be edited to create exact county line joins. This project covers 49,850 acres. It will involve one staff person and be completed within 1 year.

Example 10.

Review of Barnes series, an extensive benchmark soil in MLRA 55A and 55B that is mapped across Souris, Leeds, and Red River till lobes, produced concerns that physical and chemical properties and hydrology within each lobe were not adequately reflected by MLRA map units. Representative pedons will be identified, documented, and sampled. Selected locations will be instrumented with monitoring wells and rain gauges to justify or refute consolidation, separation, and classification and assist in modeling hydrology, all of which will benefit State interpretations and planning. Analyzed MLRA field project data and KSSL samples (salt analysis group) collected on all lobes by two staff in two field seasons (KSSL results to follow) will augment NASIS and document areas with high probability of being affected by salinity/sodicity. Cumulative hydrologic monitoring over multiple MLRA field projects, completed by two staff in five field seasons, initiated with this project will provide a measure of seasonal wetness variability.

Example 11.

Condit soils are very poorly drained soils that occur in depressions and drainageways where water table features significantly influence plant condition. A single ponding frequency, duration, and depth is currently assigned to all Condit map units. Landform features that influence hydrologic properties were not considered in the existing database. Using digital soil mapping tools and LIDAR analysis, a hydrologic model will be used to identify landform features known to influence water tables. Those features will then be used to differentiate condit map units into phases that assign ponding frequency, depth, and duration, which will help farmers to better evaluate their potential for crop production. Landowner evaluations of the phased maps will be used to test their usefulness for predicting water features. This project covers the portion of LRU 111E behind the Broadway end moraine, but the hydrologic model can be adapted for other ponded soils. Required SSO staff time: 0.5 staff year.

Example 12

Bangor, Dixmont, and other acidic tills mapped on the calcareous Waterville Formation may not best represent soil conditions as they exist across portions of a 10-county area in MLRA 144B and 143 in central Maine. Recently sampled lab data supports correlation to high lime soils of the recently established Sebec catena. Interpretations and program applications would be improved by this revised data. Selective field investigation, review of lab and other published data, and geospatial analysis of bedrock geology will be used to determine the best correlation. This project covers about 250,000 acres. SSO staff time is estimated at 1.75 staff years for production and quality control; regional office staff time is estimated at .10 staff years for support, quality assurance, correlation, and certification. Publication of the data to the Web Soil Survey is done by the State soil scientist. The project is proposed to begin in FY 2018 and last 1 year.

Example of a Complete Project Description

Soil erosion of the MLRA 72 - Ulysses silt loam, 3 to 6 percent slopes map units has significantly changed the soil condition in 27 counties in MLRA 72. Transects will be run on these map units to verify map unit composition and identify phase characteristics. Significant KSSL samples are available;

however, additional samples will be collected to compare surface soil properties between non-eroded and eroded phases of these map units. Soil classification may change due to erosion. The evaluation of these map units found a potential difference in soil properties impacting the Kf value interpretation. This study is significant with almost 150,000 acres, and may take 2 staff years to complete with extensive travel throughout western Kansas and eastern Colorado.

Project Details:

Project: MLRA 72 - Ulysses sil, 3-6, maintenance continued (58549)

Objectives and Procedures

This project will complete the maintenance for the Ulysses silt loam, 3 to 6 percent slopes map units. The maintenance was started in 1999 as part of the Kansas initiative to investigate the degree of erosion in the Ulysses map units that have slope greater than 3 percent. The maintenance was suspended in 2012 so staff could focus on the SDJR initiative.

The Garden City SSO collected pedons in FY 2011 and FY 2012 and entered the pedons that were collected in 1999, 2003, 2011, and 2012 into NASIS. For the 1859 map units in Kansas, 512 pedons have been entered in NASIS and analyzed. Pedons remain to be collected in the following counties:

Rawlins Co., Kansas (ks153)
Sherman Co., Kansas (ks181)
Thomas Co., Kansas (ks193)
Wallace Co., Kansas (ks199)
Wichita Co., Kansas (ks203)
Hayes Co., Nebraska (ne085)

This project will include:

- Field investigation of Ulysses silt loam, 3 to 6 percent slopes (1859) in the counties listed above
- Field investigation of Ulysses silt loam, 3 to 6 percent slopes, eroded (1860) in Chase (ne029) and Hitchcock (ne087) Counties of Nebraska
- Joins along the Kansas-Nebraska State line where 1859 polygons in Kansas join Nebraska
- Joins along the Kansas-Nebraska State line where 1860 polygons in Nebraska join Kansas

The project extent is 538,584 acres with 6,203 polygons. The extent is 90 percent in MLRA 72 and 10 percent in MLRA 73. The extent is listed by county in a table at the end of this document. All of the Kansas and Colorado extent was combined during the first phase of this maintenance in 2013, and that extent is represented by national mapunit symbol 2mb5b, which is supported by DMUID 626924. We did not submit the Nebraska extent to the SDJR process.

The originally mapped Ulysses silt loam, 3 to 6 percent slopes map units were assigned to the Loamy Upland ESD and were not HEL, with WEI/WEG values of 48/6. The maintenance of 1999 was started because of complaints that the Ulysses silt loam map units, with slopes greater than 3 percent, should be HEL and in the Limy Upland ecological site because they have free carbonates in the surface layer. The resource soil scientists thought the difference was caused by erosion that occurred after the original mapping. In the past 3 years, the ecological site specialists have indicated that this map unit has some areas that support the Loamy Upland plant community and some that support the Limy Upland community. The ecologists focused on this map unit because part of it is in prime Lesser Prairie Chicken habitat.

Areas Included in the Project

We will begin by describing the Ulysses TUDs in the counties listed below. We will try to incorporate these TUDs in the traverses we plan to complete.

Finney Co., Kansas (ks055)
Gove Co., Kansas (ks063)
Gray Co., Kansas (ks069)
Greeley Co., Kansas (ks071) (Ulysses type location)
Lane Co., Kansas (ks101)
Logan Co., Kansas (ks109)
Rawlins Co., Kansas (ks153)
Scott Co., Kansas (ks171)
Sheridan Co., Kansas (ks179)
Sherman Co., Kansas (ks181)
Stanton Co., Kansas (ks187)
Thomas Co., Kansas (ks193)
Wallace Co., Kansas (ks199)
Wichita Co., Kansas (ks203)
Chase Co., Nebraska (ne029)
Hayes Co., Nebraska (ne085)
Hitchcock Co., Nebraska (ne087)

The following counties only have a few polygons because 1859 was added to facilitate SSURGO joins, so the TUDs will not be described.

Cheyenne Co., Colorado (co017)
Cheyenne Co., Kansas (ks023)
Decatur Co., Kansas (ks039)
Ford Co., Kansas (ks057)
Graham Co., Kansas (ks065)
Greeley Co., Kansas (ks071)
Ness Co., Kansas (ks135)
Trego Co., Kansas (ks195)
Lincoln Co., Nebraska (ne111)

We will then collect three 5-hole traverses in each of the counties listed below, focusing on the various surface morphometries that are expressed within the polygons. This approach was chosen instead of the 10-hole equidistant transect method because we want to be able to analyze the pedons by surface morphometry. We may need to collect more traverses to define the 1860 map unit, but I think the 1859 map unit will be well served with twenty-four more 5-hole traverses.

Rawlins Co., Kansas (ks153)
Sherman Co., Kansas (ks181)
Thomas Co., Kansas (ks193)
Wallace Co., Kansas (ks199)
Wichita Co., Kansas (ks203)
Chase Co., Nebraska (ne029)
Hayes Co., Nebraska (ne085)
Hitchcock Co., Nebraska (ne087)

For each county listed above, we also will collect a full pedon description in a location we feel is representative of the major component. We will do this in five polygons in each county. The chosen polygons will not be those that received a traverse.

Title 430 – National Soil Survey Handbook

In addition to the 512 pedons already collected, this plan will result in a new full description at seventeen Ulysses TUD sites, twenty-four 5-hole traverses, and 40 full pedon descriptions for the 1859 map unit. The 1860 map unit will have six 5-hole traverses and 10 full pedon descriptions collected. This collection will provide 690 full pedon descriptions by the end of the project.

Project Extent by County

Ulysses silt loam, 3 to 6 percent slopes (1859)

Survey	NMUsym	DMUID	acres	polygons
Cheyenne (co017)	2mb5b	626924	16	1
Cheyenne (ks023)	2mb5b	626924	560	17
Decatur (ks039)	2mb5b	626924	3,934	29
Finney (ks055)	2mb5b	626924	22,961	485
Ford (ks057)	2mb5b	626924	27	2
Gove (ks063)	2mb5b	626924	34,996	916
Graham (ks065)	2mb5b	626924	340	3
Gray (ks069)	2mb5b	626924	6,387	110
Greeley (ks071)	2mb5b	626924	98	1
Kearny (ks093)	2mb5b	626924	820	19
Lane (ks101)	2mb5b	626924	11,274	363
Logan (ks109)	2mb5b	626924	48,255	520
Ness (ks135)	2mb5b	626924	474	19
Rawlins (ks153)	2mb5b	626924	76,874	782
Scott (ks171)	2mb5b	626924	8,095	127
Sheridan (ks179)	2mb5b	626924	101,982	555
Sherman (ks181)	2mb5b	626924	58,048	782
Stanton (ks187)	2mb5b	626924	2,499	36
Thomas (ks193)	2mb5b	626924	72,674	358
Trego (ks195)	2mb5b	626924	70	2
Wallace (ks199)	2mb5b	626924	57,405	446
Wichita (ks203)	2mb5b	626924	18,314	181
Hayes (ne085)	1v170	69718	918	41
Lincoln (ne111)	2dhv5	69718	14	1

Ulysses silt loam, 3 to 6 percent slopes, eroded (1860)

Survey	NMUsym	DMUID	acres	polygons
Chase (ne029)	1v10l	69639	2,399	30
Hitchcock (ne087)	1v18m	69765	9,624	396
Project total			539,058	6,222

Joins

Map unit 1859 in Cheyenne Co., Colorado (co017) has a join with Wallace Co., Kansas (ks199) that needs attention. The Wallace Co. map unit that 1859 joins is:
(1580) Colby silt loam, 5 to 15 percent slopes (2w5d4)

- (1859) in section 30-12s-41w joins (1580) in section 25-12n-43w

Map unit 1859 in Rawlins Co., Kansas (ks153) has a join with Red Willow Co., Nebraska (ne145) that needs attention. The Red Willow Co. map unit that 1859 joins is:
(4121) Holdrege and Keith silt loams, 3 to 7 percent slopes, eroded (2s7w5)

- Two polygons of (1859) in section 1-1s-31w join two polygons of (4121) in section 31-1n-30w

Map unit 1859 in Rawlins Co., Kansas (ks153) has joins with Hitchcock Co., Nebraska (ne087) that need attention. The list of joins below is from east to west along the Rawlins-Hitchcock County line. The Hitchcock Co. map units that 1859 joins are:

(1620) Keith silt loam, 1 to 3 percent slopes (2r2fs)
(1630) Keith silt loam, 3 to 6 percent slopes, eroded (2s7vx)
(1632) Keith silt loam, 1 to 3 percent slopes, eroded (2s7vw)
(1860) Ulysses silt loam, 3 to 6 percent slopes, eroded (1v18m)
(1869) Ulysses-Sulco silt loams, 6 to 9 percent slopes, eroded (2r9kt)

- (1859) in section 3-1s-31w joins (1630) in section 35-1n-31w
- (1859) in section 4-1s-31w joins (1630) in section 34-1n-31w
- (1859) in section 1-1s-32w joins (1630) in section 31-1n-31w
- (1859) in section 3-1s-32w joins (1869) in section 35-1n-32w
- (1859) in section 3-1s-32w joins (1860) in section 35-1n-32w
- (1859) in section 1-1s-33w joins (1630) in section 31-1n-32w
- (1859) in section 2-1s-33w joins (1630) in section 36-1n-33w
- (1859) in section 4-1s-33w joins (1630) in section 35-1n-33w
- (1859) in section 2-1s-34w joins (1630 & 1620) in section 36-1n-34w
- (1859) in section 3-1s-34w joins (1632 & 1860) in section 35-1n-34w
- (1859) in section 3-1s-34w joins (1869) in section 35-1n-34w
- (1859) in section 4-1s-34w joins (1630) in section 35-1n-34w
- (1859) in section 3-1s-35w joins (1860) in section 36-1n-35w
- (1859) in section 4-1s-35w joins (1620 & 1860) in section 36-1n-35w

Map unit 1859 in Rawlins Co., Kansas (ks153) has a join with Dundy Co., Nebraska (ne057) that needs attention. The Dundy Co. map unit is (1855) Ulysses loam, 3 to 6 percent slopes (2sbwd).

- (1859) in section 3-1s-36w joins (1855) in section 35-1n-36w

Map unit 1860 in Hitchcock Co., Nebraska (ne087) has joins with Rawlins Co., Kansas (ks153) that need attention. The list of joins below is from east to west along the Rawlins/Hitchcock county line. The Rawlins Co. map units are:

(1581) Colby silt loam, 10 to 25 percent slopes (2v9g1)
(1619) Keith silt loam, 0 to 1 percent slopes (2s7vs)
(1859) Ulysses silt loam, 3 to 6 percent slopes (2mb5b)

- (1860) in section 35-1n-32w joins (1859) in section 3-1s-32w
- (1860) in section 35-1n-34w joins (1581 & 1859) in section 3-1s-34w
- (1860) in section 36-1n-35w joins (1619 & 1859) in section 3-1s-35w
- (1860) in section 34-1n-35w joins (1581) in section 4-1s-35w

Summary of work completed to date.—The Garden City SSO has reviewed the 512 pedons that were collected and find the following. Additional data collected in this project will be reviewed to determine if the trends, summarized below, are representative of the entire extent.

Classification

- 41 percent of the pedons classify as fine-silty, mixed, superactive, mesic Torriorthentic Haplustolls (Quinter [tentative])
- 23 percent classify as fine-silty, mixed, superactive, mesic Aridic Haplustepts (Buffalo Park)
- 11 percent classify as fine-silty, mixed, superactive, mesic Aridic Haplustolls (Ulysses)

The 512 pedons suggest this map unit is more complicated than its consociation designation indicates. The map unit is a patchwork of plant communities that cannot be modeled by landform. I think the map unit may become a Quinter consociation with a Ulysses, Buffalo Park, and swale minor component.

There is evidence that the Torriorthentic Haplustolls should be separated from the Aridic Haplustolls. This would require a new soil series (Quinter), for which I have selected a type location, acquired KSSL data, and developed a tentative OSD. The separation will be especially helpful for the Ulysses map units that have slope greater than 6 percent because we have not found Ulysses soils in these polygons.

Timeframe

This extensive project covers many counties and will begin in April 2016 with major fieldwork completed by November 2016. Field lab analysis, database population, and spatial editing will be completed by April 2017. Field travel to each county will be from 30 minutes to 2 hours. While at each site, a 10-hole transect will be obtained on designated polygons. Polygons outside the heart of the map units will be field checked and pedon descriptions obtained. The project will include fieldwork for transecting, field descriptions, and sample selection collecting the needed analyses as explained above. This project is planned to be submitted to the regional office for quality assurance and correlation in July 2017.

Benefits

The major benefit is to develop a consistent map unit across the southern reaches of MLRA 72 recognizing the erosion of the Ulysses map unit.

Outcome and Deliverables

Improving the population of soil properties associated with eroded Ulysses will help planners better determine conservation practices needed on these eroded soils.

Ecological Site Descriptions (ESD).—Recent interdisciplinary work on the Loamy Tableland ESD established a depth to free carbonates of greater than 15 cm (6 inches) for the Loamy Tableland soils and less than 15 cm (6 inches) for the Limy Tableland soils. The statistics below are developed from that depth to free carbonate break and landform.

- 48 percent of the pedons would be assigned to the Loamy Upland ESD
- 43 percent of the pedons would be assigned to the Limy Upland ESD
- 8 percent of the pedons would be assigned to the Swales ESD

Surface effervescence class (Highly Erodible Land, or HEL).—Twenty percent of the 512 pedons would be HEL. The Buffalo Park component (Aridic Haplustepts) would represent these soils. The effervescent strength (tested with 1M HCL) is described below.

- Noneffervescent 70 percent
- Very slightly effervescent 2 percent
- Slightly effervescent 8 percent
- Strongly effervescent 12 percent
- Violently effervescent 8 percent

Maximum effervescence (0-25cm)

- 36 percent of the pedons have strong effervescence
- 33 percent are noneffervescent
- 21 percent have violent effervescence
- 57 percent of the pedons have strong or violent effervescence in the root zone
- Average depth to the top of the strong or violent effervescence is 12 cm, for pedons with strong or violent effervescence as maximum strength in the root zone

Surface layers with strong to violent effervescence are considered to be HEL. More than half of the 512 pedons have strong or violent effervescence in the root zone and this affects the plant communities. This map unit (1859) will not be HEL, but it needs an HEL component for the planners to use where needed. Based on work already completed, the Ulysses map units with slope greater than 6 percent are probably going to be considered HEL map units and will no longer be considered Ulysses.

The pedon data suggests this map unit should be a consociation of Quinter that is not HEL (48/6) and in the Loamy Upland ESD. Quinter could represent the Aridic Haplustolls (Ulysses) if a Ulysses minor component needs to be avoided.

There should be a Buffalo Park minor component (10 percent component composition) that is HEL (86/4L) because 20 percent of the pedons have strong to violent effervescence in the surface and more than 50 percent have this effervescent strength in the root zone. The Buffalo Park component will provide an HEL component and a Limy Upland component for the users to allow for the patchy areas of HEL.

With 20 percent of the map unit eligible for HEL designation, we may want to create a Quinter-Buffalo Park undifferentiated group, but that is not often desirable. Statistics cannot define the landform position of the HEL component. The HEL (Buffalo Park) and non-HEL (Quinter) components are predominantly on backslopes of side slopes.

Of the 512 pedons collected to date for the 1859 maintenance in Kansas, 60 pedons (12 percent) fit the current Ulysses classification. A Ulysses minor component could be added to provide the users with a component that is non-HEL and in the Loamy Upland ESD, and this minor component would have interpretive rankings that are very similar to the Torriorthentic Haplustolls component.

With 8 percent of the pedons in swales, there is a case for another minor component, probably Duroc.

Field review of plant communities within previously collected transects is advised. The ecological site specialist and Garden City SSO have found that broom snakeweed can be used as an indicator species for the Limy Upland sites. This indicator was not documented when transects were collected, and verification may be helpful in the future.

Travel Budget

Considering an average 90-mile round trip, 4 days per week, for 10 months, is 14,400 miles with an average 15 mpg, and \$2.50 gasoline cost per gallon, there is a potential \$2,400 cost associated with this project. No overnight travel is associated with this project.

Part 614 – Applying Soil Taxonomy

Subpart A – General Information

614.0 Definition and Purpose

The national system of soil classification identifies sets of soil properties and groups them in taxonomic classes. The system is dynamic and amended as needed. The purpose of soil classification is to order, name, organize, understand, remember, transfer, and use information about soils.

614.1 Policy and Responsibilities

A. The National Cooperative Soil Survey (NCSS) is directed, administered, managed, conducted, and supported at various organizational levels within NRCS. Additional information about responsibilities at various levels of the organization can be found in section 608.1 of this handbook and in Title 430 General Manual, Part 402 “Soil Survey.”

B. The partnership of the NCSS is represented by a broad diversity of educational, research and scientific, land management, and operational organizations that have a stake in the content, detail, quality, and utility of soil survey products. It is the responsibility of all NCSS partners to participate in the review, update, and management of soil survey standards as well as adhere to these standards relative to the Soil Survey Program. Specific responsibilities of principle partners and staff are outlined below.

C. NRCS maintains and provides leadership for amending Soil Taxonomy and for maintaining the soil series classification data. All soil surveys within NCSS must use Soil Taxonomy.

D. National Headquarters (NHQ)

The director of the Soil and Plant Science Division—

- (i) Provides concurrence to additions or amendments to Soil Taxonomy and NCSS standards documents.
- (ii) Supports the function of the International Committee on Soil Taxonomy (ICOMTAX):
 - Recommends membership
 - Supports international participation
- (iii) Facilitates logistical support and communication.
- (iv) Supports regional and Soil Survey Office (SSO) staff participation in regional technical committees.

E. National Soil Survey Center (NSSC)

- (1) The director of the NSSC—
 - (i) Provides facilities and staff necessary to review and publish approved amendments and additions to NCSS standards and other documents.
 - (ii) Concurs on recommendations forwarded by the national leader for soil survey standards.
- (2) The national leader for soil survey standards—
 - (i) Coordinates the review of proposals and amendments.
 - (ii) Facilitates review by NCSS regional committees and ICOMTAX:
 - Notifies regional committee chairs and the chair of ICOMTAX of needs

- Develops charges to the committees
- Establishes a review schedule or timetable
- (iii) Collates recommendations from all interested entities.
- (iv) Serves as the primary contact for the person initiating the proposal and reports interim status and final decisions.
- (v) Posts original proposal, reviews and recommendations, and final decisions to publicly accessible online sites.
- (vi) Develops comprehensive recommendations to the director of the NSSC and the director of the Soil and Plant Science Division for concurrence.
- (vii) Codifies and publishes changes to Soil Taxonomy and other impacted standards documents, including the current version of the “Keys to Soil Taxonomy” and the “Soil Survey Manual.”
- (3) The functional branches at the NSSC, within their area of responsibility or technical expertise—
 - (i) Assess, as assigned, the scientific validity of a proposal.
 - (ii) Assess impacts of proposed amendments to other technical documents and standards of NCSS.
 - (iii) Evaluate changes to soil survey information and products, including soil survey descriptions and information, interpretations and ratings, maps and geospatial products, data collection and management, survey methodologies, training, and publication.

F. NCSS Regions and Cooperators

- (1) NRCS staff and cooperators within NCSS regions participate as members of the various technical and business committees on standards.
- (2) NRCS staff and cooperators within NCSS regions provide reviews of and support for Soil Taxonomy and other technical documents of NCSS.
- (3) The chair of the Regional Committee on Standards—
 - (i) Conducts reviews and develops report recommendations in timely manner.
 - (ii) Coordinates input and comments from cooperators and stake holders.
 - (iii) Provides written responses to the national leader for soil survey standards.

G. The International Committee on Soil Taxonomy

- (1) The committee reviews proposals forwarded by the national leader for soil survey standards.
- (2) The committee analyzes the international applications or impacts of a proposal.
- (3) The committee sponsors proposals originating from the international community.
- (4) The chair of ICOMTAX—
 - (i) Coordinates reviews by members of ICOMTAX.
 - (ii) Collates responses from members.
 - (iii) Reports on findings to the national leader for soil survey standards.
- (5) The U.S. soil taxonomy specialist at the NSSC serves as secretary to ICOMTAX.

H. Soil Survey Regional Offices (SSRs)

The regional director—

- (i) Provides data and technical support to the review committees.
- (ii) Coordinates proposals originating from soil survey offices.

I. Soil Survey Offices (SSOs)

The MLRA SSO leader—

- (i) Collects data to support the review and analysis of proposals.
- (ii) Develops and forwards proposals to regional standards committees in order to improve soil survey standards documents (e.g., Soil Taxonomy and the Soil Survey Manual).

J. State Offices

State soil scientists (SSS)—

- (i) Assist and coordinate with NCSS State partners regarding proposals and amendments to Soil Taxonomy and NCSS standards.
- (ii) In general, assist all users of soil survey and ecological site information.

614.2 National Soil Classification System

A. The national soil classification system has two parts. The first part is “Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys,” second edition, Agriculture Handbook No. 436, herein referred to as “Soil Taxonomy” (available at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053577). This part provides definitions and nomenclature for classifying soils. NCSS adopted this system in January 1965, and the first edition of “Soil Taxonomy” was published in 1975. Amendments to the system are periodically placed into a revised edition of the “Keys to Soil Taxonomy” (available at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053580).

B. The second part consists of the official soil series descriptions. The Soil and Plant Science Division maintains the official soil series descriptions in a file-share storage system (available online at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/?cid=nrcs142p2_053587) and the soil series classifications in a database (available online at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/?cid=nrcs142p2_053583). The file share and database list the classification of established, tentative, and inactive soil series of the United States, Puerto Rico, the Pacific Basin, and the U.S. Virgin Islands. The file share of the official soil series description is the official reference to soil series descriptions. The soil series classification (SC) database is the official source for the taxonomic classification of the soil series. The database contains other information about the soil series, such as which soil survey regional office (SSR) has responsibility for the series, the series status, dates of origin and establishment, related geographic areas, and benchmark soil designation. Both the official soil series description file and the soil series classification database are available on the Internet.

614.3 Use of the National Soil Classification System in Soil Surveys

A. Soil surveys use “Soil Taxonomy” to provide—

- (1) A connotative naming system that enables those users familiar with the nomenclature to remember selected properties of soils.
- (2) A means for understanding the relationships among soils within a given area and in different areas.
- (3) A means of communicating concepts of soils and soil properties.
- (4) A means of projecting experience with soils from one area to another.
- (5) Names that can be used as reference terms to identify soil map unit components.

B. Chapter 5 of “Soil Taxonomy” provides general information on the application of soil classification to soil maps of various scales.

C. The names of soil taxa are reference terms for naming the soil components of a map unit in most soil surveys. Soil taxa are classes at any categorical level in the multicategorical system of “Soil Taxonomy,” but typically range from the great group level for taxons in reconnaissance mapping to soil series for mapping of lands of intensive use. The name used is generally from a taxon of the lowest

category that identifies the dominant kinds of soil. Chapter 7 of “Soil Taxonomy” provides more information on the derivation of the nomenclature, definition of the terminology, and structure of the taxonomic names. Even though names of one or more taxonomic classes identify components of map units, components are not the same as soil taxa. If the fixed limits of soil taxa are superimposed on the pattern of soils in nature, the limits of taxonomic classes rarely coincide precisely with mappable areas. In addition to the named component or components, a map unit commonly includes components of minor extent that may be similar or dissimilar to the named soil. Part 627 of this handbook discusses major and minor map unit components and dissimilar and similar soils.

D. A map unit name is distinguished from a soil taxon name by adding one or more phase terms to the soil taxon reference name. For example, Gamma is a soil taxon; Gamma silt loam, saline, 0 to 2 percent slopes, is a map unit name. Part 627 of this handbook provides direction in naming map units. Chapter 5 of “Soil Taxonomy” and chapter 4 of the “Soil Survey Manual” provide additional information on the relationship between soil taxa and map units and the naming of map units.

614.4 Soil Taxonomy Committees, Work Groups, and Referees

A. Regional Soil Taxonomy Committees

Each group of states within the NCSS region has a soil taxonomy committee (or other standards-related committee) as part of the Regional Cooperative Soil Survey Conference. The membership and operational procedures of the committee are described in the regional conference bylaws. These committees work on standards-related issues that are identified as being important within the region and also review proposed amendments referred to them by the national leader for soil survey standards. Members serve on a continuous basis, as needed.

B. National Soil Taxonomy Committee

The National NCSS Conference has a Standing Committee on Standards that includes some members from the regional committees as well as members appointed by the Conference Steering Committee. The membership and operational procedures of the committee are described in the national NCSS conference by-laws. This committee works on standards-related issues that are identified by the Conference Steering Committee as being important, considers business items referred to it by the regional committees, and reviews proposed amendments that are referred to it by the national leader for soil survey standards.

C. International Committee for Soil Taxonomy

- (1) In order to continue the improvement of “Soil Taxonomy” and broaden interests and global application, ICOMTAX was established to actively promote input from the international community. ICOMTAX evaluates the technical soundness and appropriateness of international proposed amendments for inclusion in “Soil Taxonomy” and the “Keys to Soil Taxonomy.” It may also provide review of any amendments having potential international application.
- (2) ICOMTAX operates in an advisory capacity under the director of the Soil and Plant Science Division. Membership is by invitation of the director. It promotes the international use of “Soil Taxonomy” and supports the submission and review of proposals to amend “Soil Taxonomy” for greater use and applicability worldwide.
- (3) ICOMTAX reviews, analyzes, and develops recommendations on amendments to “Soil Taxonomy,” including issues of nomenclature, diagnostic properties, features and horizons, and classes.

- (4) ICOMTAX addresses international soil classification issues relative to “Soil Taxonomy” as referred from the national leader for soil survey standards. The business of ICOMTAX is conducted remotely by mail or email, teleconferences, and public comment forums.
- (5) When feasible, face-to-face meetings concurrent with meetings of professional societies, such as the Soil Science Society of America (SSSA), the International Union of Soil Science (IUSS), and the World Congress of Soil Science (WCSS), are conducted.
- (6) Members of ICOMTAX are selected from active members of NCSS, IUSS, and similar national professional soil science organizations.
- (7) A chair and co-chair, who are appointed by the director of the Soil and Plant Science Division, lead ICOMTAX business. The chair conducts meetings, develops reports of analyses, and provides recommendations to the national leader for soil survey standards. The co-chair assists the chair and takes over the position when the term of the current chair expires. The NRCS national soil classification specialist at the National Soil Survey Center serves as secretary and permanent member of the committee. This person facilitates communication, distributes proposals and recommendations, and maintains records of meetings and reports.
- (8) Membership consists of 9 to 17 rotating members recommended by IUSS and NCSS and appointed by the director of the Soil and Plant Science Division. Terms are 3 years. Consecutive terms are permitted, and terms are staggered to provide continuity. Ad hoc participation by invited technical experts is recommended to address little known or complex issues.
- (9) The committee develops operational procedures (bylaws) and guidance documents, as needed. These documents need to clearly address—
 - (i) Receipt of proposed amendments.
 - (ii) Discussion, analysis, and development of recommendations.
 - (iii) The recommendations to present to the national leader for soil survey standards.
- (10) The national leader for soil survey standards reviews and processes the recommendations of ICOMTAX for final determination.

D. National Ad Hoc Work Groups

The director of the Soil and Plant Science Division appoints working groups as needed. The working groups review reports from regional Soil Taxonomy committees and recommend additional study or implementation of proposed amendments. Members include representatives of state and federal agencies and may also include international representatives. The chairperson of a group, usually a member of the National Soil Survey Center staff, and other members are chosen according to the nature of the recommended changes and the expertise needed.

E. International Committees

The director of the Soil and Plant Science Division may establish international committees under the structure of ICOMTAX to address technical or scientific issues that affect international users of “Soil Taxonomy” and require major additions or changes in the soil classification system. Membership is open to any user of “Soil Taxonomy” and usually includes representatives of State and Federal agencies as well as international cooperators. Charges are focused and specific, and committees operate for a specified duration.

F. Referees

The director may request that referees prepare position papers on proposed amendments. The referee requests, as needed, a review by peers and assumes the responsibility for decisions regarding the proposal.

614.5 Procedures for Amending Soil Taxonomy

A. Soil Taxonomy is a dynamic system for classification of soils. It is designed to be open-ended, permitting the addition of diagnostic features and classes that help explain the pedogenic history and broad interpretative qualities of soils. Inferred taxonomic classes are not added until they are actually described and documented.

B. Recommendations for amending “Soil Taxonomy” must be fully developed and documented prior to submission to the national leader for soil survey standards. Established guidelines are followed in proposals and the submission of proposals as well as in the evaluation and testing. Proposals that meet requirements and are approved are drafted into amendment form and posted for open review and comment. Based upon review comments, the proposal is adopted and integrated, rejected, or sent back for further development and documentation. Part 614, subpart B, section 614.10, illustrates the processing of proposals to amend “Soil Taxonomy.”

C. Considerations in Proposing Amendments to “Soil Taxonomy”

- (1) An amendment should address questions of soil classification, including diagnostic features, diagnostic criteria, and taxonomic classes through the family level.
- (2) An amendment should add value and clarity to “Soil Taxonomy,” or accommodate needed classes as discovered.
- (3) An amendment should be based upon soil properties that can be observed or measured and serve as the basis for diagnostic criteria.
- (4) An amendment should be placed logically within the Soil Taxonomy hierarchy (i.e., within the order, suborder, great group, subgroup, family, or series).
- (5) Definitive diagnostic criteria should be developed and defined.
- (6) The impacts or consequences to the overall system of Soil Taxonomy should be considered. For example—
 - (i) Does the amendment provide clarity to the classification system or improve interpretative value?
 - (ii) Will the amendment require excessive modifications throughout the Soil Taxonomy system, affecting a large number of taxa or series?
 - (iii) Will the amendment impact existing State or Federal regulations or statutes?
 - (iv) Can the amendment be implemented readily?

D. Submitting Proposed Amendments

Proposals may be made by anyone using “Soil Taxonomy” from within or outside the United States. Proposals should be submitted to the national leader for soil survey standards. This individual determines routing to the appropriate regional Soil Taxonomy committee chairs and ICOMTAX. Send proposals to the national leader for soil survey standards at the National Soil Survey Center, Federal Building, Room 152, 100 Centennial Mall North, Lincoln, NE, 68508-3866. Proposals may be surface mailed or sent as attachments in email messages. (See the National Soil Survey Center directory at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053895 for the current email address of the national leader for soil survey standards.)

E. Documenting Proposed Amendments

Criteria for New Taxa Above the Family Category.—The minimum supporting evidence for all proposed classes must include pedon descriptions, the impact on interpretations, an estimate of geographical extent, and certain laboratory data. Laboratory data is required for at least the critical parts of diagnostic horizons in the proposed new class if the limits between the proposed class and the other recognized classes cannot be adequately identified using field criteria alone.

- (1) Criteria for a New Class in the Family Category.—The minimum supporting evidence includes about 10 pedon descriptions or a description of a proposed soil series and the expected impact on interpretations for the intended use. Laboratory data is required for at least the critical parts of the proposed new class if the limits between the proposed class and the other recognized classes cannot be adequately identified using field criteria alone.
- (2) Criteria for a New Class in the Family Category.—The minimum supporting evidence includes about 10 pedon descriptions or a description of a proposed soil series and the expected impact on interpretations for the intended use. Laboratory data is required for at least the critical parts of the proposed new class if the limits between the proposed class and the other recognized classes cannot be adequately identified using field criteria alone.
- (3) Support of the Review Process.—Proposals should include the following materials:
 - (i) Soil and site descriptions, as appropriate to support the proposal
 - (ii) Definitions of new terminology
 - (iii) Analytical results using procedures in SSIR #42 (Laboratory Methods Manual)
 - (iv) Graphics, illustrations, maps, and photos
 - (v) Citations and technical references
 - (vi) Justification of metrics and limits for the classes or differentiae being proposed
 - (vii) Brief analysis of improvement to soil survey maps, data, and descriptions relative to use and management of soil or improvements to soil science procedures and processes in general
 - (viii) Brief analysis of geographic extent or application of the proposal
 - (ix) If appropriate, brief analysis of impacts to NCSS soil survey standards and procedures, such as the “Keys to Soil Taxonomy” and “Soil Survey Manual”

F. Evaluating Proposed Amendments

- (1) The national leader for soil survey standards, located at the National Soil Survey Center, circulates the proposed amendment to NCSS cooperators and ICOMTAX for review. Proposed amendments are also posted online on the “Soil Taxonomy” web page (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053577) under the heading, “Proposals to Amend Soil Taxonomy.” Review and comment are welcome from any interested cooperators. Those who are current members of the regional taxonomy committees have a special obligation to review and comment on proposals. Appropriate review recommendation would be for approval without change, approval with change, or rejection. Notes of discussions and reasoning for the recommendation should also be given.
- (2) The national leader for soil survey standards evaluates all proposals from the international committees and other proposals that originate outside the United States, arranges a review of these proposals by cooperators or work groups and by ICOMTAX, and determines disposition for proposals.
- (3) If a significant proposal is rejected, the originator is typically sent recommendations for improving the amendment for a future resubmission. Rejected amendments may be appealed to the director of the Soil and Plant Science Division for reconsideration.
- (4) Recommendations to change or reject the proposal are documented. The national leader for soil survey standards reviews the recommendations and either makes a decision to return the proposal to the originator with reasons for the rejection or includes the proposal in a transmittal (by email or surface mail) to the chairs of the regional Soil Taxonomy committees and ICOMTAX.
- (5) If the proposal is accepted and concurred by the director of the Soil and Plant Science Division, it is incorporated into “Soil Taxonomy” and related standards documents.

- (6) The deputy chief for Soil Science and Resource Assessment in NRCS issues a national bulletin to announce changes to the “Keys to Soil Taxonomy” or “Agriculture Handbook 436” (“Soil Taxonomy”). Issuance of this bulletin gives the final official approval for the changes.

G. Distributing Amendments

The publication of proposed amendments constitutes final approval. New editions of the “Keys to Soil Taxonomy” and “Soil Taxonomy” include these amendments. All soil scientists of NCSS and other soil scientists, both national and international, receive new editions of these documents.

614.6 The Soil Series

A. The soil series is the lowest category of the national soil classification system. The name of a soil series or the phase of a soil series is the most common reference term used in soil map unit names. The name of a soil series is also the most common reference term used as a soil map unit component. The purpose of the soil series category is closely allied to the interpretive uses of the system. Map unit components provide the interpretive applications within soil survey for the most detailed purposes. Soil series are the most homogeneous classes in the classification system.

B. Chapter 21 of “Soil Taxonomy” and chapter 17 of the current edition of the “Keys to Soil Taxonomy” provide guidance for series differentiae within a family.

C. Establishing Norms and Class Limits for Soil Series

- (1) In developing or revising soil series concepts, systematic procedures are essential. They reduce the possibility of recognizing more soil series than are necessary to organize and present existing knowledge about soil behavior. The distinctions between one soil series and its competitors must be large enough to be consistently recognized and to be recorded clearly. Clearly differentiate each soil series from all other soil series. Simplify this differentiation by using the systematic procedure described in this section.
- (2) Assemble and study all available information on morphology, composition, position on the landscape, and geographic distribution of the soils being considered. Compare the available information with the concepts of existing soil series and evaluate possible concepts for new soil series. Refine soil characteristics that define higher categories of Soil Taxonomy to differentiate one soil series from another. Only use those characteristics that are observed or measured within the soil series control section to differentiate soil series. Chapter 21 of “Soil Taxonomy” provides more information on the series control section. A significant soil characteristic is one that has genetic implication, such as the nature or arrangement of horizons or the absence of horizons, or it is one that has an influence on use and management, such as percent of gravel or reaction. Exercise judgment in the selection and weighing of soil characteristics used to separate soil series. Chapter 21 of “Soil Taxonomy” and chapter 17 of the current edition of the “Keys to Soil Taxonomy” further discuss soil series and their differentiae.
- (3) Competing soil series are those that are in the same family as the soil series under study. Changing the concept of one soil series may necessitate modification to the concepts of other soil series in the family. It may be necessary to revisit and redescribe competing series to assess the adequacy of the description for proper taxonomic placement and appropriateness of competing statements.
- (4) When proposing a new series, conceptualize a model of it. Develop a model with a specific norm and range in characteristics for the proposed soil series description. The range for differentiating characteristics may not overlap that of an existing soil series in the same family. Limits of the range in soil characteristics for the proposed soil series may be as wide as those permitted in the family to which it belongs. Generally, keep the range in differentiating soil

- characteristics of the soil series narrower than that for the span of the family. The permissible ranges must not be too narrow for precise and consistent identification. They must be practical to use with the natural variation of soils.
- (5) Select a pedon that is typical for the soil series concept. The typical pedon is a reference specimen that illustrates the central concept for the soil series. This pedon, along with other very similar pedons, forms the model for the soil series class. Thus, the selection of a typical pedon is a very important process and must be done with great care. Base it on the arrayed data on morphology, composition, and geographic distribution. A pedon is not likely to be central for all ranges, but the representative pedon should lie reasonably near the center of the ranges for most physical and chemical properties and for the geographic distribution. If the pedon selected to typify a soil series has one or more properties unusual for the soil series class, record the properties as part of the range of characteristics and note them in the “Remarks” section of the description. Select a pedon that is typical for the soil series concept. The typical pedon is a reference specimen that illustrates the central concept for the soil series. This pedon, along with other very similar pedons, forms the model for the soil series class. Thus, the selection of a typical pedon is a very important process and must be done with great care. Base it on the arrayed data on morphology, composition, and geographic distribution. A pedon is not likely to be central for all ranges, but the representative pedon should lie reasonably near the center of the ranges for most physical and chemical properties and for the geographic distribution. If the pedon selected to typify a soil series has one or more properties unusual for the soil series class, record the properties as part of the range of characteristics and note them in the “Remarks” section of the description.
 - (6) After selecting the typical pedon, define the permissible ranges for soil properties and qualities. Use the arrayed information on morphology and composition of the soils, especially the profile descriptions, field notes, and laboratory analyses. If laboratory data are used to define ranges in soil properties, use the conventional rules for rounding (see section 614.13). To determine significant digits for soil property or quality measurements used as criteria in “Soil Taxonomy,” see section 614.14.
 - (7) Soils are classified to the family level using only a selected set of properties occurring within specified depths. When defining new soil series, all properties that separate it from similar but competing soil series are essential to include in the series description. Emphasize these properties in the statement of the range of characteristics. Also describe the ranges in significant properties that do not differentiate between the soil series being described and its competing soil series.
 - (8) Test the soil series concept. Check the norm and ranges in characteristics against the class limits for the family to which the soil series belongs. Do not cross the limits of the family with the ranges specified for the soil series. The distinctions in definitive characteristics between the norms for the proposed soil series and the norms for competing soil series must be clearly greater than what may be due to normal errors of observation or be based on laboratory data and geomorphic or geographic information. Do not overlap ranges in differentiating characteristics.
 - (9) Differences in a single characteristic are seldom used to separate soil series. Preferably, use the distinctions in several characteristics to separate soil series. Some may have greater importance than others. A new soil series is justified if the differences in morphology and composition are clearly greater than what could be attributed to normal errors of observation and if these differences are significant to use and management of the soil. Deciding whether or not to propose a new soil series is difficult when two or more properties of the soils to be classified are outside but near the limits of an existing soil series. Propose new soil series if the soils differ in characteristics that have practical significance to use and management.

D. Allowing Normal Errors of Observation

- (1) A new soil series differs appreciably in either morphology or composition, or both, from already defined soil series. Differences in relevant characteristics must be larger than what may be normal errors of observation or estimates. The following paragraphs give examples of allowed normal errors of observation and tolerance. Soils within these tolerances do not need a new series, nor do they need to be named as taxadjuncts.
- (2) Identification of soil color in the field is subject to errors because of changes in the quality of light and in soil moisture, differences in the visual acuity and skill of individuals, and limitations in the standards used to determine color. Chapter 3 of the “Soil Survey Manual” provides a discussion of soil color. Field observations of soil color are taken at different times of the day and at differing soil moisture contents. These variables could result in differences as large as a full interval between chips in the Munsell color system. The differences in identification of soil color resulting from one person looking at the same specimen at different times and under different conditions or from a group of individuals looking at the same specimen together are an example of normal errors of observation. Optimum field conditions allow soil color to be matched to within one-half interval between chips on the color chart. The normal range of difference between careful observations is plus or minus a half interval between chips of the same hue or between chips of the same value and chroma on adjacent hues. Color distinctions, if definitive, between the soils of two soil series must be greater than this normal range.
- (3) Field estimates of texture are commonly within plus or minus one-half class of the actual texture, though errors by highly skilled individuals are smaller. To separate soil series that are based in part on differences in texture, use distinctions that are greater than the probable error of field estimates or use laboratory data and geomorphic or geographic information. This rule applies to the entire soil series control section and any of its parts. Not all differences among soil series are obvious. The limit between the fine-loamy and fine particle-size classes is a clay content of 35 percent. The experienced mapper has little difficulty in distinguishing between 30 percent and 40 percent clay. However, only the laboratory can consistently distinguish between 34 percent and 36 percent clay content. If this is the only difference, the distinction is not important for most uses of the soil map. Name the map unit for either of the two soil series that have a common conceptual boundary at 35 percent clay. Differences that are no greater than the normal errors of observation can cause many needless decisions, even for an experienced mapper. If the estimate of the properties varies by these normal errors, the similar soils do not seriously affect the use of the map as long as the map units are defined to allow for the variation.
- (4) Occurrence of soil pedons having properties that in their normal range on the landscape extend only slightly outside class limits but do not otherwise impact use and management should not be considered for establishment of a new series.

E. Proposing and Naming a Soil Series

- (1) Soil scientists in NCSS write and complete descriptions of new soil series and their ranges for soil properties. Ranges for soil properties are estimated, measured, or both. Part 627, subpart A, section 627.8(E)(1), of this handbook contains documentation requirements.
- (2) The SC database contains a complete list of active and inactive soil series. It provides the official classification for all soil series in the official soil series description (OSD) file share. When naming a proposed series, give preference to the names of geographic places as a source of possible names. In choosing a name, avoid using—
 - (i) Names consisting of very long words.
 - (ii) Names with any characters other than letters, spaces, periods, apostrophes, or grave accents.
 - (iii) Bizarre, discriminatory, comical, or vulgar words.

- (iv) Geological terms, such as the names of rocks, minerals, landforms, and the formations of a locality.
- (v) Names of plants and animals.
- (vi) Given names of persons, unless the name is a known geographic location or feature.
- (vii) Copyrighted names and registered trademarks.
- (viii) Names essentially identical in pronunciation to a name already in use (e.g., Whit vs. Witt).
- (ix) Names similar in spelling to a name already in use (e.g., Tonnor vs. Tonor).
- (3) Series names with a similar spelling should differ by at least two characters. Names consisting of two words must differ by more than just the space between the two words from similarly spelled single-word series names. Names of local geographic features or places are preferred. If these are unavailable, coined names may be used. Geographic place names must also avoid all restrictions listed above. Coined names must be consistent with American usage and free from the restrictions listed above. The series name may contain only letters, spaces, periods, or apostrophes (single quotes) and the grave accent (`) as characters. The words “AUX,” “CON,” “NUL,” and “PRN” are considered reserved and cannot be used as soil series names due to constraints imposed by the SC database. Refer to the “SC/OSD Maintenance Tool User’s Guide” (available at https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052428.pdf) for more information on series names.
- (4) After the proposed soil series description is revised within the soil survey region, the SSR that has responsibility for the new series approves the name and reserves the series by entering required data into the SC database. The minimum data required to enter a new series into the SC database consists of the series name, responsible SSR, State having the type location, complete taxonomic classification, and at least one MLRA in which that series occurs. By default, the new soil series is identified as having tentative status and the current year of proposal is assigned. The SSR enters the soil series description into the OSD file share, where it is available for the adjoining SSRs and cooperators to review and provide comment. The entry of new OSDs should occur as soon as possible in order to minimize the inconvenience to other users of having series in the SC database without a corresponding OSD for viewing. A notification and request for comments are sent to adjoining SSRs, State soil scientists within the MLRA, and all other SSRs that have soil series in the same family as the proposed series.
- (5) The responsible SSR evaluates any comments and prepares a revision of the soil series description. The revised description is transmitted to the official soil series description file. If the decision is made not to use the series, the SSR removes the tentative soil series from the SC database. This causes the tentative soil series description in the OSD file share to move to an inaccessible file.
- (6) The responsible SSR resolves disagreements on concepts of soil series. It assembles and evaluates available evidence on the points in question and, if necessary, requests additional information about the soils under consideration from one or more MLRA soil survey regions. If the soil series is in dispute or if the questions about the soil series concept are of considerable importance, a joint field study may be necessary. After the differences have been resolved, the SSR updates the soil series description in the OSD file share.

F. Revising Official Soil Series Descriptions

- (1) Soil scientists must revise soil series descriptions if one or more of the following conditions exist:
 - (i) A change in the concept of the soil series, including the range in characteristics.
 - (ii) A change in the classification of the soil series.
 - (iii) A change in the type location of the soil series.
- (2) Any soil scientist in NCSS may write revisions of soil series descriptions. These descriptions are submitted to the SSR assigned responsibility for the series. The responsibility for

maintenance of a series is populated in the SC database and is shown in the OSD. The revision is based on pedon descriptions, laboratory data, and other available sources of information about the soils that represent the series.

- (3) If the soil series classification, range in characteristics, or type location is changed, the SSR reviews these changes within the soil survey region and with other soil survey regions and States in which the soil series or competing series is known or expected to occur. After critical review, scientists return comments to the originating SSR. The staff soil scientist at the SSR evaluates the comments and makes the necessary changes in the revised description of the soil series. The SSR soil scientist updates the classification of the soil series in the soil series classification file, if necessary, and then revises the official soil series description.

G. Inactivating an Established Soil Series

When it is appropriate, SSRs may change the status of a soil series from “established” to “inactive.” They support the decision to inactivate a soil series with documentation as to why the soil series should be made inactive and a recommendation for the disposition of the soils that have been classified in the inactive series. Before changing the status of a soil series to inactive, the SSR with responsibility for the series sends a memorandum of intentions and supporting reasons to affected State soil scientists and SSRs. The responsible SSR notifies members of other disciplines and cooperators who may use the series name in databases and publications. About 45 days are allowed for filing objections to the recommendation. If the SSR determines that the soil series should be made inactive, it notifies the affected regions. The memorandum includes the reclassification to the appropriate soil series or to a taxon of a higher category of all pedons in the inactive series that have been sampled and analyzed by NRCS, cooperating universities, highway departments, or other laboratories. Inactive soil series are retained in the soil series classification database. The OSD of the inactivated series is updated with information from the memorandum of intentions that provides the reason for the status change and the recorrelation of existing components to other named series.

H. Reactivating an Inactive Soil Series Name

The name of a soil series that is placed on the inactive list is not reused unless the series concept is the same as in the previous description. If a SSR wants to reactivate a soil series name, they follow the procedure that is used to propose a soil. A notation is made under “Remarks” that the soil series name is being reactivated.

I. Dropping a Tentative Soil Series

- (1) A tentative soil series is dropped from the soil series classification database if it duplicates an already recognized series.
- (2) If multiple SSRs use the soil series, the SSR with responsibility for the series requests concurrence from affected SSRs to drop the series. Note that responsibility for maintenance is generally determined by the type location of a series. Upon concurrence, the SSR notifies the users that the series is dropped. The notification includes a statement of reasons for dropping the series. The name of the dropped series is noted in the correlation document of the soil survey area that has the type location.
- (3) If only the SSR with responsibility is using a soil series listed as tentative, it drops the series by listing it as dropped in the correlation document of the survey area that has the type location.
- (4) The name and record from the soil series classification database are removed. This causes the description in the official soil series description file to move to an inaccessible file. A tentative soil series is not listed as inactive.

J. Transferring Responsibility for a Soil Series and Changing the Type Location

Approval for transfer of the responsibility for a soil series and change of type location is as follows:

- (i) The responsible SSR approves changes within the MLRA soil survey region.
- (ii) Mutual consent of the SSRs allows transfers of responsibility between soil survey regions. All transfers of soil series responsibility and changes of type location require a series description using the new type location. The SSR receiving responsibility enters the new description into the database.

K. Establishing a Soil Series

A soil series is established when it is used in the correlation of a survey area and the correlation document is approved and signed by the SSR. The correlation document contains a list of the soil series that are established by that correlation. If a soil series is established by a correlation, the responsible SSR changes the status of the series in the official soil series description file and the soil series classification database from “tentative” to “established” and concurrently changes the heading from “SERIES PROPOSED” to “SERIES ESTABLISHED” in the official description.

The SSR also enters the year that the soil series is established in both the soil series classification database and the official series description file and then enters the name of the survey area (which may be an MLRA) in which it is established. The SSR uses the SC/OSD maintenance tool (a Web application protected by USDA eAuthentication) to perform these tasks. If a tentative soil series is not used and established in the correlation document for the survey area in which it was proposed and no other potential use is pending, the soil series is removed from the soil series classification database.

L. Making and Managing Official Soil Series Descriptions

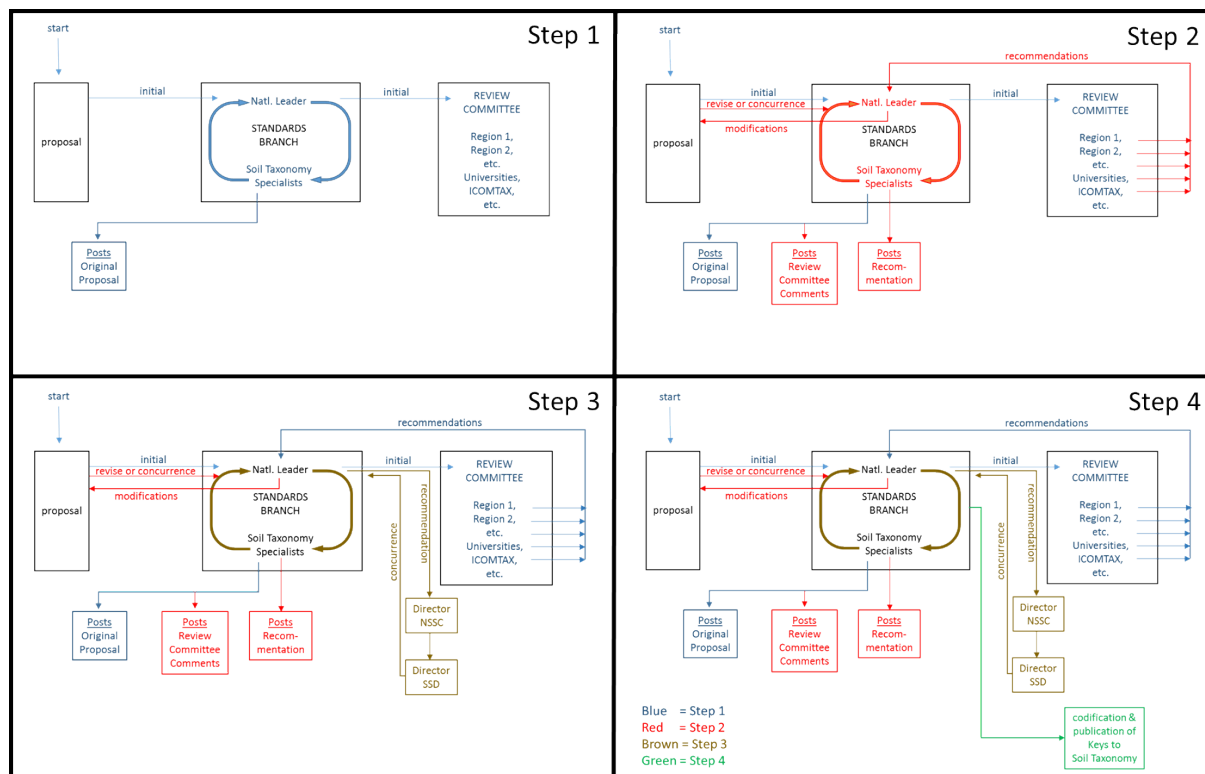
- (1) The term “official soil series description” indicates the description approved by the SSRs that defines a specific series in the United States. The description follows a prescribed format, which is defined in section 614.12. An official soil series description needs to be revised if more information about the soils in the series is available or if the classification of the series changes because of revisions to the national system of soil classification. All soil scientists working in NCSS must be familiar with the requirements for adequate soil series descriptions. The “Soil Survey Manual” and chapter 21 of “Soil Taxonomy” discuss the concept of the soil series and requirements for descriptions. Field descriptions and official soil series descriptions should use metric units of measurement.
- (2) The official soil series descriptions are descriptions of the taxa in the series category of the national system of soil classification. They mainly serve as specifications for identifying and classifying soils. Scientists in other disciplines, such as agronomists, horticulturists, engineers, planners, and extension specialists, also use the descriptions to learn about the properties of soils in a particular area.
- (3) The major items in descriptions and the order in which they appear are listed below. Every official soil series description includes all but the “additional data” item, which is used only as needed. Part 614, subpart B, section 614.11, gives an example of an official soil series description as it would appear on the internet. Part 614, subpart B, section 614.12, explains the content of a soil series description.
 - (i) Location line with first instance of series name and the states using it (FIPS code)
 - (ii) Status of soil series (tentative, established, or inactive)
 - (iii) Initials of authors
 - (iv) Date of latest revision (autogenerated in mm/yyyy format)
 - (v) Name of soil series

- (vi) Introductory paragraph
 - (vii) Taxonomic class
 - (viii) Typical pedon
 - (ix) Type location
 - (x) Range in characteristics
 - (xi) Competing series
 - (xii) Geographic setting
 - (xiii) Geographically associated soils
 - (xiv) Drainage and saturated hydraulic conductivity (permeability in older series)
 - (xv) Use and vegetation
 - (xvi) Distribution and extent
 - (xvii) SSR responsible
 - (xviii) Series proposed or series established
 - (xix) Remarks on diagnostic horizons and features recognized in the pedon
 - (xx) Additional data as needed
- (4) Each description must be complete and as brief as possible without omitting any essential information. It must clearly differentiate between the series being described and all other series. It must state the present concept of a soil series rather than past concepts or its evolution. The description must record the soil properties that—
- (i) Define the soil series.
 - (ii) Distinguish it from other soil series.
 - (iii) Serve as the basis for the placement of that soil series in the soil family.
 - (iv) Are needed to generate soil interpretations in the National Soil Information System (NASIS).
- (5) In the competing series paragraph, give differentiae used to separate other soils in the same family in terms of soil properties, diagnostic horizons, or features.
- (6) Use the standard terminology that is defined in the “Soil Survey Manual” as appropriate. If applicable, use terms defined in “Soil Taxonomy.” The rule for the use of standard terms applies to all parts of soil series descriptions but is especially important for descriptions of individual horizons. Some soil descriptions need to use some terms that are not defined in the “Soil Survey Manual” or “Soil Taxonomy.” Use such terms in their ordinary, standard dictionary sense.

Part 614 – Applying Soil Taxonomy

Subpart B – Exhibits

614.10 Flow Chart of Amendment Process



614.11 Example of an Official Soil Series Description in HTML

LOCATION GAMMA

AA

Established Series
Revised AAA-BBB-CCC
04/2023

GAMMA SERIES

Depth class: Very deep
Drainage class: Poorly drained
Saturated hydraulic conductivity class: Moderately high
Flooding: Occasionally or frequently flooded for brief periods
Parent material: Silty alluvium from loess and till
Geomorphic location: Flood plains of narrow drainageways
Slope range: 0 to 2 percent
Mean annual temperature: 10 degrees C (50 degrees F)
Mean annual precipitation: 660 millimeters (26 inches) at the type location

Taxonomic Class:

Fine-silty, mixed, superactive, nonacid, mesic Mollic Fluvaquents

Typical Pedon:

Gamma silt loam with a north-facing, linear, 1 percent slope in an alfalfa field at an elevation of 210 meters. (Colors are for dry soil unless otherwise noted.)

Ap—0 to 15 centimeters; grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, friable; neutral (pH 6.7 in 1:1 water); abrupt smooth boundary. (10 to 23 centimeters thick)

C—15 to 33 centimeters; stratified grayish brown (10YR 5/2) and light brownish gray (10YR 6/2) silt loam, very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) moist; massive with evident bedding planes; slightly hard, friable; few fine prominent reddish brown (5YR 4/4) masses of oxidized iron in the soil matrix; neutral (pH 6.7 in 1:1 water); abrupt smooth boundary. (15 to 30 centimeters thick)

Cg1—33 to 48 centimeters; stratified dark gray (10YR 4/1) and grayish brown (10YR 5/2) silt loam, very dark gray (10YR 3/1) and dark grayish brown (10YR 4/2) moist; massive with evident bedding planes; slightly hard, friable; few fine prominent reddish brown (5YR 4/4) masses of oxidized iron in the soil matrix; neutral (pH 6.8 in 1:1 water); abrupt smooth boundary. (10 to 25 centimeters thick)

Cg2—48 to 81 centimeters; stratified grayish brown (10YR 5/2) and light brownish gray (10YR 6/2) silt loam, very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) moist; massive with evident bedding planes; slightly hard, friable; few fine prominent reddish brown (5YR 4/4) masses of oxidized iron in the soil matrix; neutral (pH 6.9 in 1:1 water); abrupt smooth boundary. (25 to 51 centimeters thick)

Agb1—81 to 112 centimeters; dark gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) moist; massive; hard, friable; neutral (pH 6.8 in 1:1 water); gradual wavy boundary. (0 to 38 centimeters thick)

Agb2—112 to 153 centimeters; dark gray (N 4/) silt loam, black (N 2.5/) moist; massive; hard, friable; neutral (pH 6.8 in 1:1 water).

Type Location:

Any County, Anystate; located about 4.8 kilometers (3 miles) west of Brainard; 415 meters (1360 feet) south and 61 meters (200 feet) east of the northwest corner, sec. 14, T. 14 N., R. 3 E.

USGS Quadrangle: Brainard

Latitude: 32.6830080

Longitude: -96.5158030

Datum: WGS84

Coordinates source: From hand-held GPS

Range in Characteristics:

Depth to identifiable secondary carbonates: Typically not present within a depth of 150 centimeters, but in some pedons they occur at depths of 30 to 76 centimeters

Soil moisture control section: Wet from 15 to 46 centimeters to more than 183 centimeters from November to June

Moisture regime: Aquic

Depth to redox concentrations: 10 to 23 centimeters

Depth to endosaturation: 15 to 46 centimeters from November to June

Particle-size control section (weighted average):

Clay content—24 to 34 percent

Sand content—2 to 12 percent

A or Ap horizon:

Hue—10YR

Value—4 or 5 dry, 2 or 3 moist

Chroma—1 or 2

Texture—silt loam or silty clay loam

Clay content—20 to 27 percent

Reaction—neutral or slightly alkaline

Reaction in calcareous overwash phase—slightly alkaline or moderately alkaline

C and Cg horizons:

Hue—10YR or 2.5Y

Value—4 to 6 dry, 2 to 5 moist

Chroma—1 or 2 dry or moist

Redoximorphic concentrations—hue of 7.5YR or 5YR; value of 4; chroma of 4

Texture—silt loam or silty clay loam

Clay content—24 to 35 percent

Reaction—neutral to moderately alkaline

Agb horizons, when present:

Hue—10YR or 2.5 Y or N

Value—3 or 4 dry, 2 or 3 moist

Chroma—0 to 1

Redoximorphic concentrations—hue of 7.5YR or 5YR; value of 4; chroma of 4

Texture—silt loam or silty clay loam

Clay content—24 to 35 percent

Reaction—neutral to moderately alkaline

Competing Series:

These are the Alpha and Beta soils:

Alpha soils have a fine loamy particle size class.

Beta soils are more acid than neutral throughout the series control section.

Geographic Settings:

Parent material: Silty alluvium and till

Landform: Flood plains

Slope ranges: 0 to 2 percent

Mean annual temperature range: 9.4 to 11.7 degrees C (49 to 53 degrees F)

Mean annual precipitation range: 610 to 710 millimeters (24 to 28 inches)

Frost-free period: 140 to 160 days

Elevation: 180 to 250 meters (591 to 820 feet)

Geographically Associated Soils:

These are the Alcester, Judson, Aowa, and Colo soils:

Alcester and Judson soils formed in colluvial-alluvial material on foot slopes above the Gamma Soils and have a seasonal high water table below a depth of 2 meters (6 feet). Also, Judson soils are cumulic.

Aowa soils are on similar landscapes but are calcareous.

Colo soils are on similar landscapes and are cumulic.

Drainage and Saturated Hydraulic Conductivity:

Drainage class: Poorly drained

Saturated hydraulic conductivity: Moderately high

Flooding: Occasionally or frequently flooded for brief periods from March to July

Seasonal high water table: Ranges from 0.15 to 0.46 meters (0.5 to 1.5 feet) below the surface at some time between November and May in normal years

Use and Vegetation:

Most areas are used for pasture, range, or hayland. Cultivated areas that have been drained are in corn or sorghum. Common grasses are big and little bluestem, switchgrass, prairie cordgrass, varieties of sedges, and Kentucky bluegrass. Willow and cottonwoods are common in many places. See Remarks section for native vegetation cover in Nebraska.

Distribution and Extent:

Pleistocene marine terraces in the northwestern United States; MLRA 1. These soils are moderately extensive.

Soil Survey Region (SSR) Responsible:

City, State

Series Established:

Any County, Anystate, 2009

Remarks:

Typical Pedon Taxonomic Features:

Ochric epipedon—the zone from 0 to 15 cm (Ap horizon)

Buried soil—the zone from 81 to 153 cm (Agb1 and Agb2 horizons)

Taxonomic Version: Keys to Soil Taxonomy, 13th edition (2022)

Other: Gamma is pronounced Gaah-muh

Additional Data:

Partial laboratory data from pedon 89P0197, samples 89P1199-1202 from Any County, Anystate, is available from the NRCS-NSSC-Kellogg Soil Survey Laboratory, Lincoln, NE.

National Cooperative Soil Survey

U.S.A.

614.12 Explanation and Content of a Soil Series Description

A. Explanation of a Soil Series Description

After the introductory paragraph in semi-tabular or sentence format, the format for soil series descriptions arranges the subject matter in two main parts. The first part includes the taxonomic classification, description of the typical pedon, type location, range in characteristics, and competing series. This part and the description of the taxonomic features of the typical pedon in the “Remarks” section define the soil series as a class in the soil classification system. The second part includes the remaining sections of the soil series description, which provide additional descriptive information.

The guidelines for keying soil series descriptions are as follows:

- Left margin is in column 1. Right margin is in column 66.
- Tabs, stop codes, required hyphen codes, required backspace codes, automatic centering, and underlines are not used. The spacebar is used instead of tabs.
- Everything is left justified. The horizon designations do not need to be indented.
- Section headings are in title case, for example, “Taxonomic Class and Typical Pedon,” and are followed by a colon (:).
- The text under a section heading starts on the next line. It is solid and justified left.
- First-level sideheads use colons (:). Only the first letter of the sidehead is capitalized. The first letter of the first word after a colon is capitalized. Phrases following first-level sideheads start on the same line as the sidehead unless the sidehead is immediately followed by a second-level sidehead, in which case the second-level sidehead starts on the line below.
- Second-level sideheads use em dashes (—). Only the first letter of the sidehead is capitalized. The first word after an em dash is lowercase. Phrases following second-level sideheads start on the same line as the sidehead.

Note: The validation of descriptions with the SC/OSD Maintenance Tool will return error messages for unexpected headings unless attention is given to proper format.

- Depths and thickness (cm), temperature (whole degrees C), precipitation (mm), and elevation (m) are in metric units of measure; acreage and legal descriptions (longitude and latitude in decimal degrees with WGS84 as horizontal datum are preferred) are in English units. Temperature, precipitation, and elevation may be given in English units in parentheses after the metric units. General locations can be given in metric (m) units followed by English units (feet or miles) in parentheses.
- Special symbols, subscripts, and superscripts must be expressed as words. (For example: “10°” is changed to “10 degrees,” “CaCO₃” is changed to “calcium carbonate,” and “10%” is changed to “10 percent.”)
- The first 8 lines and the last line of the soil series description must be standardized for the validations of the SC/OSD maintenance tool to work. All entries are left justified and start in column 1.

The line-by-line instructions are as follows:

Line 1: LOCATION GAMMA NE (This line is entered in capital letters. The first letter of the state where the soil series is located must be in the 33rd character location starting from the leftmost side at the first character location. If other states are using the series, the first letter of the other state must be in the 36th character location. Any other states using the series follow in alphabetical order.)

Line 2: Blank line

Line 3: Tentative Series or Established Series (Note: Even series with inactive status are shown as such on this line.)

Line 4: Revised MLD-JRC [These are the initials of the individuals who last revised the soil series. The initials are separated by a hyphen (-) preferred, or a slash (/), or a comma (,).]

Line 5: 08/2012 (This is the two-digit month and four-digit year in which the official soil series description was last revised in the soil series classification database or in the official series description file share. The system enters this date automatically.)

Line 6: Blank line

Line 7: GAMMA SERIES (All letters are capitalized.)

Line 8: Blank line

Line 8 is followed by the introductory paragraph in semi-tabular or sentence format, and the rest of the soil series description.

Next to last line: National Cooperative Soil Survey

Last line: U.S.A. (All letters are capitalized and do not have spaces in between.)

The completed description must be run through a spell checker in word-processing software.

B. Content of a Soil Series Description

- (1) **Introduction.** This section carries no side heading. It briefly describes the depth, drainage class, soil parent materials, landforms, and any other significant features that characterize the soil series and the geomorphic setting. This information benefits people who refer to the official soil series descriptions but are not well acquainted with the taxonomic classification system. If used in the introduction, depth refers to depth to bedrock unless some other restrictive feature that is important to plants or engineering interpretations is specified. If a restrictive feature is at some depth within the soil profile, describe by such statements as “very shallow to sandstone or shale,” “very deep soils that have gravel layers at a depth of 15 to 100 cm (6 to 40 inches),” “moderately deep to rhyolite,” or “shallow to a duripan.” The temperature and precipitation are mean annual values for the soil series. Do not use the terminology in *Soil Taxonomy* in the introductory paragraph. Do not use hyphens in drainage classes (e.g., “well drained,” not “well-drained”).

Examples of the introduction are:

Depth class: Very deep

Drainage class: Poorly drained

Saturated hydraulic conductivity class: Moderately high

Parent material: Silty alluvium from loess and till
Geomorphic location: Flood plains and narrow drainageways
Slope range: 0 to 2 percent
Mean annual temperature: 10 degrees C (50 degrees F)
Mean annual precipitation: 710 millimeters (28 inches) at this type location

or

The Sigma series consists of very deep, well drained soils that formed in a thin deposit of loess overlying loamy till. Sigma soils are on moraines, drumlins, and till plains. Slope ranges from 0 to 25 percent. The mean annual precipitation is about 600 mm (24 inches), and the mean annual temperature is about 8 degrees C (46 degrees F).

or

The Beta series consists of very deep, very poorly drained soils in drainageways and depressions on moraines, lake plains, and outwash plains. These soils formed in highly decomposed organic material over loamy glacial and lacustrine deposits. The organic material was derived from herbaceous plants. Slope ranges from 0 to 2 percent. The mean annual precipitation is about 800 mm (31 inches), and the mean annual temperature is about 2 degrees C (36 degrees F).

- (2) **Taxonomic Class.** This statement gives the family classification. If the classification is questionable, explain it in the “Remarks” section.
- (3) **Typical Pedon.** Use the heading, as indicated. The soil series name and texture phase term or the word “series” are aligned left in solid text under the heading. Next are the aspect (if relevant), shape, and percent of slope, a word or phrase, such as “forested,” “pasture,” “cultivated field,” or other term, for use or cover that shows if the soil at the site has been disturbed, and elevation. Place a parenthetical statement to specify the moisture state of the soil when it was described. A statement is required to identify if the colors in the typical pedon are for moist or dry soil, unless otherwise stated. If the soil was nearly dry in the upper 60 cm and moist below, the statement, “When described, the soil was slightly moist above a depth of 60 cm and moderately moist below” is used.

An example of this statement is: “Gamma silt loam on a southeast-facing, concave, 3percent slope under mixed hardwoods at an elevation of 500 meters. (Colors are for moist soil unless otherwise stated. When described on July 1, 1985, the soil was slightly moist to a depth of 60 cm and moderately moist below that depth.)”

- (i) *Descriptions of horizons.* These descriptions are in sentence format. They ordinarily consist of three parts: the horizon designation, the horizon depths, and the detailed description of the observed horizon morphology.
- (ii) *Pedon described.* Describe an actual pedon. The pedon chosen as the typical pedon must reflect the norm for the soil series as closely as possible. The norm is the concept or mental image of the central nucleus of pedons for the soil series. The pedon may depart in minor ways from the norm without a need for explanation. If it departs from the norm in some obvious feature, however, indicate the departure in the range of characteristics and in the “Remarks” section of the description. Describe the typical pedon in its dominant land use. Describe the pedon to a depth that is at least equal to that for the series control section. Describe the relevant characteristics of Cr and R layers.

- (iii) *Horizon designations.* Identify horizons using the horizon designations defined in chapter 3 of the “Soil Survey Manual” and chapter 18 of the current edition of the “Keys to Soil Taxonomy.” Use an em dash after the horizon designation.
- (iv) *Depth of horizons.* Give the depths to the upper and lower boundaries of horizons in centimeters after the corresponding horizon designations. Insert a semicolon after “cm.” Use of the corresponding horizon depths in English units should not be included due to the potential confusion and errors in conversion. Use the soil surface, excluding live and fresh (i.e., undecomposed) leaves and twigs, as a reference plane for depth and thickness measurements for all mineral and organic soil horizons.
- (v) *Features described for most horizons.* These features are as follows:
 - Color (dry or moist, the most common condition)
 - Texture class (including texture modifiers for fragments and composition)
 - Color (dry or moist, opposite of the condition initially given)
 - Mottles (dry or moist colors given; not related to wetness)
 - Structure (no commas used to separate terms in the phrase that describes structure; the word “structure” used only once in describing compound structure, such as “weak coarse prismatic structure parting to moderate medium subangular blocky.”)
 - Consistence (dry, moist, stickiness, plasticity)
 - Roots
 - Pores
 - Additional features (examples shown in paragraph 614.12, B, (3), (viii) below)
 - Reaction
 - Lower boundary
 - Range in thickness
- (vi) *Sequence for describing features.* Describe the features of each horizon in the order listed above to make comparisons easier among horizons and among soil series. All features may not occur in every horizon.
- (vii) *Soil Color.* Give descriptions of colors, including Munsell notations, for individual horizons. Describe color by using Munsell notations to the nearest color chip. All surface horizons require both moist and dry colors. Other horizons require colors for both moist and dry conditions if the information is necessary for the classification of the soil series. Give moisture conditions for individual color identifications or for the whole pedon, as previously specified for the typical pedon. Most horizons have a dominant color that changes in value and, less commonly, in hue and chroma as the moisture content changes. See chapter 3 of the “Soil Survey Manual” for more information on dominant color. The color listed first represents the moisture content that is most often observed. In arid regions this is the color of dry soil, and in humid regions it is the color of moist soil. Identify the positions of individual colors unless they are obvious from the context. Do not use hyphens in soil color names (e.g., “yellowish brown,” not “yellowish-brown”).
- (viii) *Additional features.* List these features separately because they do not occur in all soils or horizons. Examples include the following (in random order):
 - Artifacts
 - Bioturbation (krotovinas, insect casts, wormcasts, etc.)
 - Cementation
 - Clay films and clay bridging
 - Concretions (from various cementing agents)
 - Cracks
 - Detached fragments of cemented genetic horizons (duripan, ironstone, petrocalcic, etc.)
 - Durinodes and opaline silica coats

- Fibers
- Gelic materials (involutions, ice lenses, ice wedges, etc.)
- Gypsum
- Hydrophobicity
- Identifiable secondary carbonates
- Lamellae
- Manner of failure (brittleness, fluidity, smeariness)
- Nodules (from various cementing agents)
- Odor
- Pararock fragments
- Pipes or tongues of other soil materials
- Plinthite
- Pressure faces (stress cutans)
- Reaction to indicator solutions (alpha, alpha-dipyridyl, HCl, H₂O₂, etc.)
- Redoximorphic features (concentrations, depletions, reduced matrix)
- Rock fragments
- Silt coats or films
- Skeletans
- Slickensides
- Stone lines
- Thin strata, laminae, or lenses
- Visible soluble salts
- Wood fragments

If such features are not mentioned in the description of a horizon, it is assumed they are absent. If these features are described, use the appropriate nomenclature as provided in Chapter 3 of the “Soil Survey Manual.”

- (ix) *Reaction*. Record reaction using the descriptive class terms listed in chapter 3 of the “Soil Survey Manual.” Give the pH value in parentheses following the descriptive terms. An example is “very strongly alkaline (pH 9.8 in 1:1 water)” or “very strongly acid (pH 4.8 in 1:2 0.01 M calcium chloride).”
- (x) *Range in thickness of individual horizons*. Although this range is part of the range in characteristics for the soil series, include it in parentheses with each horizon description in the typical pedon for convenience. It should follow the period at the end of the description. The combined thickness of subhorizons may be given instead.
- (xi) *Examples of descriptions of individual horizons*.
- a. A sequence of two horizons:

Oe1—0 to 20 cm; dark reddish brown (5YR 3/2) mucky peat, broken face hemic material, very dark brown (10YR 2/2) rubbed; about 60 percent fiber, 25 percent rubbed; massive; herbaceous fiber; about 15 percent mineral material; slightly acid (pH 6.5 in 1:2 0.01 M calcium chloride); abrupt smooth boundary.

Oe2—20 to 45 cm; very dark grayish brown (10YR 3/2) mucky peat, broken face and rubbed hemic material; about 40 percent fiber, 20 percent rubbed; massive; herbaceous fiber; about 35 percent mineral material; few small snail shells; strongly effervescent; slightly alkaline (pH 7.6 in 1:2 0.01 M calcium chloride); abrupt smooth boundary. (Combined thickness of the Oe horizons is 15 to 50 cm)

b. A sequence of three horizons:

E—2 to 25 cm; very pale brown (10YR 7/3) loam, light yellowish brown (2.5Y 6/4) moist; weak thin platy structure; soft, very friable, slightly sticky, nonplastic; few fine roots; few very fine pores; few fine black and dark brown concretions; 2 percent cobbles; slightly acid (pH 6.4 in 1:1 water); clear smooth boundary. (15 to 30 cm thick)

Bt1—25 to 50 cm; grayish brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) moist; strong coarse columnar structure; extremely hard, firm, moderately sticky and moderately plastic; common fine roots; many very fine vesicular pores in clean silt caps about 2.5 cm thick on tops of soil columns and many very fine tubular pores immediately below caps; few medium pores in lower part of columns; many distinct very dark brown (10YR 2/2) clay films on vertical faces of peds; common dark stains and clean sand grains on vertical faces of peds; slightly alkaline (pH 7.8 in 1:1 water); clear wavy boundary. (18 to 56 cm thick)

2Bt2—50 to 75 cm; olive (5Y 5/3) silty clay loam; moderate fine subangular blocky structure; hard, firm, moderately sticky and moderately plastic; few fine tubular pores; common fine faint brown (10YR 5/3) and many fine prominent yellowish brown (10YR 5/8) masses of oxidized iron; common fine prominent gray (10YR 5/1) iron depletions; common distinct very dark grayish brown (2.5Y 3/2) clay films on surfaces along pores and on all faces of peds; thin black (5Y 2/1) flecks inside peds; slightly acid (pH 6.5 in 1:1 water); gradual wavy boundary. (15 to 35 cm thick)

c. A single horizon:

Cg3—125 to 150 cm; gray (10YR 5/1) silty clay loam; massive, hard, firm, moderately sticky and slightly plastic; few fine roots; few fine tubular pores; few medium distinct pale brown (10YR 6/3) masses of oxidized iron; common medium distinct black (10YR 2/1) manganese concretions and masses; common prominent reddish brown (5YR4/4) masses of oxidized iron on surfaces along root channels; moderately acid; gradual smooth boundary.

(xii) *General guidance for preparing pedon descriptions.*

- a. Use “few,” “common,” or “many” for classes of numbers of redoximorphic features, roots, pores, and concentrations. Refer to chapter 3 of the “Soil Survey Manual” for a definition of the terms that apply to each of the features. Express rock fragments, pararock fragments, wood fragments, and artifacts as a percentage of the volume on a whole soil base.
- b. Use “uncoated” or “clean silt and sand grains” rather than “bleached silt and sand” or “grainy coats.”
- c. “Ped” is the preferred terminology for a natural structural unit. Clods and fragments result from tillage or cultural practices. The term “aggregate” is confusing because it has many different meanings. Use the expression “faces of peds” and not “ped faces.”
- d. Avoid expressions such as “weak to moderate” for grade of structure (or other property). Use “weak and moderate” if two grades of structure are present. If peds separate to form smaller peds, use the verbs “parting” or “separating” to describe the formation of secondary peds. In contrast to a complete ped, a fragment of a ped has fracture surfaces rather than natural faces. The zero grade of structure (structureless) is single grain or massive. Do not use the term “structureless” because it is redundant if used with “massive” or “single grain.” Do not give a type of structure with either massive or single grain. Soil material of single grains does not have structure. Very fine or fine grade granular peds cannot be described as single grain. In addition, single grain soil material has a loose rupture resistance class.

- e. Do not use hyphens in the class names for stickiness and plasticity. For example, “nonsticky” (not “non-sticky”) is the correct spelling of the class name.
- f. By definition, concretions are coherent. Thus, the phrase “soft lime concretions” is not correct. Use “calcium carbonate masses” or “calcium carbonate concretions” if coherent, or some other appropriate description. Use “extremely weakly coherent iron masses” or, if coherent, describe it as “weakly coherent iron concretions.”
- g. Carbonates commonly are criteria used to separate soil series. Carbonates may be present in segregated forms or disseminated in parts of the mass or throughout the mass. Soil series descriptions must specify the kind and distribution of carbonates within horizons.

The degree of effervescence after the soil is treated with 1N hydrochloric acid is described as very slightly, slightly, strongly, and violently effervescent. The degree of effervescence is related to the surface area of the carbonate minerals and to the kinds of minerals rather than to the total carbonate content. Thus, effervescence is not a reliable basis for estimating the amount of carbonates. A small amount of finely divided carbonates can produce a violent effervescence for a short time. Field tests for estimating the amount of carbonates in a soil are available. Record the content in parentheses after the degree of effervescence, such as “strongly effervescent (8 percent calcium carbonate equivalent).” Estimate carbonates to the nearest 1 percent if the content is less than 20 percent and to the nearest 5 percent if it is more than 20 percent. An example is “slightly effervescent (2 percent calcium carbonate equivalent); slightly alkaline (pH 7.6 in 1:1 water).”

- h. If E and Bt horizons are described, parts that refer to each horizon are indicated as follows:
E and Bt—95 to 145 cm; yellowish brown (10YR 5/4) fine sand (E); single grain; loose; lamellae and bands of dark brown (7.5YR 4/4) fine sandy loam (Bt); coarse subangular blocky structure in thicker bands; friable; wavy and discontinuous 2- to 4-cm-thick lamellae in upper part and bands 5 cm thick in lower part; moderately acid (pH 5.8 in 1:1 water); gradual wavy boundary. (40 to 75 cm thick)
- i. Neutral colors are written like “gray (N 5/).” The hue is neutral (N) if the chroma is zero. The character (0) is not used.
- j. Do not place a plus sign after the last stated depth in the profile description. The last stated depth is the depth to which the profile was examined.
- k. Chapter 3 of the “Soil Survey Manual” and chapter 18 of the of the “Keys to Soil Taxonomy” provide guidance and conventions on the designations used for horizons and layers.
- l. Indicate the range in thickness of horizons as follows:
 - The thickness of horizons that have two or more subhorizons can be combined. Note the range in thickness after the last subhorizon. For example, “The combined thickness of the Bw horizons is 50 to 75 cm.”
 - The thickness of horizons that are not essential to the classification and are not in all profiles is expressed as zero to an appropriate number of centimeters. For example, “0 to 60 cm thick.”

- (4) **Type Location.** This is the specific location where the typical pedon for the OSD was described. It includes only the county, parish, borough, or census area and State; USGS Quadrangle name; WGS84 latitude and longitude in decimal degrees; and a narrative description of the pedon location. The narrative and the latitude and longitude information must place the location in the correct county, parish, borough, or census area and State. The location information on the OSD must be the same in NASIS.

The county and State names are given first: for example, “Lucky County, Nebraska.” The narrative statement of the location is listed after the county and State information. If the area is part of the Public Land Survey System (PLSS), then you must use the PLSS to describe the location. Metric and English units are used. For example, “about 27 meters (90 feet) west and 9 meters (30 feet) south of the northeast corner of sec. 7, T. 12 N., R. 26 W.”

If describing the location in an area that is not part of the PLSS, use the distance from permanent landmarks or traveling on roads between landmarks. Metric and English units are used: for example, “Travis County, Texas; from the intersection of Farm Road 973 and U.S. Highway 290 in Manor, approximately 5.6 kilometers (3.5 miles) east on U.S. Highway 290, 3.9 kilometers (2.4 miles) northeast on Farm Road 1100, 1.6 kilometers (1.0 mile) northwest and 4.8 kilometers (3.0 miles) northeast on Manda Road, 0.8 kilometers (0.5 mile) southeast on Lund Road, 274 meters (900 feet) southwest on field road, 32 meters (105 feet) east in pastureland.”

The WGS84 latitude and longitude coordinates in decimal degrees are included last, after the narrative description. Always use 7 decimal places right of the decimal. If your coordinates have less than 7 decimal places, extend the values with zeros. For example, if the coordinate is -112.5476, enter “-112.5476000.” Always ensure the correct use of the negative sign. Most longitude values on OSDs will be negative and most latitude values will be positive. The source of the coordinates must be recorded. If you do not know how the coordinates were recorded, enter “Unknown.” Other options include, but are not limited to, “Hand-held GPS,” “Estimated from PLSS location,” “Estimated from non-PLSS location.”

Only WGS84 latitude and longitude in decimal degrees are allowed. If there is a unique need for retaining historic, alternate coordinates information, such as UTM or degrees minutes seconds, include that information in the Remarks section.

Example:

Lucky County, Nebraska; about 16.1 kilometers (10 miles) and 11.3 kilometers (7 miles) east of Eden; 27 meters (90 feet) west and 9 meters (30 feet) south of the northeast corner of sec. 7, T. 12 N., R. 26 W.

USGS Quadrangle: Brainard

Latitude: 32.6830080

Longitude: -96.5158030

Datum: GS84

Coordinates source: Hand-held GPS

- (5) **Range in Characteristics.** This section defines observed ranges in soil properties for the soil series class. Emphasis should be on properties that are definitive for the soil series or that affect use and management. As much as practical, give quantitative limits for the ranges in properties. The ranges specified must fall within the ranges of the family in which the soil series is classified. If the allowable range of a given property coincides with the range of the family or a higher category, the range does not have to be repeated in the description because it is implied by the classification given. If a range in a soil series property commonly is narrower than the range for the family class, give the narrower range. The ranges given are those that are limiting for the soil series and do not extend to taxadjuncts. Limit the recorded ranges to those that have been observed in the field or determined in the laboratory. Record assumed properties in the “Remarks” paragraph.

A standard arrangement of information in this section makes comparisons among soil series easier. Both semi-tabular (preferred) and sentence formats are acceptable. The arrangement first presents information on the soil as a whole and then on the major individual horizons.

Enter numerical values for ranges after using the conventional rules for rounding shown in section 614.13. Significant digits for soil properties used in taxonomic classification, such as percent clay content, are shown in section 614.14.

(i) *First section.*

Include general pedon features that apply to the soil as a whole rather than to individual horizons. Present such features as the thickness of the subsoil, depth to bedrock, depth to a fragipan, stoniness, mineralogy, range in soil temperature, and frequency and duration of periods when soil moisture is at or below the wilting point. Information that has been obtained through direct observations or that can be reliably inferred is recorded.

- a. Use terms for diagnostic horizons or features in this section. Specify their relationship to the horizons and subhorizons of the typical pedon.
- b. Paralithic and lithic contacts, as defined in “Soil Taxonomy,” form the boundary between soil and paralithic materials and coherent underlying materials, respectively. Paralithic materials can be used to differentiate soil series if the materials are within the series control section. Refer to chapter 17 in “Keys to Soil Taxonomy” for the key to control section for the differentiation of series. The properties of materials below the lithic contact cannot be used to differentiate soil series but can be considered as a basis for phase distinctions. Thus, soil series must not be defined as or differentiated from competing series by having a “paralithic contact over a lithic contact,” for example. If paralithic materials become harder and more coherent with depth, this fact can be stated in the “Range in Characteristics” section.
- c. Characteristics should be presented in the first and subsequent paragraphs in a semi-tabular (preferred) or sentence format. Only metric units are used.

(ii) *Second section.*

Describe each major horizon of mineral soils separately. Start each horizon on a new line with a blank line in between. Use tiers or combinations of similar layers for organic soils.

- a. The horizons covered in the subsequent paragraphs are the major ones described and are significant to the definition of the soil series. Discuss the ranges in soil properties in the same order as they are listed in the typical pedon description.
- b. Subdivisions of major horizons may be helpful for some soil series. The sequence begins with the uppermost horizon in the pedon and continues downward.
- c. List the most common range of a soil characteristic before giving the complete range. For example, “The A horizon commonly is loamy sand and less commonly is loamy fine sand, fine sand, or fine sandy loam” or “The A horizon is most commonly sand, but the range includes fine sand and loamy sand.”
- d. If there is no known range of a particular characteristic, repeat the information provided in the typical pedon for clarification and ease of comparison.
- e. Preferred expressions:
 - “Typically” or “in some pedons” rather than “frequently” or “occasionally”
 - “Some pedons” rather than “some places” (for example, “The lower part of the fragipan in some pedons has evidence of illuviation”)
 - “Do not have” rather than “lack”
 - “Is” or “are” rather than “may be”
 - “2C horizon” rather than “2C material”

- “Bedrock” rather than “R layer”
- “BC horizon” rather than “BC”
- “Some pedons do not have a BC horizon” rather than “the BC horizon may be missing”
- “The upper part of the B horizon” rather than “the upper B horizon”
- “Interfingering of albic materials into the Bt horizon” rather than “interfingering of the albic horizon into the argillic horizon”
- “A thin stone line is at the boundary between the two materials” rather than “a thin stone line separates the two materials”

- (6) **Competing Series.** This section discusses the distinctions between the soil series being described and its major taxonomic competitors. It lists all the soil series of the same family and gives the principal differentiating characteristics that set them apart from the series being described. Because the properties that govern the classification of the soil series being described have already been stated, this section emphasizes those features that distinguish it from the competing series. The comparisons are as specific and quantitative as available information warrants. Comparisons may include reference to diagnostic horizons and other features.

List all soil series (tentative and established) in the same family in alphabetical order followed by a colon. For example, “These are the Alpha and Beta soils:” and then individually state the differentiating characteristics for soil series on separate lines in the order of listing unless some can be grouped together and differentiated. If no soil series are in the same family, list series that are in similar families and their differentiating characteristics.

- (i) Features that are used to differentiate or group soils include but are not limited to:
- a. The presence or absence of a diagnostic horizon or feature
 - b. The texture in some part of the series control section (the range is given in percent of soil separates)
 - c. Carbonates above or within a specified depth
 - d. Depth to a lithic or paralithic contact
 - e. Content or type of fragments in the soils
 - f. Colors that are redder or yellower than a specified hue
 - g. Redoximorphic features that have low chroma within a specified depth
 - h. Soil temperature differences
 - i. The thickness of the subsoil
 - j. The thickness of the epipedon
 - k. Soil moisture differences
 - l. Reaction in the series control section
- (ii) In selecting preferred expressions, change:
- a. “Thicker darker surface horizon” to “Gamma soils have a mollic epipedon” when indicating that a soil has a mollic epipedon
 - b. “Light colored surface” to “Gamma soils have an ochric epipedon” when distinguishing a soil that does not have a mollic epipedon
 - c. “Lower subsoil” to “lower part of the subsoil”
 - d. “Are redder” to “have hue redder than 10YR”
 - e. “Soils lack argillic horizons” to “soils do not have an argillic horizon”
 - f. “Soils have higher organic matter” to “soils contain more than __ percent organic matter”
 - g. “Have siltier textures in the upper subsoil” to “contain more than __ percent silt in the upper part of the subsoil”
 - h. “Lower value” to “colors of lower value than”

- i. “Moist value” to “moist color value”
- j. “Small proportion” to “small part”
- k. “Have up to and including 10 cm” to “have as much as 10 cm”
- l. “Strongly developed horizons” to “strongly expressed horizons”
- m. “Gamma soils have argillic horizons with fine-silty textures” to “Gamma soils have a fine-silty particle-size class in the argillic horizon”

(7) **Geographic Setting.** The items in this section should be presented in semi-tabular format and include landscapes, landforms, relief, nature of regolith, climate, and any other features that are especially helpful in identifying the soil series. Indicate the names of the landforms and the range in slope gradient, kind of slope, and, if significant, aspect. Record landscape features that mark areas of the soils, such as common outcrops of rock, an erosional surface, or a depositional surface.

- (i) Briefly describe the nature of the regolith in which the soils formed. Also list underlying rock if significant to the formation of the series or if the rock influences the landscape. The purpose of this statement is to characterize the regolith to aid in identifying the soils rather than to define the soil series in the terms of underlying rock and mode of accumulation of the regolith.

Characterize climate in terms of temperature, precipitation, and indices. For example, express PE index as a range for the soil series. Only use indices that have been defined in widely available publications. Give information on climate in the descriptions of soil series. Give the range of the number of mean annual temperature (in degrees C) and mean annual precipitation (in millimeters). Also give the range of numbers for the frost-free period (in days), if pertinent. The statements should apply to the geographic setting and not to the information on soil temperature and soil moisture that is given in the range in characteristics section. If pertinent, give the range of elevation (in meters).

- (ii) Preferred expressions include:
 - a. “Gamma soils are nearly level” rather than “Gamma soils occur on nearly level”
 - b. “The soil formed in calcareous” rather than “The soil developed in calcareous”
 - c. “Mean annual temperature” rather than “Mean annual air temperature”

(8) **Geographically Associated Soils.** This section uses the same format as the “Competing Soils” section. List the geographically associated soils to inform users of the names of soil series in the same locality. List the geographically associated soil series followed by a colon. For example, “These are the Alcester, Judson, Aowa, and Colo soils:” and then include a brief comment to distinguish each soil from the series being described on separate lines. Relate the landscape positions of the associated soil series. The comments do not clearly differentiate soil series but rather highlight major distinctions. Do not repeat the differentiae that are used in the section on competing soil series. A preferred expression for “associated landscapes” is “nearby landscapes.”

(9) **Drainage and Saturated Hydraulic Conductivity.** In semi-tabular format or sentence format, give the soil drainage class for each soil series. Drainage is usually assigned as a single drainage class, or occasionally, two drainage classes. For some soil series, include segments of two adjacent drainage classes. Give the sequence of soil water states in addition to drainage class if it is a more useful way to record moisture regimes. Also include the characterization of saturated hydraulic conductivity in this section. Consider saturated hydraulic conductivity to a depth of 180 cm or to bedrock and describe it according to major changes, for example, “high in the upper part and moderately low in the lower part.” Always cite very high saturated hydraulic conductivity in the lower part of the profile. Surface runoff may be given in this section, but it is not required. If it is important, describe run-on moisture in this section. If needed, also give statements about type and depths of saturation, flooding, and ponding. Avoid expressions such as “well drained to moderately well drained.” Instead use “well drained or moderately well

drained” or “well drained and moderately well drained.” Do not assign more than two drainage classes to a soil series.

Example of semi-tabular format:

Drainage class: Poorly drained

Saturated hydraulic conductivity: Moderately high

Flooding: Occasionally or frequently flooded for brief periods from March to July

Seasonal high water table: Ranges from 0.15 to 0.46 meters (0.5 to 1.5 feet) below the surface at some time between November and May in normal years

Examples of sentence format:

- Well drained; moderately high saturated hydraulic conductivity.
- The soils are moderately well drained and have moderately low saturated hydraulic conductivity. They are flooded for brief periods in early spring.
- The soils are well drained. Runoff is medium on the gentle slopes and high on the steeper slopes. Saturated hydraulic conductivity is moderately high in the subsoil and low in the underlying material.

- (10) **Use and Vegetation.** In sentence format, list the major uses of the soil series in this section. If soils are used for crops, pasture, or forests or for urban or other uses, indicate the uses as well as the general extent of each, if known. Do not discuss productivity levels, yields, limitations, or hazards. When describing native vegetation, limit the list to a maximum of 3 to 5 dominate or characteristic species. If the kind of native vegetation is uncertain and no longer important because of current use, do not describe the vegetation. Do not include references to ecological sites.

There are four ways to identify a plant: the scientific name, symbol, National Vernacular Name (USDA Plants Common Name), and local plant name. The first three are maintained in the USDA PLANTS database. The local plant name, if given, should exist in the NASIS database.

Vegetation should be specified using the national plant symbols from the USDA PLANTS database with the National Vernacular (USDA Plants common name) and other local plant names in parenthesis. Example: AGNA Navasota false foxglove, GAPU Indian blanket (firewheel). Site specific plant lists for States should be placed in the “Remarks” section.

A preferred expression for “Soils are under cultivation with corn and wheat, the principal crops” is “Soils are cultivated. Corn and wheat are the principal crops.”

- (11) **Distribution and Extent.** This section is used to provide more information on the distribution of the series by States, MLRAs, or both. If State information is given, use the complete spelling of State names. Indicate the extent of the soil series using one of three classes given below. Use either the substantive or adjective forms of the name, depending on which is more appropriate for the text.

The terms and the extent ranges are as follows:

- Small extent or not extensive—less than 10,000 acres
- Moderate extent or moderately extensive—10,000 to 100,000 acres
- Large extent or extensive—more than 100,000 acres

Supplement the designation of classes for soil series with extent figures when the soil series is not extensive and when the soil series is of large extent. Some examples:

- “The soils of this series are not extensive; their total extent is about 6,000 acres”
- “These soils are extensive, with about 214,000 acres of the series mapped”

- (12) **Soil Survey Regional Office (SSR) Responsible.** Use this heading to indicate which SSR has responsibility for maintenance of the OSD. Check the entry against a like entry in the Soil Classification (SC) database at the time of updating. It must match the entry in the SC database

- for update of the series description to proceed. The format of the entry should look like:
Portland, Oregon. The entries must be spelled correctly and must exactly match one of the 12 SSRs. This entry will be automatically changed to match the corresponding entry in the SC database when responsibility for the series is transferred. Responsibility is transferred by revising the entry in the “Responsible SSR” field in the SC part of the SC/OSD Maintenance Tool.
- (13) **Series Proposed or Series Established.** Use one of these headings, depending on the current status of the series. For tentative series, the place where the soil series was proposed and the date when the series received tentative status go under the heading “Series Proposed.” For established soil series, the place and date of establishment go under the heading “Series Established.” Give the names of the county and State and the year in which a soil series received tentative status or was established. If the survey area is a geographical or political subdivision other than a county, include the name of that subdivision. Give the source of the name for a soil series in the first description of a newly proposed series. A revised description does not need to include the source of the name if it has been recorded in an earlier description.
- (14) **Remarks.** List the typical pedon taxonomic features needed to classify and characterize the series. Restrict other remarks to those that can help in identifying soils of the soil series as it is currently conceived. For example, a proposal of a new soil series for soils originally from an already established series can be included in the “Remarks” section of the description of the new series. List any unresolved problem with defining the soil series or with differentiating it from others, or its status (active or inactive). Do not list laboratory data in this section. Include series pronunciation when it cannot be commonly predicted by a user and the taxonomic version in the last two lines. Example: “Kezan is pronounced Kee-zan. Taxonomic Version—Keys to Soil Taxonomy, 13th edition (2022).”
- (15) **Additional Data.** This section is optional. It lists sources of data, including pedons in the NCSS soil characterization database, study thesis information, data from State laboratories, and advance copies of data from unpublished soil survey investigations reports that were used in defining properties of the soil series. This section is intended to provide a reference to sources of additional information and should not be used to reproduce data that is best accessed from the source. Do not include copies of the Soil Interpretation Records or data tables from NASIS components.

614.13 Rounding Numbers from Laboratory Data

Analytical data on soils will often be reported by laboratories using levels of precision that do not match the precision level of the criteria used in Soil Taxonomy (ST). For example, ST requires using percentages for clay content in whole numbers (integers) when applying criteria such as the required characteristics of the argillic horizon and the key to particle-size classes. However, primary characterization data supplied from the NSSC Kellogg Soil Survey Laboratory reports clay content (by weight) in tenths of a percent (one decimal place).

When evaluating numerical data to determine if the critical values used in ST are met, you must round the numbers to the same number of digits as used in the criteria. So if critical limits for percent clay are presented as whole numbers in a particular criteria, then weighted average clay contents must be rounded to a whole number. However, when using a series of numbers in a calculation (for example, when calculating a weighted average clay percentage for the particle-size control section), only round the final result, not the individual values used in the calculation. The conventional rules for rounding numbers are as follows:

- A. If the digit immediately to the right of the last significant figure is more than 5, round up to the next higher digit.
Example: 34.8 rounds to 35 (Round up because the digit to be dropped is more than halfway between 34 and 35.)
- B. If the digit immediately to the right of the last significant figure is less than 5, round down to the next lower digit.
Example: 34.4 rounds to 34 (Round down because the digit to be dropped is less than halfway between 34 and 35.)
- C. If the digit immediately to the right of the last significant figure is equal to 5, round to the adjacent even number, either up or down.
Example: 17.5 rounds to 18 (Round up because the result is an even number.)
Example: 34.5 rounds to 34 (Round down because the result is an even number.)

614.14 Significant Digits for Soil Property or Quality Measurements Used as Criteria in Soil Taxonomy

(This exhibit references items in the 12th edition of the “Keys to Soil Taxonomy,” (2014). In the third column, information in brackets indicates the location of specific information under each item)

Measurement of soil property or quality (units)	Significant digit used in Soil Taxonomy	Taxonomic criteria and taxa in Soil Taxonomy [item code]
Al plus ½ Fe content, by ammonium oxalate (%)	Tenths (0.1)	Required characteristics for Andic soil properties [2.c and 3.c]; Andic (except Kandic), Aquandic, and Vitr subgroups
Al plus ½ Fe content, by ammonium oxalate (%)	Hundredths (0.01)	Definition of spodic materials [2.b.3]; Spodic subgroups of Entisols, Gelisols, Inceptisols, and Ultisols
Anhydrite content (% by weight)	Whole number (0)	Required characteristics for Anhydritic horizon [2]; Anhydritic [C.1] mineralogy class
Base saturation, by NH ₄ OAc at pH 7 (%)	Whole number (0)	Required characteristics for mollic [4] and umbric [4] epipedons; Key to soil orders [I.2]; Xerollic, Ustollic, Mollic, and Eutric subgroups of Alfisols; Dystric and Humaqueptic subgroups of Entisols; Humic subgroups of Aquepts; Eutric subgroups of Inceptisols; Dystric (“Dystr”) and Eutric (“Eutr”) great groups of Inceptisols; Eutric (“Eutr”) great groups and subgroups of Oxisols
Base saturation, by sum of cations at pH 8.2 (%)	Whole number (0)	Key to soil orders [H.1. and H.2.b]; Ultic subgroups of Alfisols, Andisols, and Mollisols; Some Alfic [KFFT] and Dystric subgroups [KDEU] of Inceptisols; Alfic subgroups of Spodosols

Measurement of soil property or quality (units)	Significant digit used in Soil Taxonomy	Taxonomic criteria and taxa in Soil Taxonomy [item code]
Bulk density, moist (g/cm ³)	Tenths (0.1)	Definitions of mineral and organic soils; Required characteristics for folistic and histic epipedons [1.a]; Key to soil orders [B.2.d]
Bulk density, at 33 kPa (g/cm ³)	Hundredths (0.01)	Required characteristics for andic soil properties [2.a]
Bulk density, at 33 kPa (g/cm ³)	Tenths (0.1)	“Andic” (except Kandic), Aquandic, and Vitrandic (“Vitr”) subgroups
Calcium carbonate equivalent (%)	Whole number (0)	Required characteristics for the mollic epipedon [3.b and 3.c], calcic horizon [2], and sulfidic materials [2]; Rendolls suborder [IC.3]; Rendollic Eutrudepts subgroup [KFES]; carbonatic mineralogy class [C.3]
Cation-exchange capacity, by 1N NH ₄ OAc pH 7 (cmol(+)/kg clay)	Whole number (0)	Required characteristics for kandic [5] and oxic [6] horizons; Kandic and Kanhaplic subgroups of Alfisols and Ultisols; Udoxic and Ustoxic subgroups of Quartzipsamments; Oxic subgroups of Inceptisols and Mollisols
Cation-exchange capacity (cmol(+)/kg organic matter, measured by loss on ignition)	Whole number (0)	Definitions of coprogenous earth and diatomaceous earth

Measurement of soil property or quality (units)	Significant digit used in Soil Taxonomy	Taxonomic criteria and taxa in Soil Taxonomy [item code]
Clay content (% by weight)	Whole number (0)	Definition of mineral soil material; required characteristics for the folistic and histic epipedons; required characteristics for the argillic, calcic, kandic, natric, and oxic horizons; required characteristics for the abrupt textural change; required characteristics for lamellae; key to soil orders [E.2, F.2, and K.2.a]; Kandi and Pale great groups; Albaquic, Abruptic, and some Haplic subgroups of Alfisols; Abruptic subgroups of Aridisols; Hydric (Hydr) great groups and Haplic, Hydric, and Grossic subgroups of Entisols; Hydr subgroups of Inceptisols; Abruptic, Pale, and Haplic Palexerolls subgroups of Mollisols; Glossaquic Fragiudults [HCBC.1.c] and Haplic Plinthustults [HDAA.2] subgroups; Entic subgroups of Vertisols; key to particle-size classes of mineral soils and of Histosols and Histels; strongly contrasting particle-size classes no. 20, 21, 29, 32, and 47
Effective cation-exchange capacity, by 1N NH ₄ OAc pH 7 plus 1N KCl-extractable Al (cmol(+)/kg clay)	Whole number (0)	Required characteristics for kandic [5] and oxic [6] horizons
Effective cation-exchange capacity (cmol(+)/kg clay)	Hundredths (0.01)	Acric (Acr) great groups of Oxisols
Effective cation-exchange capacity, by 1N NH ₄ OAc pH 7 plus 1N KCl-extractable Al (cmol(+)/kg clay)	Tenths (0.1)	Acric (Acr) subgroups of Ultisols
Electrical conductivity, in the extract from a saturated paste (dS/m)	Whole number (0)	Required characteristics for salic horizon; Halic subgroups of Vertisols
Electrical conductivity, in the extract from a saturated paste (dS/m)	Tenths (0.1)	Dystic (Dystr) great groups of Vertisols
Electrical conductivity, in 1:1 mixture of soil and water (dS/m)	Whole number (0)	Halic subgroups of Haplosaprists

Measurement of soil property or quality (units)	Significant digit used in Soil Taxonomy	Taxonomic criteria and taxa in Soil Taxonomy [item code]
Electrical conductivity, in 1:5 mixture of soil and water (dS/m)	Tenths (0.1)	Frasiwassists [BBA.] and Frasiwassents [LAA.] great groups
Exchangeable magnesium plus sodium greater than calcium plus extractable acidity at pH 8.2 (cmol(+)/kg fine-earth fraction)	Tenths (0.1)	Required characteristics for natric horizon [5.b]; Albic subgroups of Natraqualfs
Exchangeable sodium percentage, or ESP (%)	Whole number (0)	Required characteristics for natric horizon [5]; key to soil orders [K.2.b(3)]; Albic subgroups of Natraqualfs; Natric subgroups of Alfisols; Sodic subgroups of Aridisols, Entisols, Inceptisols, and Vertisols; Haplic (Hapl) subgroups of Natrustalfs and Natrargids; key to suborders of Inceptisols [KA.2] and Mollisols [IB.2]; Halaquepts great group [KAC.2]
Extractable Al^{3+} , by 1N KCl (cmol(+)/kg fine-earth fraction)	Tenths (0.1)	Alic and some Eutric subgroups of Andisols
Extractable Fe_2O_3 , by dithionite-citrate (% by weight)	Whole number (0)	Aquic conditions [1.c.(2)(c)]; ferritic [A.1 and C.4], ferruginous [A.4], and sesquic [A.3.a] mineralogy classes; ferrihumic soil material
Extractable Fe_2O_3 , by dithionite-citrate (% by weight)	Tenths (0.1)	Parasesquic mineralogy class [D.1 and E.2]
Extractable iron, by ammonium acetate (%)	Hundredths (0.01)	Alaquods [CAB] and Alorthods [CED] great groups; Amorphic [B.2] and ferrihydritic [B.3] mineralogy classes
Extractable silicon, by ammonium acetate (%)	Hundredths (0.01)	Amorphic [B.2] and ferrihydritic [B.3] mineralogy classes
Fiber content, after rubbing (% by volume)	Whole number (0)	Definitions of kinds (fibric, hemic, sapric) of organic soil materials
Gibbsite content (% by weight)	Whole number (0)	Gibbsitic [A.2 and C.5], sesquic [A.3.b], allitic [A.5], and parasesquic [D.1 and E.2] mineralogy classes

Measurement of soil property or quality (units)	Significant digit used in Soil Taxonomy	Taxonomic criteria and taxa in Soil Taxonomy [item code]
Gypsum content (% by weight)	Whole number (0)	Required characteristics for gypsic [3] and petrogypsic [4] horizons; gypseous substitute classes [B.4]; strongly contrasting particle-size classes no. 17, 42, 43, and 49; gypsifactic human-altered and human-transported material class [A.4]; hypergypsic [B.1], gypsic [C.2], and carbonatic [C.3] mineralogy classes
Linear extensibility (cm)	Tenths (0.1)	Vertic (Ertic) subgroups
Melanic index (ratio)	Hundredths (0.01)	Required characteristics for melanic epipedon [2.c]
Mica content (% by grain count)	Whole number (0)	Micaceous mineralogy class [E.1]
Nitrate concentration, in 1:5 extract of soil and water (mmol(-)/L)	Whole number (0)	Nitric subgroups of Gelisols
<i>n</i> value	Tenths (0.1)	Required characteristics for anthropic, mollic, and umbric epipedons; definitions of <i>n</i> value and manner of failure classes; key to soil orders [K.2.a]; key to great groups of Aquents [LBB] and Wassents [LAD]; Haplic Sulfaquents [LBAA.1], Hydric Frasiwassents [LAAA], Grossic Hydrowassents [LADB], and Haplic Sulfiwassents [LACB.1] subgroups of Entisols; Hydraquentic Humaquepts [KAHA.1] and Hydraquentic Sulfaquepts [KAAB] subgroups of Inceptisols
Optical density of oxalate extract	Hundredths (0.01)	Definition of spodic materials [2.b.(4)]; Spodic subgroups of Entisols, Gelisols, Inceptisols, and Ultisols
Organic-carbon content (kg/m ²)	Whole number (0)	Humic subgroups of Oxisols; Humults suborder [HB.2]; Humicryerts great group [FBA]
Organic-carbon content (% by weight)	Whole number (0)	Mineral soil material; required characteristics for folistic, histic, and melanic epipedons; required characteristics for andic soil properties [1]

Measurement of soil property or quality (units)	Significant digit used in Soil Taxonomy	Taxonomic criteria and taxa in Soil Taxonomy [item code]
Organic-carbon content (% by weight)	Tenths (0.1)	Required characteristics for mollic, plaggén, and umbric epipedons; definition of spodic materials [1]; Fluvents [LD.3.a], Humods [CD], and Humults [HB.1] suborders; Mollic subgroups of Haploxeralfs and Palexeralfs; Pachic and Thaptic subgroups of Andisols; Fluv great groups of Entisols; Humic great groups (Humi) and Humic and Entic subgroups of Spodosols; some Cumulic subgroups and many Fluv subgroups
Particles 0.02 to 2.0 mm in diameter (% by weight)	Whole number (0)	Required characteristics for andic soil properties [3.a]; description of resistant minerals, volcanic glass content, and weatherable minerals; Aquandic and Vitrandic (Vitr) subgroups; key to particle-size classes [B.1.b]; siliceous mineralogy class [E.4]
Percentage of clay (2.5[% water at 1500 kPa tension - % OC])	Whole number (0)	Required characteristics for kandic horizon [5]; key to particle-size classes [section C]; cation-exchange activity classes
Percentage of clay (3[% water at 1500 kPa tension - % OC])	Whole number (0)	Required characteristics for oxic horizon [6]; Torroxic [IGGK] and Oxic [IGGL] subgroups of Haplustolls
pH, in ratio of 1:2 soil and 0.01M CaCl ₂ solution (pH units)	Tenths (0.1)	Dystric (“dystr”) great groups of Vertisols; key to calcareous and reaction classes
pH, on undried samples, in a ratio of 1:2 soil and 0.01 M CaCl ₂ solution (pH units)	Tenths (0.1)	Key to reaction classes for Histosols and Histels
pH, by 1N KCl (pH units)	Tenths (0.1)	Acric (“acr”) great groups and Anionic subgroups of Oxisols
pH, in suspension of 1 g soil and 50 ml 1M NaF (pH units)	Tenths (0.1)	Isotonic mineralogy class [D.2.f.(2) and E.3.b]

Measurement of soil property or quality (units)	Significant digit used in Soil Taxonomy	Taxonomic criteria and taxa in Soil Taxonomy [item code]
pH, in ratio of 1:1 soil and water (pH units)	Tenths (0.1)	Definition of spodic materials [1]; required characteristics for sulfidic materials; Sulfic subgroups of Entisols and Inceptisols; Anionic subgroups of Oxisols; Sulfaqueptic Dystraquepts subgroup [FAFA]
pH, in saturated paste (pH units)	Tenths (0.1)	Dystrusterts [FEA] and Dystruderts [FFA] great groups
Phosphate retention (%)	Whole number (0)	Required characteristics for andic soil properties [2.b and 3.b]
Positive water potential at the soil surface (hours of each day in all years)	Whole number (0)	Wassists [BB] and Wassents [LA] suborders
Ratio of cation-exchange capacity (cmol(+)/kg fine-earth fraction) to clay content (% by weight)	Hundredths (0.01)	Key to cation-exchange activity classes
Ratio of fine clay to total clay content	Tenths (0.1)	Required characteristics for argillic horizon [1.b.(5)]
Ratio of 1500 kPa water content to measured clay content	Hundredths (0.01) and tenths (0.1)	Key to particle-size classes; cation-exchange activity classes
Ratio of 1500 kPa water content to measured clay content	Tenths (0.1)	Oxic subgroups of Inceptisols; isotopic mineralogy class [D.2.f.(3) and E.3.c]
Resistant minerals, in 0.02 to 2.0 mm fraction (% by weight or grain count)	Whole number (0)	Quartzipsamments great group [LCC]; siliceous mineralogy class [E.4]
Sand fraction content (% by weight)	Whole number (0)	Key to particle-size classes of mineral soils [sections B.4.b and C]; strongly contrasting particle-size classes no. 26, 45, 50, 70, and 71
Saturated hydraulic conductivity (cm/hr)	Tenths (0.1)	Albaqualfs [JAH] and Albaquults [HAC] great groups
Saturation with water (month) ^{1/}	Whole number (0)	Key to soil orders [G.2.a)]; Aquisalids [GBA] and Aquicambids [GGA] great groups; Aquic (“aqu”) subgroups of Aridisols

^{1/} For the saturation criterion, “1 month or more” is equivalent to “more than 15 days.”

Measurement of soil property or quality (units)	Significant digit used in Soil Taxonomy	Taxonomic criteria and taxa in Soil Taxonomy [item code]
Slope gradient (%)	Whole number (0)	Fluvents suborder [LD.2 and LD.4.b.(2)]; Fluvaquents great group [LBF.2]; Cumulic and Fluv subgroups of Orthels and Cumulic subgroups of Turbels; Cumulic and Fluv subgroups of Inceptisols; Fluv subgroups and most Cumulic subgroups of Mollisols
Sodium adsorption ratio	Whole number (0)	Required characteristics for natric horizon [5]; key to soil orders [K.2.b.(3)]; Natric subgroups of Alfisols; Sodic subgroups of Aridisols, Entisols, Inceptisols, and Vertisols; Haplic (“hapl”) subgroups of NatrustalFs and Natrargids; key to suborders of Inceptisols [KA.2] and Mollisols [IB.2]; Halaquepts great group [KAC.2]
Soil temperature (°C)	Whole number (0)	Required characteristics for mollic [7], plaggen [5], and umbric [7] epipedons; required characteristics for anhydrous conditions; soil moisture and temperature regimes; key to soil temperature classes; Aridic (Id), Torric (Torr), Udic (Ud), Ustic (Ust), and Xeric (Xer) subgroups of Alfisols, Aridisols, Entisols, Inceptisols, Mollisols, and Ultisols; Torrerts suborder [FD]
Sulfur, dry mass (%)	Hundredths (0.01)	Required characteristics for sulfidic materials
Sum of extractable bases by NH ₄ OAc plus extractable Al ³⁺ , by 1N KCl (cmol(+)/kg fine-earth fraction)	Tenths (0.1)	Acric (“acr”) and Dystric subgroups of Andisols
Sum of extractable bases, by NH ₄ OAc (cmol(+)/kg fine-earth fraction)	Tenths (0.1)	Most Eutric subgroups of Andisols

Measurement of soil property or quality (units)	Significant digit used in Soil Taxonomy	Taxonomic criteria and taxa in Soil Taxonomy [item code]
Volcanic glass content (% by grain count)	Whole number (0)	Required characteristics for andic soil properties [3]; Fluvents suborder [LD.4.b.(2)] Aquandic and Vitrandic (“vitr”) subgroups; key to particle-size classes [B.1.b]; glassy mineralogy class [B.4]
Water retention, at 1500 kPa tension, on either air-dried or undried samples or both (%)	Whole number (0)	Vitrands suborder [DF]; Vitric (Vitr) and Hydric (Hydr) great groups and subgroups of Andisols; key to particle-size classes [section B]; strongly contrasting particle-size classes no. 5, 51, 52, and 56
Water-soluble sulfate (%)	Hundredths (0.01)	Required characteristics for sulfuric horizon [1.b]
Weatherable mineral content (% by grain count)	Whole number (0)	Required characteristics for oxic horizon [3]

Part 617 – Soil Survey Interpretations

Subpart A – General Information

617.0 Purpose

A. Soil survey interpretations predict soil behavior for specified soil uses and under specified soil management practices. They can be used for establishing criteria for laws, programs, and regulations at local, State, and national levels. They assist the planning of broad categories of land use, such as cropland, rangeland, pastureland, forestland, or urban development. They are used to assist in preplanning and postplanning activities for national emergencies. Soil survey interpretations also help plan specific management practices that are applied to soils, such as irrigation of cropland or equipment use. Soil interpretations provide users of soil survey information with predictions of soil behavior to help in the development of reasonable and effective alternatives for the use and management of soil, water, air, plant, and animal resources. Prediction of soil behavior results from the observation and record of soil responses to specific uses and management practices, such as seasonal wet soil moisture status and the resultant effect in a basement. Recorded observations validate predictive models. The models project the expected behavior of similar soils from the behavior of observed soils.

B. Soil interpretations use soil properties or qualities that directly influence a specified use or management of the soil. Soil properties and qualities that characterize the soil are criteria for interpretation models. These properties and qualities include site features, such as slope gradient; individual horizon features, such as particle size; and characteristics that pertain to soil as a whole, such as depth to a restrictive layer. Soil interpretation criteria may change with technology.

C. Laboratory and field measurements, models and inferences from soil properties, morphology, and geomorphic characteristics provide the values used for estimating soil properties. Sources of laboratory data commonly are the NSSC Kellogg Soil Survey Laboratory, agricultural experiment station laboratories, and State highway department testing laboratories. Pedon descriptions record field measurements, field observations, and descriptions of soil morphology. Develop lab sampling plans to fill data gaps. Changes to soil features in the database change soil interpretive results. Soil scientists prepare entries and change entries with interdisciplinary assistance of engineers, agronomists, foresters, biologists, resource conservationists, range conservationists, and others.

D. Interpretations are categorized as national, standard, and regional, State or local:

- (1) National Interpretations.—National soil survey interpretations are nationwide in scope and application, and are mandated by Federal legislation, policy, or regulation. National interpretations may not be modified for State or regional uses because they are designed exclusively for national use across all political boundaries by NRCS and other agencies. Federal programs use national soil interpretations. Examples of national soil survey interpretations are highly erodible land, prime farmland, “T” and “I” factors, hydric soils, and the entire suites of interpretations designated with “MIL” (military) and “DHS” (Department of Homeland Security) as part of their name. The Federal agency that is responsible for the mandated program provides the leadership to develop the criteria and documentation cooperatively with the national leader for soil survey interpretations.
- (2) Standard Interpretations.—Standard soil survey interpretations and their related criteria that are nationwide in scope and application but are not mandated by Federal legislation, policy, or regulation. These interpretations and their criteria are the national standard. The soil survey interpretations generated by these criteria and templates are provided in soil survey publications,

data downloads from the Web Soil Survey, and other soil reports. Most surveys use standard interpretations.

- (3) Regional, State, or Local Interpretations.—Regional, State, or local soil survey interpretations are local or regional in scope and application. These interpretations and their related criteria support interpretations within a local area or region.

E. The cooperators in the National Cooperative Soil Survey develop soil interpretations to support user needs. NRCS maintains them. Published soil surveys include soil interpretations. Thematic maps produced from geographical information systems (GISs) provide an alternate interpretation format.

F. A geographic area may have a wide range of land uses for which soil interpretations are developed, maintained, and published. Local, State, and soil survey regional offices (SSRs) along with National Cooperative Soil Survey participants select the land uses and primary interpretations to be published.

G. National technology support centers, States, and cooperators develop additional interpretations after publication for users requesting assistance. Interpretation developers must appropriately label and date these interpretations. They must provide metadata such as the discipline specialists that developed the interpretation, the status of testing, validation and certification, and the intended extent of the soil interpretation's applicability.

617.1 Responsibilities

Soil survey interpretations are generated within the National Soil Information System (NASIS) using the soil properties that are stored in the Soil Data Warehouse. Exact joins across county and State lines ensure consistency of soil interpretations in Web Soil Survey across these boundaries. Soil survey products use generated interpretations. Do not adjust the ratings. Ratings that are contrary to the experience of those persons familiar with the soil and other performance standards of users should be evaluated. If the performance of the soil is not consistent with the computer estimates, review the soil properties and selected criteria. Also review the assumptions and definition of the practice being rated. A new interpretation with new criteria may be needed.

- (1) Null Values and Consistency of Entries.—Completely populate all data elements that are used as criteria in an interpretation in order to generate reliable interpretations. Data fields with null values or missing data cause the soil interpretation to fail and tables will carry the phrase “not rated” for these components. To ensure consistency of data entry for soil properties and qualities, use the procedures in part 618 of this handbook. Because many entries are subjective and up to interpretation by the soil scientist, training within major land resource areas is encouraged.
- (2) Populating Major and Minor Components.—Completely populate the data elements for major and minor components including map unit components that are entered as series, taxadjunct, family, taxon above family, and miscellaneous area except as noted below in section 617.1(4) Policy guidance related to major and minor components of map units is contained in part 627 of this handbook and in chapter 2 of the Soil Survey Manual. Important points as they relate to database population are summarized here.
 - (i) The number of components listed for any map unit is kept to a minimum. Only those major and minor components required to understand and interpret the map unit should be entered in the database. Components used to describe a map unit should meet the following criteria. Each component—
 - Commonly exists in most delineations of the map unit (except for undifferentiated groups).
 - Contributes to the understanding of the map unit.
 - Contrasts with other major and minor components listed for the map unit.
 - Provides useful data and interpretations.

- (ii) Each major component is correlated to a series, taxadjunct, family, taxon above family, or miscellaneous area and is named accordingly. Similar soils, unless needed for the understanding of the map unit, are not listed as additional components. Rather they may be selectively incorporated into the data ranges populated for the properties and qualities of the named component (see part 618 of this handbook).
- (iii) Minor components occupy a relatively small percentage of the map unit. To be included in the database they should meet the four criteria listed in item 1 above. They are correlated to series, taxadjunct, family, taxon above family, or miscellaneous area as the kind of component. Two or more minor components that are contrasting with a named major component, but that are similar to one another, should be correlated to one minor soil component. The data ranges populated for the properties and qualities for this single component are reflective of the combined similar soils in the same way as is done for major components.
- (iv) Each component entered into the database is populated as fully as possible to maximize the understanding and interpretive value of the map unit.
- (3) Application of National Interpretations.—National program applications use national interpretations and deviations by States or other offices are not allowed.
- (4) Deviation From Standard Interpretations.—Deviations from the nationally supported standard interpretations and their related criteria are documented and renamed by the State. Interpretation development follows the procedure in section 617.10.
- (5) Retention of Criteria and Documentation.—Offices creating local, State, or regional interpretations retain the criteria and performance documentation.
- (6) Responsibilities
 - (i) The national technology support centers are responsible for regional multidisciplinary coordination and quality assurance for the development and maintenance of regional interpretive criteria and information for private and State lands.
 - (ii) The SSR is responsible for—
 - Ensuring that data entries for map unit components meet national standards for data population (refer to parts 618 and 627 of this handbook) and that data are joined and correlated within a major land resource area (MLRA).
 - Reviewing interpretations to assure correlation, technical accuracy, and consistency of the soil data and interpretations across MLRA boundaries.
 - Ensuring that soil performance is correlated to soils according to current policy and guidelines.
 - Maintaining the criteria and templates for regional interpretations within NASIS.
 - (iii) The State soil scientist is responsible for—
 - Coordinating with the responsible soil survey office to ensure the accuracy, consistency, currency, and completeness of all soil data in the NASIS database and the field office technical guides.
 - Assisting soil survey users in understanding and applying soil survey information.
 - Maintaining the criteria and templates for State and local interpretations within NASIS.
 - Coordinating the development of State or local soil interpretations as needed.
 - Fully documenting State and local interpretations as outlined in section 617.10.
 - Maintaining the criteria and templates for State and local interpretations.
 - Ensuring the technical content, coordination, and quality of soil information in the field office technical guides.
 - Providing soils input to all NRCS program activities.
 - Migrating NASIS data to the Soil Data Warehouse.
 - (iv) Federal agencies are responsible for soil interpretations on federally administered lands that are developed in addition to the standard or national soil interpretations.
 - (v) The National Soil Survey Center (NSSC) is responsible for—
 - Developing standards, guidelines, and procedures for making soil interpretations.

- Approving and maintaining the criteria, templates, and documentation for all national interpretations in cooperation with specific disciplines at the national level.
 - Coordinating with other disciplines and program managers in the development of soil interpretations with national application.
 - Initiating regional soil interpretation reviews for standard interpretations through the national technology support centers.
 - Sharing and providing guidance on soil interpretations that are used in soil survey publications, reports, and databases.
 - Providing training in developing, maintaining, storing, and retrieving soil interpretations.
- (vi) Program areas and various disciplines determine the policy for acceptance or application of interpretation criteria for specific uses.
- Responsibilities for engineering interpretations are in Title 210, National Engineering Manual, Part 533, Subpart C, Section 533.22. Soil-related fish and wildlife interpretations and responsibilities are provided in Title 190, National Biology Manual, Part 512, and Part 513, Section 513.15.
 - Soil-related forestry and agroforestry interpretations are provided in Title 190, National Forestry Manual.
 - Soil-related range and pasture land interpretations responsibilities are described in Title 190, National Range and Pasture Handbook, Part 600, Chapter 3, Section 600.0305, and other parts of chapter 3.

617.2 Interpretations for Map Unit Components and Map Units

A. Interpretations. Soil interpretations support detailed soil survey maps, such as from the Soil Survey Geographic (SSURGO) database, general soil association maps, such as from the General Soil Map of U.S. (STATSGO2) database; and the more general soil maps, such as from the national major land resource area map.

(1) Map Unit Components

- (i) Soil survey interpretations primarily address map unit components. Most map unit components have a complete set of data elements sufficient for making interpretations, but some components (e.g., miscellaneous areas) lack needed data. The completeness and accuracy of data and information that are used as soil interpretation criteria determine the accuracy of interpretations. Components lacking necessary data for any interpretation will receive a “not rated” result. Soil scientists review the completeness and accuracy of the database prior to release of interpretations to users. The reports from the NASIS interpretation generator show where data are missing.
- (ii) Map unit components that are miscellaneous areas may have adequate data available to generate some standard interpretations, and may be listed in interpretive tables. Otherwise, suitabilities and limitations can be developed by onsite investigation.

(2) Map Units

- (i) Soil survey interpretations can represent the map unit as a whole. Performance statements which apply to soil map units as a whole use one of two methods for presentation:
 - As percentages of the unit with a specific rating, such as “map unit Alpha-Beta complex, 0 to 3 percent slopes is 60 percent well suited and 40 percent poorly suited for the specified use”
 - As a single rating that was averaged from values or determined from preset percentages, for example, a single yield of crops is given, which may have been calculated on a weighted average based on the percent composition of the map unit.
- (ii) Generally, map unit interpretations are the result of queries from users, who may need information on the major components of a map unit or information on the minor components if the minor components are important to a specific use.

B. Generalized Applications.—Interpretations for map units displayed on smaller scale maps (e.g., 1:250,000), such as the U.S. General Soil Map (STATSGO2), the major land resource area database, or from other general soil maps, are more general than the interpretations displayed on larger scale maps (e.g., 1:12,000), such as the Soil Survey Geographic (SSURGO) database and other detailed soil survey maps of the U.S. General soil map units of the STATSGO2 database commonly contain more map unit components or more broadly defined soil property ranges in characteristics than the map units of the more detailed soil survey maps of the SSURGO database. Performance statements for general soil map units apply to the map unit as a whole and express the percentage of the map unit that meets the performance criteria. For example, “the Alpha-Beta-Gamma map unit is 60 percent well suited, 25 percent poorly suited, and 15 percent unsuited for the specified use.”

617.3 Developing and Maintaining Interpretation Guides and Ratings

A. Standard Interpretative Group Guides.—Standard interpretative groups rely on criteria and information for interpreting soils as referenced in part 622 of this handbook or as approved separately by the national leader for soil survey interpretations and other national disciplines.

B. Responsibilities.—The national leader for soil survey interpretations leads the development, maintenance, and revision of soil interpretive technology and develops policy relating to the application of soil data for standard and national interpretations. Discipline specialists, such as agronomists, foresters, and range conservationists, are essential to the development of soil interpretation guides and standards and in the technical transfer of the resultant interpretations and information to users.

C. Level of Development.—State, regional, or national offices develop soil interpretations and related guides. Interdisciplinary teams develop soil interpretations and related guides for specific soil interpretations. Specialists concerned with a given land use or resource work together in developing the initial criteria, field-testing the criteria, and developing the final guide for interpreting soils for a specified use. The procedure outlined in section 617.10 governs the development and documentation of the proposal.

617.4 Reviewing and Implementing Soil Interpretative Technologies

A. Proposed Changes to Standard Interpretations.—A project soil survey office staff, State office staff, advisory group, conference committee, National Cooperative Soil Survey participant, NSSC personnel, or other discipline specialist may propose soil interpretative guides and criteria changes. The national leader for soil survey interpretations will ensure that all soil interpretations criteria will be reviewed on a regular basis. These proposed changes to standard soil interpretative criteria and guides are submitted to the NSSC’s national leader for soil survey interpretations for distribution for peer review.

- (1) The national leader for soil survey interpretations assigns a sponsor for each interpretation. For criteria changes initiated at the NSSC, the national leader for soil survey interpretations is the sponsor.
- (2) National technology support center representatives are the review coordinators for the national leader for soil survey interpretations. The review coordinators summarize all regional feedback and provide information to the national leader for soil survey interpretations for action.
- (3) The sponsor prepares a “full description” as described in section 617.10 and assembles documentation and copies of technical references supporting the current and proposed criteria for any NSSC, State, or regional variation to the interpretation. The sponsor prepares a list of contacts that support the variations to the standard interpretation and works with regional soil interpretations coordinating team that consists of soil scientists and other disciplines from NRCS

and other agencies. These teams are standing or ad hoc committees within the regional conference committee structure.

- (4) The regional teams—
 - (i) Review the purpose and the scope of the interpretation.
 - (ii) Compare the standard template to the locally tailored interpretations with attention to the documentation provided for the local interpretation.
 - (iii) Determine if any current soil properties used in the standard interpretation are repetitive, should be dropped or rewritten, or if additional properties should be added based on local criteria.
 - (iv) Evaluate technical references or documentation that must accompany suggested changes.
 - (v) Determine if criteria used in local variations warrant using them in standard criteria.
 - (vi) Determine research needs to support criteria changes.
 - (vii) Identify problems or questionable areas with the current or proposed criteria.
 - (viii) Develop documentation for recommended changes in properties or criteria.
 - (ix) Provide a recommendation to the interpretation sponsor.
- (5) The interpretation sponsor monitors and assists each regional team's activities and progress and with their input consolidates the recommendations of each into one recommendation to the national leader for soil survey interpretations.
- (6) The national leader for soil survey interpretations provides a cooperator comment period before the standard interpretation is finalized in concert with other national discipline specialists and before it is implemented in NASIS.
- (7) The national leader for soil survey interpretations arranges for all NCSS cooperators to be notified of changes that have been made to an interpretation.

B. Regional, State, or local interpretation submissions. Submission of regional, State, or local interpretations to the national leader for soil survey interpretations will ensure these developments are shared with potential users. Soil interpretations must meet the requirements outlined in section 617.10. Field observations, research (laboratory and field), and other documentation should support them.

617.5 The National Soil Information System

A. NASIS stores soil survey data, soil performance, and interpretation criteria. Soil interpretations attach to map unit components. Part 618 of this handbook discusses specific data entry for components of detailed map units. NASIS stores all necessary criteria for computer-generated interpretations. Changes to soil properties made in NASIS do not generate new interpretations in the Soil Data Warehouse until they are exported from NASIS to the warehouse.

B. NASIS depends on adherence to National Cooperative Soil Survey policy and procedures and consistent and complete entry of specific soil properties.

617.6 Presenting Soil Interpretations

The method by which soil interpretations are presented, such as tables, databases, interpretative sheets, thematic maps, and special reports provides easily understood soil limitations, suitabilities, or potentials for a specific use. Thematic maps effectively present soil limitations and potentials. A series of thematic maps, each focusing on a single soil attribute, or interpretation, helps many users. For more general use, tables or narrative forms of soil interpretations and potentials are the more common technique.

617.7 Updating Soil Interpretations

A. Changes in Application.—The evaluation and maintenance of soil interpretations is a dynamic process. Changes in soil use or land management practices may require new, revised, or updated interpretations. Soil use changes initiate the revision of soil interpretations. Soil interpretations are updated periodically as more information is gained about a soil and its behavior or as soil properties change due to activities by human activity or nature. Interpretations may change due to changed entries for soil or landscape features or from changes in interpretive criteria. The change is applied when the NASIS data is exported to the Soil Data Warehouse or downloaded directly from NASIS reports.

B. Changes in Soil Information.—Soil maps contained in published soil surveys generally remain valid for many years. However, the information about the soils that are delineated on the maps is continually updated and enhanced as research is conducted or as new kinds of data are collected and entered into the information system.

C. New Uses.—New uses for a soil or new practices that have no existing soil interpretations may become important in an area and thus require the development of new interpretations or the modification of an existing interpretation for a similar use or practice.

617.8 Coordinating Soil Survey Interpretations

A. Similar Soils.—For the major land resource area, specific interpretations for similar phases of a named kind of soil are identical except for minor differences that can be justified by local variations, such as in climate or topography. Similar soils by definition have similar interpretations. In order to generate similar interpretations, soil landscape and soil features and properties must be the same or utilize the same data map unit and interpretation criteria. Interpretations in field office technical guides and soil handbooks are generated from properties and interpretation criteria.

B. Coordinating Soil Properties and Features Used in Soil Interpretations.—Soil data entries and joining are the basis for coordinated soil survey interpretations. Responsibility also consists of coordinating with the adjoining regions and reviewing measured and observed data from all areas in which similar map units occur. State and local program-specific interpretive groups and special interpretative criteria are the responsibility of the State soil scientist.

617.9 Writing Soil Interpretation Criteria

Developing interpretations criteria involves the user. Interdisciplinary involvement is required in developing criteria for interpretations in order to assure that the needs of potential users are addressed. Also consider the clarity, accuracy, and the ability of the criteria to be easily created and modified. Local, State, regional, and national offices develop criteria to represent user needs. They follow a consistent procedure and firmly establish principles for documentation. Consider the ease of development and the stability of the interpretation. Use the expert judgment of specialists and the scientific literature as resources. People who work with the intended use and application know more than what can be speculated by those people with less experience. The following steps lead to the goals for interpretation criteria.

- (1) Define the Activity.—Clearly and very specifically define the activity or use to be interpreted. Cite references that help to define the activity. Literature citations, such as information from the State Health Department, bulletins, or soil performance research, support the decision made and help track the procedure. When defining the activity—
 - (i) Describe the activity or use.

- (ii) Identify the purpose or purposes of the activity or use.
- (iii) Define the desired performance of the activity or use.
- (iv) Specify the soil depths that are affected.
- (v) Identify the type of equipment for installation.
- (vi) Mention resource conditions that indicate a different activity or use or the misuse of this practice.
- (vii) Define the needed specific geographic detail, including the length and width and the direction of application if important.
- (viii) Define the needed map and interpretation reliability and uniformity.
- (2) **Separate Aspects.**—Separate different aspects of the activity for separate interpretations. Aspects of interpretations are planning elements that require different criteria, such as installation, performance, maintenance, and effect. Proceed through the steps to develop criteria for each aspect. Each aspect is a unique interpretation that has separate criteria and users. Mention other aspects that may need interpretation but are not addressed.
- (3) **Identify Site Features.**—Identify site features significant for the interpretation and any assumptions about them. Site features are not soil properties, but are instead features such as climate factors, landscape stability hazard, vegetation, and surface characteristics. Identify and record site features and their relevance to interpretations. Although site features are not soil properties, they are commonly recorded on soil databases and are valuable for developing interpretations because they are geographically specific to soils.
- (4) **List Soil Properties.**—Identify and list all specific soil properties that are significant to the interpretation. Use only basic properties, qualities, or observed properties. Do not make interpretations from previous interpretations or models. Generally, terms that refer to classes fit in this category. Only use derived soil qualities when they are derived within the criteria to ensure the integrity of the data and the resultant interpretation. Terms used as properties or qualities that have inconsistent entries or derivation pathways result in inconsistent interpretations. Concentrating on the basic influencing property that has the most consistent database entries provides for more consistent interpretations. For example, consider the soil moisture status during a construction period and not the drainage class. Minimize the list of properties by identifying only the basic properties. Review the list to ensure that the same property is not implied several times. For example, USDA texture, clay, and AASHTO do not need to appear on the same list.
- (5) **Select the Number of Separations.**—Select the number of interpretative separations, and define the intent of the separation or classification. Each separation should have a purpose, which normally represents a significant management grouping and a need for separate treatment. Commonly used terms in separations are slight, moderate, and severe or good, fair, and poor. User needs dictate the number of separations. The levels of user needs may vary. Some users do not use groupings.
- (6) **Document Assumptions.**—Document assumptions about the significance of the property and established values for separating criteria.
 - (i) A record of the significance of the property helps to define the property and allows for future understanding and modification. It provides a basis for the criteria so that changes can be made if different equipment is used.
 - (ii) Indicate why the feature is important and why the specific break was chosen, such as why a 6-percent slope was used instead of 10-percent slope. If the limit is arbitrary or speculated, state that it is but also indicate the intent of the separation. The new interpretation generator recognizes the progressive effect of a property on the interpretation. The curve for approximate reasoning (fuzzy logic) reflects the increasing, decreasing, or constant effect that varying degrees of a property have on the interpretation. The evaluation phase of the interpretation generator uses the curve.

- (iii) Establish values that are significant to the interpretation and not to the mapping. The values should represent the significance to an activity. Do not consider how soils were grouped in mapping since these groupings may have been made for other interpretations.
- (7) Develop the Criteria Table.—Assign feature and impact terms, and develop the criteria table. The following categories of column headings are recommended for use in the criteria table. Information in the feature and impact columns is helpful in designing ways to overcome the limitation. Ensure that all terms are added to data dictionary.
 - (i) Factor (this is the soil property)
 - (ii) Degree of Limitation (such as slight, moderate, severe)
 - (iii) Feature (the term to be displayed for soil property)
 - (iv) Impact (the dominant impact that the soil property has on the practice being rated)
- (8) Application, Presentation, and Testing
 - (i) Database Needs.—Provide a description of the calculation procedure. The calculation procedure is a set of instructions for the correct access to dataset entries. It is needed to sort criteria from a database without questioning the intention of the interpretation. The description should be specific to the database being used. Instructions for using high, low, or central values of data should be given in this description.
 - (ii) Temporal Considerations for Application.—Identify time dependent or temporal properties or events from the measured permanent features of the soil.
 - Flooding and periods of freezing, wetness, or dryness are significant at the time they occur but not at all times. For example, in planning an installation phase, remember that this phase can be scheduled for alternate times when these events are not significant to the criteria. In these situations, temporal properties should not be part of the criteria unless a practice is being rated for a particular time of the year.
 - If temporal events are important for the permanent performance of the interpretation, then include them in the rating criteria.
 - State the soil moisture condition or the time of the year to which the interpretation applies. Since the conditions of soil moisture and soil freezing vary throughout the year and these conditions affect soil properties, criteria should define stated moisture conditions. Criteria can be developed for different times of the year by defining the criteria for the conditions that exist at the desired time of the year. Information on soil moisture status and freezing conditions are in NASIS.
 - (iii) Reliability
 - Each soil property has a reliability connected to it. Soil property entries may come from measurements, derivations, or estimates. Consider the soil property reliability to inform the users of the reliability of the expected interpretation.
 - Properties can vary according to time of the year. If so, specify a time of the year for the interpretation. The reliability of the interpretation often depends on the seasonal variation of the property. Information presented to the user on temporal variation helps to describe the reliability of the interpretation.
 - Geographic reliability refers to the aerial extent to which an interpretation can be applied. Statements about the consistency, variability, or uniformity of a soil delineation help to define the geographic reliability of the interpretation.
 - (iv) Testing.—Interpretations should be tested against the actual effects on activities or practice performance. Many properties and criteria need further refinement before they can be used. Some terms, such as flooding, require clarifying statements such as for velocity, depth, or duration. Sources of information other than NASIS soil interpretations may be available and should be considered at this stage of criteria development. Also consider related refinements and onsite investigations.
 - Keep in mind that a soil interpretation is for planning purposes. Additional refinements or other resource information can be used for site selection. Soil interpretations alone may not answer all the questions. Inform the intended user about other information that

may be needed. Honestly express the limitations of the interpretation but do not undersell the information. Many users have no other resource information.

- For the final site selection, an onsite investigation may be needed to provide information more specific than that collected and stored in a standard soil survey. Onsite investigation is recommended for expensive installations and for the determination of design criteria.
 - Use benchmark soils for testing interpretations. A benchmark soil and site description and the desired interpretation rating may help to stabilize the criteria. As criteria is developed and adjusted, test the criteria against the benchmark set of properties.
 - Report suspected errors and discrepancies in criteria or constructed interpretation logic to the owner of the interpretation. Contact the national leader for soil survey interpretations for national or standard interpretation errors. When reporting suspected errors in an interpretation include the following:
 - Name of the interpretation
 - Description of the suspected error
 - If known, detail the elements, rules, evaluations, properties, or logic construct that are the problems
 - Reference one or more soil survey map unit components that demonstrate the error
 - Interpretation owner will review and evaluate the reported error:
 - Determine if the interpretation indeed contains an error from its original intent
 - If after review and evaluation the owner determines that the interpretation is functioning as designed, notify the person reporting the error
 - If the interpretation does have an error, notify State soil scientists and NCSS cooperators of the interpretation that contains the error and consider changing the interpretation from “Ready to Use” status to “No” in NASIS
- (9) Date the Interpretation and Criteria.—It is very important to date the criteria and the interpretation tables. As criteria are modified, it may not be apparent that the tables were not generated from current criteria.

617.10 Documenting Soil Interpretation Criteria

A. General. It is important to document information used during development and maintenance of soil interpretations. Soil interpretation users should be able to locate information and references used to develop the interpretation’s rules and criteria. Information regarding the interpretation’s ratings and the person who developed the soil interpretation are helpful in testing or validating interpretations and for determining the geographic extent of intended use of the interpretation. The standard procedure to document soil interpretations is within NASIS. This ensures critical information accompanies products delivered through the Web Soil Survey.

B. Levels of Interpretation Documentation.—Three levels of interpretation documentation are provided for national, standard, regional, State, and local interpretations.

- (1) Summary Description.—A one to two-page narrative summary of the intent of the primary interpretation, its scope, general description of the interpretive criteria, and citations used to support criteria.
- (2) Mid-Level Description.—A more detailed description. It includes contents of the Summary Description plus a description of each interpretive criteria (sub-rule) used in the primary interpretation. It provides the NASIS properties that are used to retrieve data from the NASIS database.
- (3) Full Description.—Information from the mid-level description and the details of data evaluations used in the interpretation.

C. Development and Storage of Documentation

- (1) Summary Description.—Store as prewritten text in the “Rule Description” field of the primary rule in the rule table in NASIS (see example of each below).
- (2) For child rules, evaluations, and properties, store a description of each in their respective description field in their respective table in NASIS (see part 617, subpart B, section 617.20).
- (3) NASIS reports have been written to generate the summary, mid-level, and full interpretation description versions as outlined above. These NSSC Pangaea reports are as follows:
 - (i) INTERP – Rule and Criteria Narration – full
 - (ii) INTERP – Rule and Criteria Narration – mid-level
 - (iii) INTERP – Rule and Criteria Narration – summary

Note: To run these reports in NASIS, all that is needed is to have the primary rule in the selected set.

- (4) During export to the staging server, these three reports will automatically be run and the results stored in the export file.
- (5) These same reports will automatically run when interpretations are updated or added to datasets on the staging server.
- (6) These reports will also be added to the Access template and be available through the Web Soil Survey.

D. Responsibility

- (1) The summary description text and descriptions for each child rule, evaluation, and property are to be developed by the owner of each entity.
 - (i) The national leader for soil survey interpretations maintains documentation for all national and standard interpretations and their component parts.
 - (ii) Each State or local entity is responsible for completing and maintaining documentation for their respective State or local soil interpretations.
- (2) This scheme facilitates a standard delivery mechanism for documenting NASIS interpretations.

617.11 Requirements for Naming Reports and Interpretations

The Web Soil Survey allows the State soil scientist to develop a list of available reports for their particular State. This enhancement requires the development of a State SSURGO Access template database to include the desired State reports. This State-tailored Access template is used to create the State reports on the Web Soil Survey. The following procedures are necessary to provide the management of tailored reports requested by each State:

- (1) Downloading National Reports.—If a State chooses to accept the national reports on the Web Soil Survey and exports only the national and standard interpretations from NASIS to the Web Soil Survey, no additional action is necessary.
- (2) Developing Local Reports, Modifying National Reports, or Creating New Reports.—The following require a tailored SSURGO Access template detailing the exact modifications to be made for the State’s reports on the Web Soil Survey:
 - (i) Developing local interpretations (e.g., sewage lagoons (VA) or dwellings with basements (NC))
 - (ii) Modifying existing national soil property reports (e.g., chemical properties (CA) or water features (CA))
 - (iii) Creating a brand-new report (e.g., soil fact sheet (VT))
- (3) Requirements for Creating a Local Interpretation From a National Interpretation.—When creating a local interpretation from the national/standard (e.g., “ENG - Septic Tank Absorption Fields”), modify the following in NASIS:
 - (i) Naming Convention

- Use the same prefixing protocol established for NASIS interpretations (see figure 617-A1) and the interpretation text name as used for the national or standard interpretation “Rule” name.

Figure 617-A1

Ag Waste Management	(AWM)
Agronomy	(AGR)
Bureau of Land Management	(BLM)
Dept. of Homeland Security	(DHS)
Forage Suitability Groups	(FSG)
Forestry	(FOR)
Grazing Land	(GRL)
Military	(MIL)
National Commodity Crop Productivity Index	(NCCPI)
Recreation	(REC)
Standard Engineering	(ENG)
Urban	(URB)
Urban/Recreation	(URB/REC)
Water Management Systems	(WMS)
Water Quality	(WAQ)
Wildlife	(WLF)

- Modify this interpretation “Rule” name in NASIS to include the two-letter FIPS State code or agency codes (BLM, FS, NPS, etc.) in parentheses, preceded by one space, after the rule name (e.g., “ENG – Septic Tank Absorption Fields (OH)” or “WLF – Desert Tortoise Habitat (BLM)”).
 - Use only State FIPS codes or agency codes. Do not use terms such as, RSS, initials, survey area, etc. See https://www.census.gov/geo/reference/ansi_statetables.html.
- (ii) Documentation.—Use the description field in the NASIS rule table to fully document the State-created interpretation (including “Summary,” “Description,” “Scope” with source citations, and “Criteria” detailing the rule, evaluation, and property as outlined in section 617.10). See national rules for examples of acceptable format and content.
- (iii) Sharing Interpretations Developed by Other States.—To use a local interpretation created by another State or agency, copy and paste the primary interpretation (in NASIS) and change the State or agency code to reflect the new State code or simply export the interpretation as named even though it will contain a different State code.
- (iv) Report Name and Title.—Change the reports in the Access template to display the local interpretations:
- Use the report name and title for the local interpretation as described above.
 - Column headers for local interpretations include the FIPS code or agency code, but not the three-letter prefix code (ENG, WMS, etc.). For example, “Sewage Lagoons (VA)” is correct.
 - Edit the Access “Report Documentation” field to provide an explanation of the use of the State code designating the interpretation as one that has been developed using local criteria. Inform the user of any significant criteria differences or criteria references necessary to understand the use of the interpretation.
- (4) Requirements for Modifying Existing National Soil Property Reports.—If a national properties report is modified (e.g., removal of the “gypsum” column from the Chemical Properties report), the following changes are needed:
- (i) Report Name (Displayed on Drop-Down Menu on Web Soil Survey).—Add the State two-letter FIPS code or agency code to the report name to identify “State” modification of the report (e.g., Chemical Soil Properties (CA)). Place the two-character State code in

parentheses, preceded by one space, after the report name. This State “report name” supersedes the national report and replaces the national report. The Web Soil Survey drop-down list is alphabetically arranged. Multiple versions of the same report may be used within a State with the names modified to distinguish between them (e.g., Chemical Soil Properties (CA), Chemical Soil Properties for Volcanic Soils (CA)).

- (ii) Name Modification.—Use only State codes or agency codes (BLM, FS, NPS, etc.) as modifiers to the report name. Do not use terms such as MOxx, initials, survey area, etc.
- (iii) Report Title.—The report title is the actual title on the printed report page. The report title is changed to match the report name (e.g., Chemical Soil Properties (CA)).
- (iv) Documentation.—The “Report Documentation” field in the Access template table “SYSTEM - Soil Reports” is edited to reflect any report modification. This prewritten material is specific to the report and is reviewed by editorial staff.
- (5) Requirements for Creating a New Report.—When creating a new report that does not replace a national report (e.g., “Soil Fact Sheet” created by Vermont), take the following actions:
 - (i) Develop the Report Name.—The report naming convention should include the State code or agency code as described above (e.g., “Soil Fact Sheet (VT)”).
 - (ii) The new State-specific report is intermingled alphabetically with the national reports.
- (6) Detailed instructions for modifying the Access template database. See the document titled “SSURGO_Template_DB_Customization_Guide.doc” for detailed instructions about modifying the Access template database. The guide is housed in a .zip file which is available for download at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053550 under the heading “Microsoft Access SSURGO Template Databases.”
- (7) Use of the National Template.—The National SSURGO Template Database is now available exclusively through the Web Soil Survey by clicking on the “Start WSS” button, “Download Soils Data” tab, and “Download SSURGO Template Database” bar at <http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>. Modify this template with State reports and submit to the national leader for soil survey interpretations for inclusion in Web Soil Survey.
- (8) Editorial Review.—Submit all reports developed or modified by a State, including report descriptions, to the national leader for soil survey interpretations for review by the editorial staff. This includes all local reports in existing Access templates.
- (9) Coordination and template delivery to the Web Soil Survey.
 - (i) The national leader for soil survey interpretations coordinates all editorial, consistency, and “look and feel” issues with State soil scientists, SSRs, editors, and others.
 - (ii) The national leader for soil survey interpretations provides the final Access template to the ITC staff for template delivery to the Web Soil Survey web site and for development of the State reports. Access templates are not posted directly to the staging server.

617.12 Interpretation Overrides

The NASIS interpretation generator has methods of overriding the standard interpretation results. This enhancement requires the development of an interpretation property that is used to flag a specific soil property to trigger the interpretation override. There are two instances that have been created to override the generated interpretations. The following population procedures in the local phase column provide an interpretation override.

- (1) Unstable Fill.—Population of the term “unstable fill” in the local phase column is used to override interpretations for soils built from mine reclamation materials. Typically, these soils will interpret with few, if any, limitations within the 2-meter zone of observation. However, these materials are susceptible to differential settlement due to reclaimed materials outside the zone of observation. To override the results of the standard interpretation, the local phase is populated with the term “unstable fill.” This term is a flag used by the NASIS interpretation generator to rate the soil as “very limited” with a restriction as “unstable fill.”

- (2) Impacted.—Population of the term “impacted” in the local phase is used to override used in soils that have become contaminated with heavy metals and other toxic elements. These soil materials may rate as favorable for uses however the contamination is an overriding factor that should preclude the soil from being rated. To override the results of the standard interpretation, the local phase is populated with the term “impacted.” This term is a flag used by the NASIS interpretation generator to rate the soil as “not rated.”

Part 617 – Soil Survey Interpretations

Subpart B – Exhibits

617.20 Example of Descriptions for Documenting Interpretations

Example Documentation of Interpretations

Following are examples of documentation content for rules, evaluations, and properties. These paragraphs are used as content to generate the Interpretation Documentation reports in NASIS described above.

The following is in the “Description” field in the “Rule” table of a primary rule:

WMS-Grape Production with Drip Irrigation

Summary: Soil interpretations for “WMS-Grape Production with Drip Irrigation” evaluate a soil’s limitations for drip irrigation of grapes. This irrigation system applies water at a very slow rate near the plants. The ratings are for soils in their natural condition. Present land use is not considered in the ratings.

The degree of limitation is expressed as a numeric index between 0 (nonlimiting condition) and 1.0 (most limiting condition). If a soil’s property within 150 cm (60 inches) of the soil surface has a degree of limitation greater than zero, then that soil property is limiting and the soil restrictive feature is identified. The overall interpretive rating assigned is the maximum degree of limitation of each soil interpretive criteria that comprises the interpretive rule. Lesser restrictive soil features are those that have a degree of limitation less than the maximum and are identified to provide the user with additional information about the soil’s capability to support the interpretation. These lesser restrictive features could be important factors where the major restrictive features are overcome through practice design and application modifications.

Soils are assigned interpretive rating classes on the basis of their degree of limitation. These classes are “not limited” (degree of limitation = 0), “somewhat limited” (degree of limitation >0 and <1.0), and “very limited” (degree of limitation = 1.0).

The “Grape Production with Drip Irrigation” interpretation was developed by the Davis, CA, interpretation staff in cooperation with the University of California-Davis, and is **neither designed nor intended to be used in a regulatory manner**. Drip irrigation is the controlled application of water to supplement rainfall for grape production. The soil properties and qualities that affect design, layout, construction, management, or performance of the irrigation system are evaluated and their degree of limitation determines the final rating.

Scope: Drip irrigation systems supply water to the soil very slowly. Generally, they are very efficient in terms of both water and energy use and are suitable for use in vineyards and orchards.

Description: The soil properties and qualities important in the design and management of drip irrigation systems are soil depth, wetness or ponding, a need for drainage, and flooding. The soil properties and qualities that influence installation are soil depth, flooding, and ponding. The features that affect performance of the system and plant growth are the amount of salts, lime, gypsum, and sodium.

Reference Information:

Criteria were adjusted as requested by NRCS staff working on the Alameda County Agricultural Enhancement Plan.

The original interpretation was developed using input from the Davis, CA, NRCS Resource Technology staff (Earth Team volunteer). The interpretation received further technical review from an irrigation specialist on staff at UC Davis.

References:

California Irrigation Guide. USDA-SCS. 1982. Developed in cooperation with the Pond-Shafter-Wasco Resource Conservation District.

Hanson, Blaine and Grattan, Stephen R. 1993. Agricultural Salinity and Drainage. University of California Irrigation Program. University of California, Davis.

National Engineering Handbook. USDA-NRCS. Aug. 1996. Part 652.

National Soil Survey Handbook. 1993. United States Department of Agriculture. Natural Resources Conservation Service. Part 620 - Soil Interpretations Rating Guides 620, Table 620-32.

The following is in the “Description” field in the “Rule” table of a child rule:

Depth to bedrock: Shallow depth to bedrock limits the soil’s water holding capacity and the thickness of the root zone. Soil feature considered is the top depth of the first restrictive layer where restrictive type is “bedrock*.” Depth to restrictive feature must be synchronized with the depth to the restrictive feature horizon shown in the horizon table.

Property used: “DEPTH TO BEDROCK (TX)” (Modality - representative value)

Restrictive limits:

Limiting	< 50cm
Not limiting	>= 50cm

Null depth is assigned to the not limiting class.

The following is in the “Description” field in the “Evaluation” table:

The evaluation checks for the presence of bedrock and if present indexes the depth. This index expresses the degree to which “depth to bedrock” is a limiting feature. Where “depth to bedrock” is—

< 50cm the soil is limited and the degree of limitation index is expressed as the number 1.0.

>= 50cm the soil is not limited and the degree of limitation index is expressed as the number 0.

The following is in the “Description” field in the “Property” table:

Data used: resdept and reskind from component restriction table.

Consideration:

1. reskind imatches “bedrock*” and if true
2. resdepth

Logic: Reports the top depth of the first restrictive layer where kind equal bedrock. Depth to restrictive feature must be synchronized with the depth to the restrictive feature horizon shown in the horizon table.

Part 618 – Soil Properties and Qualities

Subpart A – General Information

618.0 Definition and Purpose

- A. Soil properties are measured or inferred from direct observations in the field or laboratory. Examples of soil properties are particle-size distribution, cation-exchange capacity, and salinity.
- B. Soil qualities are behavior and performance attributes that are not directly measured. They are inferred from observations of dynamic conditions and from soil properties. Examples of soil qualities are corrosivity, natural drainage, frost action, and wind erodibility.
- C. Soil properties and soil qualities are the criteria used in soil interpretations, as predictors of soil behavior, and for classification and mapping of soils. The soil properties entered in the National Soil Information System (NASIS) must be representative of the soil and the dominant land use for which the interpretations are based.

618.1 Responsibilities

- A. Soil property data are collected, tested, and correlated as part of soil survey operations. These data are reviewed, supplemented, and revised as necessary.
- B. The soil survey office (SSO) is responsible for collecting, testing, and correlating soil property data and interpretive criteria.
- C. The soil survey regional office (SSR) is responsible for the development, maintenance, quality assurance, correlation, and coordination of the collection of soil property data that are used as interpretive criteria. This includes all the data elements listed below.
- D. The National Soil Survey Center (NSSC) is responsible for the training, review, and periodic update of soil interpretation technologies.
- E. The State soil scientist is responsible for working with the SSR and SSO to ensure soil interpretations are adequate for the field office technical guide and they meet the needs of Federal, State, and local programs.

618.2 Collecting, Testing, and Populating Soil Property Data

- A. The collection and testing of soil property data is based on the needs described in the project plans. The collection and testing should conform to the procedures and guides established in this handbook.

B. As aggregated component data, soil properties and qualities that are populated in NASIS are not meant to be site-specific. They represent the component as it occurs throughout the extent of the map unit. Most data entries are developed by aggregating information from point data (pedons) to create low, high, and representative values for the component.

C. Representative value (RV).—For newly populated information in NASIS, the representative value is used to approximate the 50th percentile (median) of a dataset. The 50th percentile is the value where 50% of the data are less than this value.

- (1) Low and high values are also populated. These values are meant to convey the spread of the dataset. For example, low and high values may be the 5th and 95th percentiles, where the 5th percentile is the value where 5% of the data are below that value and the 95th percentile is the value where 5% of the data are above that value. Unlike the RV, which is solely meant to approximate the 50th percentile, the low and high values can be tailored to a particular dataset. That is, 5th, 10th, 20th, etc. and 80th, 90th, 95th, etc. can be used according to which percentiles best capture the spread of a particular dataset.
- (2) The percentile approach applies only to newly populated datasets in NASIS, not previously populated datasets in NASIS.
- (3) The rationale for using the percentile approach is that it provides benchmarks for the spread and central tendency for both normal and non-normal distributions. Values will always fall within the minimum and maximum of the observed dataset. The percentile approach requires a dataset of at least 5 values. For example, the L-RV-H values are shown below for a hypothetical dataset for field-described clay content from the A horizon of 11 pedons:

Clay content: 11, 10, 12, 23, 17, 16, 17, 14, 24, 22, 14

Clay content sorted: 10, 11, 12, 14, 14, 16, 17, 17, 22, 23, 24

Low/10th percentile = 11

RV/50th percentile = 16

High/90th percentile = 23

- (4) Of primary importance is the empirical dataset itself regardless of established class limits, such as the particle-size classes or soil component concepts. If a dataset is small, some data points may range beyond established class limits. The representative value (RV), however, must fall within the range of the class (see section 618.3C).
- (5) Soil scientists have the flexibility to modify and design new data ranges that reflect the soil component and map unit concepts based on local soil-landscape models supported by field observations, measurements, and laboratory data.

D. Minimum and Full Data Population

- (1) A minimum standard and a full standard for data population are used for soil survey data posted to the Soil Data Mart for publication through Web Soil Survey and Soil Data Access.

- (i) Minimum.—The minimum standard contains those core data elements that support current national programs. All existing legends, map units, and data mapunits should comply with the current minimum standard. Data that met previous minimum standards should be reassessed to ensure compliance with the current minimum standard.
 - (ii) Full.—The full standard expands upon the minimum standard to include data elements that support other national needs, modeling efforts, and some State-level needs. Any new legends, map units, or data mapunits created through soil survey update projects or initial soil surveys should meet the full standard. The list of additional data elements for the full standard is under development and will be provided when available.
- (2) Minimum Standard Report.—A report listing the NASIS data elements that make up the minimum standard is posted to the NASIS Data Integrity Report Site. The report is named “!!!Minimum Standard (Legend, Mapunit, Data Mapunit).” The report includes the rationale for data element selection. The NASIS tables and data elements are sequenced in the order they should be populated.
- (3) Data Integrity Reports.—Data integrity reports are posted to the NASIS Data Integrity Report Site to assist with proper data population. They are applicable to national use and are an essential part of ensuring data comply to the current national minimum standard. They locate potential data population errors, omissions, and inconsistencies based on standards and guidance in this handbook and the *Soil Survey Manual*.
 - (i) Development of the data integrity reports is a dynamic process. The number of reports in the Data Integrity folder will change, and some reports may be modified to meet new program needs. Additional reports will be added as reports are completed and vetted.
 - (ii) The report “!!!!READ FIRST ABOUT DATA INTEGRITY REPORTS!!!” provides full details about why these reports were created, what errors they look for, and how they are intended to be used.
 - (iii) NASIS validations do exist for many of the minimum standard requirements and some data integrity reports replicate the validations. These redundancies are intentional because the reports create efficiencies not achievable with validations by allowing users to:
 - Analyze the national database without building a selected set in their local database.
 - Allow multiple tables to be analyzed in a single report.
 - Present errant records and columns in a format that is easy to review.
- (4) Compliance with Minimum and Full Standards.—Regional offices will incorporate the minimum standards into their annual and long-range work plans until published data is raised to the level of the minimum standard. Existing legends, map units, and data mapunits will be evaluated using the data integrity reports. The minimum standard is met when all potential data population issues identified by the data integrity reports have been resolved.
 - (i) Changes to official data are documented in text notes in the appropriate NASIS table. Data that were already populated for data elements that are not listed in the minimum standard should not be removed from the database.

- (ii) Populating data beyond the minimum standard (or to the full standard) is recommended where data are available. All new data created through update projects and initial soil surveys will be populated to the full standard.
- (5) NASIS Projects.—Regions have the option to create NASIS projects when applying the minimum standard to existing data. Some edits are minor and can be quickly addressed outside of a project. Other data population issues may be better addressed through projects, such as issues that are extensive or that require field work or in-depth research to resolve. Projects can be designed to address all data integrity population issues in a single project, or in multiple projects that are staggered over several years for completion. Output from data integrity reports can be used as the basis for project development. Examples of these reports are:
 - (i) Project description.—Each report provides an explanation of the data population issue and gives guidance on how to fix the problem. This information can be included in the project description as an executive summary for managers.
 - (ii) Project mapunits.—Each report provides a query to load the map units with the data population issues into NASIS. The map units can then be transferred to the project mapunit table, which serves to document the extent of the problem.
 - (iii) Project type.—Tabular Edit or MLRA depending on the nature of the data population issue.
- (6) Reporting Problems with Reports.—Questions, suggestions, and errors related to the data integrity reports can be submitted to the Database Focus Team.

618.3 Soil Properties and Soil Qualities

A. The following sections list soil properties and qualities in alphabetical order and provide some grouping for climatic and engineering properties and classes. A definition, classes, significance, method, and guidance for NASIS database entry are given. The listing includes the soil properties and qualities in the NASIS database. For more details on the NASIS database, refer to part 639 of this handbook. For specifics on data structure, attributes, and choices in NASIS, refer to

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/tools/?cid=nrcs142p2_053552.

B. Previous databases of soil survey information used metric or English units for soil properties and qualities. Values in English units, except for crop yields, were converted into metric units during transfer into the NASIS database. All future edits and entries in NASIS, except yields and acreage, will use metric units.

C. Ranges of soil properties and qualities that are posted in the NASIS database for map unit components may extend beyond the established limits of the taxon from which the component gets its name, but only to the extent that interpretations do not change. However, the representative value (RV) is within the range of the taxon.

618.4 Albedo, Dry

A. Definition.—“Albedo, dry” is the estimated ratio of the incident shortwave (solar) radiation that is reflected by the air-dry, less than 2 mm fraction of the soil surface to that

received by it.

B. Significance

- (1) Soil albedo, as a function of soil color and angle of incidence of the solar radiation, depends on the inherent color of the parent material, organic matter content, and weathering conditions.
- (2) Estimates of the evapotranspiration rates and predictions of soil water balances require albedo values. Evapotranspiration and soil hydrology models that are part of water quality and resource assessment programs require this information.

C. Measurement.—There are instruments that measure albedo.

D. Estimates.—Approximate the values by use of the following formula:

- (1) Soil Albedo = $0.069 \times (\text{Color Value}) - 0.114$.
- (2) For albedo, dry, use dry color value. Surface roughness has a separate significant impact on the actual albedo. The equation above is the albedo of <2.0 mm smoothed soil condition; if the surface is rough because of tillage, the albedo differs.

E. Entries.—Enter the high, low, and representative values of albedo for the map unit component. The range of valid entries is from 0 to 1, and hundredths (two decimal places) are allowed.

618.5 Artifacts in the Soil

A. Definition.—“Artifacts” are objects or materials created or modified by humans, usually for a practical purpose in habitation, manufacturing, excavation, or construction activities. Examples of artifacts include bitumen (asphalt), brick, concrete, metal, paper, plastic, rubber, and wood products. Artifacts are commonly referred to as “discrete artifacts” if they are 2 mm or larger in diameter and are not compacted into a root-limiting layer that impedes root growth or water movement.

B. Significance.—Artifacts can constitute a significant portion of the soil. The amount and type of particulate artifacts can contribute substantially to various trace metals and total carbon contents of soils. Discrete artifacts that are both cohesive and persistent, defined below, are treated in a similar manner as rock fragments when populating the standard sieves or in calculations involving sieve entries. Discrete artifacts that are noncohesive, nonpersistent, or both are not considered fragments for sieve entries or calculations involving those entries.

C. Measurement.—The fraction from ≥ 2 to < 75 mm in diameter may be measured in the field. However, 50 to 60 kg of sample material may be necessary if there is an appreciable amount of fragments near 75 mm. An alternative means of measuring is to visually estimate the volume of the 20 to 75 mm fraction, then sieve and weigh the 2 to 20 mm fraction. The fraction 75 mm (3 inches) or greater is usually not included in soil samples taken in the field for laboratory testing. Measurements can be made in the field by weighing the dry sample and the portion retained on a 3-inch screen. The smallest dimension of discrete artifacts is used to determine whether these items pass through a sieve. The quantity is expressed as a weight percentage of the total soil. A sample as large as 200 pounds to more than a ton may be needed to assure that the results are representative. Measurements of the fraction from 75 to 250 mm (3 to 10 inches)

and the fraction greater than 250 mm (10 inches) in diameter are usually obtained from volume estimates.

D. Estimates

- (1) Estimates of discrete artifacts are made similarly to the way estimates of rock fragments are made. These estimates are usually made by visual means and are on the basis of percent by volume. The percent by volume is converted to percent by weight by using the average bulk unit weights for the soil and the specific artifacts. These estimates are made during investigation and mapping activities in the field. They are expressed as ranges that include the estimating accuracy as well as the range of values for a component.
- (2) Treated and untreated wood products (e.g., lumber) are considered artifacts. They are not considered wood fragments such as those associated with the woody materials (e.g., tree branches) described in organic soils.
- (3) Measurements or estimates of discrete artifacts less than strongly coherent are made prior to any rolling or crushing of the sample.

E. Artifact Cohesion

- (1) Definition.—“Artifact cohesion” is the relative ability of the artifact to remain intact after significant disturbance.
- (2) Significance.—Artifacts that break down easily are similar to pararock fragments in that these artifacts break down to become part of the fine-earth fraction of the soil. Noncohesive artifacts are excluded from entries for the standards sieves and are not used in sieve calculations.
- (3) Entries.—Enter cohesive or noncohesive in the “Component Horizon Human Artifacts” and the “Pedin Horizon Human Artifacts” tables of the NASIS database. Cohesion is based on whether the artifact can be easily broken into <2 mm size pieces either in the hands or with a mortar and pestle. Artifacts that cannot easily be broken are cohesive. All others are considered noncohesive.

F. Artifact Kind

- (1) Definition.—“Artifact kind” is the type of object or material being described.
- (2) Significance.—Each type of artifact is associated with a combination of other property entries that is used to determine whether the artifact is considered for sieve entries and calculations. The type of artifact also gives clues to the age of the deposit as well as the potential toxicity.
- (3) Entries.—Enter the artifact kind in the “Component Horizon Human Artifacts” and “Pedin Horizon Human Artifacts” tables. Enter the appropriate choice for the kind of discrete artifact from the following list:
 - (i) Bitumen (asphalt)
 - (ii) Boiler slag
 - (iii) Bottom ash
 - (iv) Brick
 - (v) Cardboard
 - (vi) Carpet
 - (vii) Cloth
 - (viii) Coal combustion by-products
 - (ix) Concrete

- (x) Debitage
- (xi) Fly ash
- (xii) Glass
- (xiii) Metal
- (xiv) Paper
- (xv) Plasterboard
- (xvi) Plastic
- (xvii) Potsherd
- (xviii) Rubber
- (xix) Treated wood
- (xx) Untreated wood

G. Artifact Penetrability

- (1) Definition.—“Artifact penetrability” is the relative ease with which roots can penetrate the artifact and potentially extract any stored moisture, nutrients, or toxic elements.
- (2) Significance.—Artifacts that are penetrable may increase the available water-holding capacity of a soil and should be factored in such calculations. The availability of supplemental nutrients and toxic elements is also greatest in penetrable artifacts.
- (3) Entries.—Enter nonpenetrable or penetrable in the “Component Horizon Human Artifacts” and “Pedon Horizon Human Artifacts” tables based on whether roots can penetrate the solid parts of the artifact or between the component parts of the artifact.

H. Artifact Persistence

- (1) Definition.—“Artifact persistence” is the relative ability of solid artifacts to withstand weathering and decay over time.
- (2) Significance.—Artifacts that decay quickly are similar to pararock fragments and are treated as such in sieve calculations.
- (3) Entries.—Enter nonpersistent or persistent in the “Component Horizon Human Artifacts” and “Pedon Horizon Human Artifacts” tables based on whether the artifact is expected to decay in less than a decade or greater than a decade. Nonpersistent artifacts are expected to decay in less than a decade. Persistent artifacts remain intact for a decade or more.

I. Artifact Roundness

- (1) Definition.—“Artifact roundness” is an expression of the sharpness of edges and corners of objects.
- (2) Significance.—The roundness of artifacts impacts water infiltration, root penetration, and macropore space.
- (3) Classes.—The artifact roundness classes follow those used for fragment roundness:

Figure 618-A1

Roundness Class	Definition
Very angular	Strongly developed faces with very sharp, broken edges.
Angular	Strongly developed faces with sharp edges (<i>Soil Survey Manual</i> (SSM)).
Subangular	Detectable flat faces with slightly rounded corners.
Subrounded	Detectable flat faces with well rounded corners (SSM).
Rounded	Flat faces absent or nearly absent with all corners rounded (SSM).
Well rounded	Flat faces absent with all corners rounded.

- (4) Entries.—Enter the appropriate artifact roundness class name for the record of artifacts populated in the “Component Horizon Human Artifacts” and “Pedon Horizon Human Artifacts” tables.

J. Artifact Safety

- (1) Definition.—“Artifact safety” is the degree of risk to humans from contact with soils that contain artifacts. Physical contact with soils containing dangerous or harmful artifacts should be avoided unless proper training and protective clothing is available. The risk is based on toxicity to living organisms and not the physical risk that may be present from sharp or heavy objects. Harmful toxicity may be immediate or long-term, through direct or indirect contact. Examples of innocuous artifacts include brick, concrete, glass, plastic, unprinted paper and cardboard, and untreated wood. Some examples of noxious artifacts are batteries, bitumen (asphalt), fly ash, garbage, paper printed with metallic ink, and wood treated with arsenic.
- (2) Significance.—Noxious artifacts are dangerous and require special handling when sampling. Areas with noxious artifacts should have restricted human contact.
- (3) Entries.—Enter innocuous or noxious in the “Component Horizon Human Artifacts” and “Pedon Horizon Human Artifacts” tables based on whether the artifacts are potentially toxic to living beings.

K. Artifact Shape

- (1) Definition.—“Artifact shape” is a description of the overall shape of the object.
- (2) Significance.—Artifact shape differs from rock, pararock, and wood fragment shape descriptions and is important for fluid flow in the soil as well as influencing excavation difficulty.
- (3) Classes.—The artifact shape classes are: elongated, equidimensional, flat, and irregular.

- (4) Entries.—Enter the appropriate artifact shape class name for each record of artifacts populated in the “Component Horizon Human Artifacts” and “Pedon Horizon Human Artifacts” tables.

L. Artifact Size

- (1) Definition.—“Artifact size” is based on the cross-sectional diameter of the object.
- (2) Significance.—The size of discrete artifacts is significant to the use and management of the soil. Artifact sizes ranging from 2 mm to 75 mm that are both cohesive and

persistent are considered when estimating the percent passing the sieves. Artifact size affects equipment use, excavation, construction, and recreational uses.

- (3) Entries.—Enter the cross-sectional diameter size of the ≥ 2 mm artifacts described in the “Component Horizon Human Artifacts” and “Pedon Horizon Human Artifacts” tables. The range of valid entries is from 2 to 3,000 millimeters, and only whole numbers (integers) are allowed.

M. Artifact Volume

- (1) Definition.—“Artifact volume” is the volume percentage of the horizon occupied by the 2 mm or larger fraction (20 mm or larger for wood artifacts) on a whole soil base.
- (2) Significance.—The volume occupied by discrete artifacts (2 mm or larger fraction) is important in selecting appropriate texture modifiers (i.e., artifactual, very artifactual, extremely artifactual). Some soil horizons contain combinations of artifacts and rock fragments. See section 618.72 for guidance in assigning either single (artifact only), compound (artifact and rock fragment), or dual (rock fragment-artifact) texture modifiers for horizons containing artifacts.
- (3) Entries.—Enter the high, low, and representative values for the percent volume present of each size class and kind of artifact populated in the “Component Horizon Human Artifacts” and “Pedon Horizon Human Artifacts” tables. The range of valid entries is from 0 to 100 percent, and only whole numbers (integers) are allowed.

618.6 Available Water Capacity

A. Definition.—“Available water capacity” (AWC) is the volume of water that should be available to plants if the soil, inclusive of fragments, were at field capacity. It is commonly estimated as the amount of water held between field capacity and wilting point, with corrections for salinity, fragments, and rooting depth. Available water capacity is determined on each soil layer (horizon) described. AWC differs from the agronomic determination of available water supply (AWS) in that AWS is the weighted sum of AWC for each layer to a specified depth of soil.

B. Classes.—Classes of available water capacity are not normally used except as adjective ratings that reflect the sum of available water capacity in inches to some arbitrary depth. Class limits vary according to climate zones and the crops commonly grown in the areas. The depth of measurement also is variable.

C. Significance.—Available water capacity is an important soil property in developing water budgets, predicting droughtiness, designing and operating irrigation systems, designing drainage systems, protecting water resources, and predicting yields.

D. Estimates.—The most common estimates of available water capacity are made in the field or the laboratory as follows:

- (1) Field capacity is determined by sampling the soil moisture content just after the soil has drained following a period of rain and humid weather, after a spring thaw, or after heavy irrigation. Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS, provides more information.
- (2) The 15-bar moisture content of the samples is determined with pressure membrane apparatus.
- (3) An approximation of soil moisture content at field capacity is commonly made in the laboratory using 1/3-bar moisture percentage for clayey and loamy soil materials and 1/10-bar for sandy materials. Recently, some soil physicists have been using 1/10-bar instead of 1/3-bar for clayey and loamy soil materials and 1/20-bar for sandy soil materials.
- (4) Measure the bulk density of the moist soil. Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS, provides more information.
- (5) Calculate available water capacity (AWC) using the following formula: $AWC = (W_{1/3} - W_{15}) \times (Db_{1/3}) \times C_m / 100$

Where—

AWC = volume of water retained in 1 cm³ of whole soil between 1/3-bar and 15-bar tension; reported as cm cm⁻¹ [numerically equivalent to inches of water per inch of soil (in in⁻¹)]

W_{1/3} = weight percentage of water retained at 1/3-bar tension

W₁₅ = weight percentage of water retained at 15-bar tension

Db_{1/3} = bulk density of <2-mm fabric at 1/3-bar tension

C_m = rock fragment conversion factor derived from: $\frac{\text{volume moist } <2\text{-mm fabric (cm}^3\text{)}}{\text{volume moist whole soil (cm}^3\text{)}}$

Method 3A2b is used to determine volume moist <2-mm fabric (cm³).

$AWC (\text{cm cm}^{-1} \text{ or in in}^{-1} \text{ horizon}) = AWC (\text{cm cm}^{-1} \text{ or in in}^{-1}) \times \text{horizon thickness}$

- (6) If data are available, estimates are based on available water capacity measurements. If data are not available, data from similar soils are used as a guide. The relationship between available water capacity and other soil properties has been studied by many researchers. Soil properties that influence available water capacity are particle size; size, shape, and distribution of pores; organic matter; type of clay mineral; and structure.

- (7) If roots are excluded from a horizon such as a duripan, the amount of water available to plants is nearly zero. Available water capacity values are zero for layers that exclude roots. If roots are restricted but not excluded, estimates of available water capacity are reduced according to the amount of dense material in the layers and the space available for root penetration. Depending on the ability of roots to enter the soil mass and utilize the water, values for the soils with these dense layers may be significantly less than for soils of similar texture that do not have pans. Entries are made for all soil layers below dense layers only if roots are present.
- (8) Depending on their abundance and porosity, rock and pararock fragments reduce available water capacity. Nonporous fragments reduce available water capacity in proportion to the volume they occupy. For example, 50-percent nonporous cobbles reduce available water capacity as much as 50 percent. Porous fragments, such as sandstone, may reduce available water capacity to a lesser extent.
- (9) Several factors contribute to a lower amount of plant growth on saline soils. However, as a rough guide, available water capacity is reduced by about 25 percent per 4 mmhos cm⁻¹ electrolytic conductivity of the saturated extract.
- (10) Soils high in gibbsite or kaolinite, such as Oxisols and Ultisols, may have available water capacity values that are about 20 percent lower than those with equal amounts of 2:1 layer-lattice clays.
- (11) Soils high in organic matter have a higher available water capacity than soils low in organic matter if the other properties are the same.

E. Entries.—Enter high, low, and representative values for available water capacity in cm per cm for each horizon. Enter “0” for layers that exclude roots. The range of valid entries is from 0 to 0.7 cm per cm, and hundredths (two decimal places) are allowed.

618.7 Bulk Density, One-Third Bar

A. Definition.—“Bulk density, one-third bar” is the oven-dried weight of the less than 2 mm soil material per unit volume of soil at a water tension of 1/3 bar (33 kPa).

B. Significance.—Bulk density influences plant growth and engineering applications. It is used to convert measurements from a weight basis to a volume basis. Within a family-level particle-size class, bulk density is an indicator of how well plant roots are able to extend into the soil. Bulk density is used to calculate porosity. Bulk density at 33 kPa is used for soil classification in the required characteristics for andic soil properties and in the criteria for Andic, Aquandic, and Vitrandic subgroups.

- (1) Plant Growth.—Bulk density is an indicator of how well plant roots are able to extend into the soil. Root restriction initiation and root-limiting bulk densities are shown below for various particle-size classes.

Figure 618-A2

Particle-Size Class	Bulk Density (g cm ⁻³)	
	Restriction-Initiation	Root-Limiting
Sandy	1.69	>1.85
Loamy		
coarse-loamy	1.63	>1.80
fine-loamy	1.60	>1.78
coarse-silty	1.60	>1.79
fine-silty	1.54	>1.65
Clayey*		
35-45% clay content	1.49	>1.58
>45% clay content	1.39	>1.47

* Soils with high iron oxide content (e.g., sesquic mineralogy) or with andic soil properties can initiate restriction at lower bulk densities.

- (2) Engineering Applications.—Soil horizons with bulk densities less than those indicated below have low strength and would be subject to collapse if wetted to field capacity or above without loading. They may require special designs for certain foundations.

Figure 618-A3

Particle-Size Class	Bulk Density (g cm ⁻³)
Sandy	<1.60
Loamy	
coarse-loamy	<1.40
fine-loamy	<1.40
coarse-silty	<1.30
fine-silty	<1.40
Clayey	<1.10

C. Estimates.—The weight applies to the oven-dry soil, and the volume applies to the soil at or near field capacity. Bulk density is a use-dependent property. The entry should represent the dominant use for the soil.

D. Entries.—Enter bulk density at 1/3 bar with the low, high, and representative values for each horizon. The range of valid entries is from 0.02 to 2.6 g cm⁻³, and hundredths (two decimal places) are allowed.

618.8 Bulk Density, Oven Dry

A. Definition.—“Bulk density, oven dry” (pb_{od}) is the oven-dry weight of the less than 2 mm soil material per unit volume of oven-dry soil.

B. Estimates.—The value pb_{od} is derived by the following

formula: $pb_{od} = [(\text{linear extensibility percent}/100) + 1]^3 \times pb_{0.33 \text{ bar}}$

Where linear extensibility percent is adjusted to a <2 mm basis.

C. Entries.—Enter the high, low, and representative values for each horizon. The range of valid entries is from 0.02 to 2.6 g cm⁻³, and hundredths (two decimal places) are allowed.

618.9 Bulk Density, Satiated

A. Definition.—“Bulk density, satiated” (pb_{sat}) is the oven-dry weight of the less than 2 mm soil material per unit volume of soil at a water tension of 0 bar. The measurement is only used for subaqueous soils.

B. Significance.—Coastal wetland and subaqueous soils exist in their environment at saturation. Soils with very low bulk density in submerged environments often contain a large percentage of water, making them very fluid. These soil qualities are important in subaqueous soil interpretations for shellfish and rooted vegetation habitat as well as construction, dredge operations, and the calculation of carbon stocks.

C. Estimates.—The value pb_{sat} is calculated based on the dried weight of a known volume of soil at the field moisture status. Sampling methods can vary depending on environment. For samples taken as vibracores and opened by cutting, a 50-ml plastic syringe with the end removed is used to collect a mini-core. The plunger can be fixed at the 10-ml volume mark and the syringe gently pushed into the split vibracore sample to collect a known volume of sample. This technique is a variation of the field-state core method.

D. Entries.—Enter the high, low, and representative values for each horizon. The range of valid entries is from 0.02 to 2.6 g cm⁻³, and hundredths (two decimal places) are allowed.

618.10 Calcium Carbonate Equivalent

A. Definition.—“Calcium carbonate equivalent” is the quantity of carbonate in the soil expressed as CaCO_3 and as a weight percentage of the less than 2 mm size fraction.

B. Significance.—The availability of plant nutrients is influenced by the amount of carbonates in the soil. This is a result of the effect that carbonates have on soil pH and of the direct effect that carbonates have on nutrient availability. Nitrogen fertilizers should be incorporated into calcareous soils to prevent nitrite accumulation or ammonium-N volatilization. The availability of phosphorus and molybdenum is reduced by the high levels of calcium and magnesium which are associated with carbonates. In addition, iron, boron, zinc, and manganese deficiencies are common in soils that have a high calcium carbonate equivalent. In some climates, soils that have a high calcium carbonate equivalent in the surface layer are subject to wind erosion. This effect may occur in soils that have a calcium carbonate equivalent of more than 5 percent. A strongly or violently effervescent reaction to cold, dilute hydrochloric acid (HCL) defines calcareous in the wind erodibility groups because of the significance of finely divided carbonates. Calcium carbonate equivalent is used for soil classification in the criteria for several diagnostic horizons (e.g., mollic epipedon), Rendolls suborder, Rendollic Eutrudepts subgroup, and carbonatic mineralogy class.

C. Measurement.—Calcium carbonate equivalent is measured by a method that uses an aqueous solution of 3 normal hydrogen chloride. The method is outlined in Soil Survey Investigations Report No. 42, *Soil Survey Laboratory Methods Manual*, Version 4.0, November 2004, USDA, NRCS. It also may be measured in the field using calcimeters.

D. Entries.—Enter the high, low, and representative values for each horizon listed. Round values to the nearest 5 percent for horizons that have more than 5 percent CaCO_3 and to the nearest 1 percent for those with less than 5 percent. Enter 0 if the horizon does not have free carbonates. The range of valid entries is from 0 to 110 percent, and only whole numbers (integers) are allowed.

618.11 Cation-Exchange Capacity NH_4OAc pH 7

A. Definition.—“Cation-exchange capacity” is the amount of exchangeable cations that a soil can adsorb at pH 7.0.

B. Significance.—Cation-exchange capacity is a measure of the ability of a soil to retain cations, some of which are plant nutrients. Soils that have a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils that have a high cation-exchange capacity. Soils that have a high cation-exchange capacity have the potential to retain cations, which reduces the risk of the pollution of ground water. Cation-exchange capacity is used indirectly in soil classification, when recalculated for just the noncarbonate clay fraction, in the required characteristics for kandic and oxic horizons and as a criterion for specific subgroup taxa in Alfisols (e.g., Kandic Paleustalfs), Entisols, Inceptisols, and Mollisols. Cation-exchange capacity is also used in calculating the ratio of

cation-exchange capacity to percent noncarbonate clay for classifying certain soils at the family level into cation-exchange activity classes. The latest edition of the Keys to Soil Taxonomy has more information on applying this ratio in classification.

C. Measurement.—Cation-exchange capacity is measured by the methods outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS. The ammonium acetate method gives the cation-exchange capacity value (CEC-7) for soils that have pH >5.5 or contain soluble salts. This method uses a solution of one normal ammonium acetate buffered at pH 7.0 to provide the extracting index cation (NH_4^+). Cation-exchange capacity is reported, on a <2 mm base, in centimoles per kilogram ($\text{cmol}(+) \text{ kg}^{-1}$), which are equivalent to milliequivalents per 100 grams ($\text{meq } 100 \text{ g}^{-1}$) of fine-earth soil. If the pH is less than 5.5, use effective cation-exchange capacity (refer to section 618.20).

D. Entries.—Enter the high, low, and representative values of the estimated range in cation-exchange capacity, in $\text{meq } 100 \text{ g}^{-1}$, for each horizon with pH >5.5. The range of valid entries is from 0 to 400 $\text{meq } 100 \text{ g}^{-1}$, and tenths (one decimal place) are allowed. A NASIS calculation is available and can be viewed in part 618, subpart B, section 618.99.

618.12 Climatic Setting

A. Climatic setting includes frost-free period, precipitation, temperature, and evaporation. These elements are useful in determining the types of natural vegetation or crops that grow or can grow in an area and in planning management systems for vegetation.

- (1) Climatic data are observed nationally by the National Weather Service Cooperative Network, which consists of approximately 10,000 climate stations. The records are available from the Climatic Data Access Facility (CDAF) at Portland, Oregon.
- (2) Climatic data are delivered to the field through the Climatic Data Access Network. The Climatic Data Access Network consists of climatic data liaisons established in each State and at National Headquarters.
- (3) Climatic data that are input into NASIS are obtained from the respective climatic data liaison. Climatic data may also be obtained from project weather stations or from the State climatologist. NRCS has selected the current standard “normal” period of 1971 to 2000 for climate database entries. Existing entries in the NASIS database may reflect the prior period of 1961 to 1990. Always check with your State’s climatic data liaison before using a climate station that has less than 30 years of records or that is located outside a county. Footnote the source of the data, the station, and the starting and ending year of record. Means are given as a range to represent the change of the climate over the geographic extent of the assigned soil.

B. Frost-Free Period

- (1) Definition.—“Frost-free period” is the expected number of days between the last freezing temperature (0°C) in spring (January-July) and the first freezing temperature (0°C) in fall (August-December). The number of days is based on the probability that the values for the standard “normal” period will be exceeded in 5 years out of 10.

- (2) Entries.—Enter the high, low, and representative values for the map unit component. Enter 365 for each value for taxa that are frost-free all year and 0 for those that have no frost-free period. Entries are rounded to the nearest 5 days.

C. Precipitation, Mean Annual

- (1) Definition.—“Mean annual precipitation” is the arithmetic average of the total annual precipitation taken over the standard “normal” period. Precipitation refers to all forms of water, liquid or solid, that fall from the atmosphere and reach the ground.
- (2) Entries.—Enter the high, low, and representative values in millimeters of water to represent the spatial range for the map unit component. The range of valid entries is from 0 to 11,500 mm, and only whole numbers (integers) are allowed.

D. Air Temperature, Mean Annual

- (1) Definition.—“Mean annual air temperature” is the arithmetic average of the daily maximum and minimum temperatures for a calendar year taken over the standard “normal” period.
- (2) Entries.—Enter the high, low, and representative values for the map unit component to represent the spatial range in degrees Celsius (centigrade). The range of valid entries is from -50.0 to 50.0 degrees, and tenths (one decimal place) are allowed. Use a minus sign to indicate temperatures below zero.

E. Daily Average Precipitation

- (1) Definition.—“Daily average precipitation” is the total precipitation for the month divided by the number of days in the month for the standard “normal” period.
- (2) Entries.—Enter the high, low, and representative values, in millimeters. The range of valid entries is from 0 to 750 mm. Record values to the nearest whole number (integer).

F. Daily Average Potential Evapotranspiration

- (1) Definition.—“Daily average potential evapotranspiration” is the total monthly potential evapotranspiration divided by the number of days in the month for the standard “normal” period.
- (2) Entries.—Enter the high, low, and representative values for daily average potential evapotranspiration in millimeters. The range of valid entries is 0 to 300 mm. Record values to the nearest whole number (integer).

618.13 Continuous Inundation Class, Depth, and Month

A. Free water may occur above the soil. Inundation is the condition when the soil is covered by liquid, free water.

B. Definition.—Continuous inundation is permanent or nearly permanent standing water in a basin or closed depression. This includes depressions, lakes, ponds, estuaries, and seas that are inundated for extended periods with very few or no periods when the soil is not covered with water. The inundation is considered permanent, not temporal, with water on the surface more than 21 hours of each day in all years. The water is removed only by deep percolation, transpiration, evaporation, tidal flows, or by a combination of these processes.

Continuous inundation is populated with the frequency of “permanent” in the “Component” table in NASIS. In the “Component month” table, the monthly probability in which standing water occurs, monthly duration, depth of inundation above the soil, and water kind are populated.

C. Continuous Inundation Frequency

“Continuous inundation frequency” is always “permanent” since the soil is nearly permanently or permanently covered with water in every month and every day.

D. Continuous Inundation Monthly Probability

“Continuous inundation month” is the calendar months in which inundation is expected, which is all 12 months since the inundation is permanent or nearly so. The monthly probability class is “extremely high” for all 12 months.

E. Duration Class

- (1) “Continuous inundation duration class” is the duration of inundation, which is “constant” for all 12 months because the soils is covered with water every month and every day or almost every day of the year.
- (2) Classes.—The continuous inundation duration class is defined below:

Figure 618-A4

Continuous Inundation Duration Class	Duration
Constant	More than 21 hours of each day in all years or almost every day in all years

F. Kind

- (1) Definition.—The kind of free water above the soil may be classified as fresh or brackish water.
- (2) Entries and classes.—Three classes are entered in the “Component month” table for each month and may vary depending on the time of year. The classes are defined below:

Figure 618-A5

Continuous Inundation Kind	Definitio n
Fresh water	Water has electrical conductivity < 0.6 dS/m.
Brackish water	Water has electrical conductivity of $\geq$ 0.6 dS/m.
Not assigned	This entry is used if kind is unknown.

G. Depth of Inundation

- (1) Definition.—“Depth of inundation” is the depth of the surface water that continuously covers the soil.
- (2) Entries.—Enter the high, low, and representative values for the depth, in centimeters, for the map unit component. The range of valid entries is 0 to 300 cm, and only whole numbers (integers) are allowed. Depth entries may vary by month if findings support it.

H. Significance.—Continuous inundation is an important concern in designs for all kinds of uses. The depth of the water covering the soils is a critical factor in determining plant and animal species.

618.14 Corrosion

A. Various metals and other materials corrode when they are on or in the soil, and some metals and materials corrode more rapidly when in contact with specific soils than when in contact with others. Corrosivity ratings are given for two of the common structural materials, uncoated steel and concrete.

B. Uncoated steel

- (1) Definition.—“Risk of corrosion for uncoated steel” is the susceptibility of uncoated steel to corrosion when in contact with the soil.
- (2) Classes.—The classes for risk of corrosion to uncoated steel are: low, moderate, and high.
- (3) Significance.—Risk of corrosion to uncoated steel pertains to the potential soil-induced electrochemical or chemical action that converts iron into its ions, thereby dissolving or weakening uncoated steel.
- (4) Guides.—Part 618, subpart B, section 618.80, gives the relationship of soil water, general texture group, acidity, and content of soluble salts (as indicated by either electrical resistivity at field capacity or electrolytic conductivity of the saturated extract of the soil) to corrosion classes.
 - (i) Soil reaction (pH) correlates poorly with corrosion potential; however, a pH of 4.0 or less almost always indicates a high corrosion potential.
 - (ii) Ratings, which are based on a single soil property or quality, that place soils in relative classes for corrosion potential must be tempered by knowledge of other properties and qualities that affect corrosion. A study of soil properties in relation to local experiences with corrosion helps soil scientists and engineers to make soil interpretations. Special attention must be given to those soil properties that affect the access of oxygen and moisture to the metal, the electrolyte, the chemical reaction in the electrolyte, and the flow of current through the electrolyte. Special attention must be given to the presence of sulfides or of minerals, such as pyrite, that can be weathered readily and thus cause a high degree of corrosion in metals.
 - (iii) The possibility of corrosion is greater for extensive installations that intersect soil boundaries or soil horizons than for installations that are in one kind of soil or in one soil horizon.

- (iv) Using interpretations for corrosion without considering the size of the metallic structure or the differential effects of using different metals may lead to wrong conclusions. Activities that alter the soil, such as construction, paving, fill and compaction, and surface additions, can increase the possibility of corrosion by creating an oxidation cell that accelerates corrosion. Mechanical agitation or excavation that results in aeration and in a discontinuous mixing of soil horizons may also increase the possibility of corrosion.
- (5) Entries.—Enter the appropriate class of risk of corrosion for uncoated steel for the whole map unit component. The classes are: low, moderate, and high.

C. Concrete

- (1) Definition.—“Risk of corrosion for concrete” is the susceptibility of concrete to corrosion when in contact with the soil.
- (2) Classes.—The classes for risk of corrosion to concrete are: low, moderate, and high.
- (3) Significance.—Risk of corrosion to concrete pertains to the potential soil-induced chemical reaction between a base (the concrete) and a weak acid (the soil solution). Special cements and methods of manufacturing may be used to reduce the rate of deterioration in soils that have a high risk of corrosion. The rate of deterioration depends on soil texture and acidity; the amount of sodium or magnesium sulfate present in the soil, singly or in combination; and the amount of sodium chloride (NaCl) present in the soil. The presence of NaCl is evaluated because it is used to identify the presence of seawater, rather than because of its corrosive effects on concrete. Seawater contains sulfates, which are one of the principal corrosive agents. A soil that has gypsum or other sulfate minerals requires a special cement in the concrete mix. The calcium ions in gypsum react with the cement and weaken the concrete.
- (4) Guides.—Part 618, subpart B, section 618.81, gives the relationship of soil texture, soil acidity, sulfates, and NaCl to corrosion classes.
- (5) Entries.—Enter the appropriate class of risk of corrosion for concrete for the whole map unit component (i.e., low, moderate, or high).

618.15 Crop Name and Yield

- A. Definition.—“Crop name” is the common name for the crop. “Crop yield” is crop yield units per unit area for the specified crop.
- B. Classes.—The crop names and the units of measure for yields that are allowable as data entries are listed in the NASIS data dictionary. See part 618, subpart B, section 618.82, for the web address of the current NASIS data dictionary.
- C. Significance.—Crop names and units of measure are important as records of crop yield. Although the crops and yield often are specific to the time when the soil survey was completed, the ranking and comparison between soils within a soil survey are helpful. These crop and yield data are used to evaluate the soil productive capabilities, cash rent, and land values. Generally, only the most important crops are listed and only the best management is reflected.

D. Estimates

- (1) Crop names and yields are specific to the soil survey area. Although the listing of crop names is not limited to any number, only the most important crops in the survey area should be used. The yields are derived in a number of ways but should represent a high level of management by leading commercial farmers, which tends to produce the highest economic return per acre. This level of management includes using the best varieties; balancing plant populations and added plant nutrients to the potential of the soil; controlling erosion, weeds, insects, and diseases; maintaining optimum soil tilth; providing adequate soil drainage; and ensuring timely operations.
- (2) Generally, only a representative value is used for each map unit component for non-MLRA soil survey areas. MLRA soil survey areas use the high and low representative values from map unit components of non-MLRA soil survey areas. High and low values represent the range of representative values for a high level of management across the survey area or across several survey areas.

E. Entries.—Enter the common crop name and units of measure. Enter the corresponding irrigated yields, nonirrigated yields, or both, as appropriate for the component. Yields can be posted as high, low, and representative values for the map unit component.

618.16 Diagnostic Horizon Feature – Depth to Bottom

A. Definition.—The diagnostic horizon feature “depth to bottom” is the distance from the top of the soil to the base of the identified diagnostic horizon or to the lower limit of the occurrence of the diagnostic feature.

B. Measurement.—Distance is measured from the top of the soil, which is defined as the top of the mineral soil, or, for soils with “O” horizons, the top of any organic layer that is at least slightly decomposed. For soils that are covered by 80 percent or more rock or pararock fragments, the top of the soil is the mean height of the top of the fragments. See chapter 3 in the *Soil Survey Manual* for a complete discussion.

C. Entries.—The values for the diagnostic horizon feature “depth to bottom” used to populate component data in NASIS are not specific to any one point; they are a reflection of commonly observed values based on field observations and are intended to model the component as it occurs throughout the map unit. Enter the high, low, and representative values in whole centimeters. The high value represents either the greatest depth to which the base of the diagnostic horizon or feature extends or, for horizons for features extending beyond the limit of field observation, is the depth to which observation was made (usually no more than 200 cm). In the case of lithic contact, paralithic contact, and petroferric contact, the entries for depth to the bottom of the diagnostic feature will be the same as the entries for depth to the top of the feature, since the contact has no thickness.

618.17 Diagnostic Horizon Feature – Depth to Top

- A. Definition.—The diagnostic horizon feature “depth to top” is the distance from the top of the soil to the upper boundary of the identified diagnostic horizon or to the upper limit of the occurrence of the diagnostic feature.
- B. Measurement.—Distance is measured from the top of the soil, which is defined as the top of the mineral soil, or, for soils with “O” horizons, the top of any organic layer that is at least slightly decomposed. For soils that are covered by 80 percent or more rock or pararock fragments, the top of the soil is the mean height of the top of the fragments. See chapter 3 in the *Soil Survey Manual* for a complete discussion.
- C. Entries.—The values for the diagnostic horizon feature “depth to top” used to populate component data in NASIS are not specific to any one point; they are a reflection of commonly observed values based on field observations and are intended to model the component as it occurs throughout the map unit. Enter the high, low, and representative values in whole centimeters.

618.18 Diagnostic Horizon Feature – Kind

- A. Definition.—The diagnostic horizon feature “kind” is the kind of diagnostic horizon or diagnostic feature present in the soil.
- B. Significance.—Diagnostic horizons and features are a particular set of observable or measurable soil properties, defined in Soil Taxonomy, that are used to classify a soil. They have been chosen because they are thought to be the marks left on the soil as a result of the dominant soil-forming processes. In many cases, they are thought to occur in conjunction with other important accessory properties. The utilization of diagnostic horizons and features in the classification process allows the grouping of soils that have formed because of similar genetic processes. The grouping, however, is done based on observable or measurable properties rather than by speculation about the genetic history of a particular soil.
- C. Entries.—The diagnostic horizons and features are listed in the latest edition of the *Keys to Soil Taxonomy*. Allowable terms are given in the NASIS data dictionary.

618.19 Drainage Class

- A. Definition.—“Drainage class” identifies the natural drainage condition of the soil. It refers to the frequency and duration of wet periods.
- B. Classes.—The eight natural drainage classes are listed below. Chapter 3 of the *Soil Survey Manual* provides a description of each natural drainage class.
- (1) Excessively drained
 - (2) Somewhat excessively drained

- (3) Well drained
- (4) Moderately well drained
- (5) Somewhat poorly drained
- (6) Poorly drained
- (7) Very poorly drained
- (8) Subaqueous

C. Significance.—Drainage classes provide a guide to the limitations and potentials of the soil for field crops, forestry, range, wildlife, and recreational uses. The class roughly indicates the degree, frequency, and duration of wetness, which are factors in rating soils for various uses.

D. Estimates.—Infer drainage classes from observations of landscape position and soil morphology. In many soils the depth and duration of wetness relate to the quantity, nature, and pattern of redoximorphic features. Correlate drainage classes and redoximorphic features through field observations of water tables, soil wetness, and landscape position. Record the drainage classes assigned to the series.

E. Entries.—Enter the drainage class name for each map unit component. Use separate map unit components for different drainage class phases or for drained versus undrained phases, where needed.

618.20 Effective Cation-Exchange Capacity

A. Definition.—“Effective cation-exchange capacity” is the sum of ammonium acetate extractable bases plus potassium chloride extractable aluminum (if present). Effective cation-exchange capacity may also be determined as a direct measurement using NH_4Cl .

B. Significance.—Cation-exchange capacity (CEC) is a measure of the ability of a soil to retain cations, some of which are plant nutrients. Soils that have a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer and amendments than soils that have a high cation-exchange capacity. Effective CEC (ECEC) is a measure of CEC that is particularly useful in soils whose ion-exchange capacity is largely a result of variable charge components, such as allophane, imogolite, kaolinite, halloysite, hydrous iron and aluminum oxides, and organic matter. As a result, the CEC of these soils is not a fixed number but is a function of pH. Examples of taxa commonly displaying pH-dependent charge include some Andisols, Histosols, acidic Inceptisols, Oxisols, Spodosols, and weathered Ultisols with kaolinitic or halloysitic mineralogies dominated by iron and aluminum oxyhydroxide minerals.

C. Measurement.—Effective cation-exchange capacity is calculated from the analytical results of two separate laboratory methods. One method measures the basic cations (Ca^{2+} , Mg^{2+} , Na^+ , K^+) extractable in a solution of one normal ammonium acetate buffered at pH 7.0. Another method measures the aluminum extractable in a solution of one normal potassium chloride (for soil horizons with a 1:1 water pH of 5.5 or less). The ECEC value is then calculated and reported for soil horizons that have pH 5.5 or less and that are low in soluble salts. For soils that have a pH of >5.5, the ECEC usually equals only the sum of the NH_4OAc extractable bases. Manual ECEC population in NASIS for soil horizons with pH values between 5.6 and 7.0 is optional and is only

needed if there is a significant difference from the populated CEC values (based on NH_4OAc buffered at pH 7.0).

- (1) An alternate procedure exists to measure ECEC. It involves a direct measurement by using a neutral unbuffered salt (NH_4Cl) and is an analytically determined value. For a soil with a pH of less than 7.0 (in water, 1:1), the ECEC value should be less than the CEC value measured with a buffered solution at pH 7.0. The ECEC by NH_4Cl is equal to the NH_4OAc extractable bases plus the KCl extractable Al for noncalcareous soils. For more discussion on ECEC, see Soil Survey Investigations Report No. 45, Soil Survey Laboratory Information Manual, Version 2.0, February 2011, USDA, NRCS.
- (2) The laboratory methods for both the standard and alternate procedures are outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.
- (3) Effective cation-exchange capacity is reported, on a <2 mm base, in centimoles per kilogram ($\text{cmol}(+) \text{ kg}^{-1}$) of soil, which are equivalent to milliequivalents per 100 grams ($\text{meq } 100 \text{ g}^{-1}$) of fine-earth soil.

D. Entries.—Enter the high, low, and representative values of the estimated range in effective cation-exchange capacity at the field pH of the soil, in $\text{meq } 100 \text{ g}^{-1}$, for the horizon. The range of valid entries is from 0 to 400 $\text{meq } 100 \text{ g}^{-1}$, and tenths (one decimal place) are allowed. A NASIS calculation is available and can be viewed in part 618, subpart B, section 618.100.

618.21 Electrical Conductivity

A. Definition.—“Electrical conductivity” is the electrolytic conductivity of an extract from saturated soil paste.

B. Classes.—The classes of salinity are listed below:

Figure 618-A6

Salinity Class	Electrical Conductivity (mmhos cm^{-1})
Nonsaline	0-2
Very slightly saline	>2-4
Slightly saline	>4-8
Moderately saline	>8-16
Strongly saline	>16

C. Significance.—Electrical conductivity is a measure of the concentration of water-soluble salts in soils. It is used to indicate saline soils. High concentrations of neutral salts, such as sodium chloride and sodium sulfate, may interfere with the absorption of water by plants because the osmotic pressure in the soil solution is nearly as high as or higher than that in the plant cells. Salts may also interfere with the exchange capacity of nutrient ions, thereby resulting in nutritional deficiencies in plants. Electrical conductivity in the extract from a saturated paste is used for soil classification in the required characteristics for the salic horizon and in criteria for certain taxa such as Dystric great groups and Halic subgroups of Vertisols.

D. Measurement.—The electrolytic conductivity of a saturated extract is the standard measure used to express salinity. Units of measure are decisiemens per meter (dS m^{-1}), which are equivalent to millimhos per centimeter (mmhos cm^{-1}), at 25 degrees C. The laboratory procedure used to measure electrical conductivity is described in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

E. Estimates.—Field estimates of salinity are made from observations of visible salts on faces of peds, throughout the horizon matrix, on the soil surface, or some combination of the three; from plant growth or productivity; from the presence of native plant indicator species; and from field salinity meters. The occurrences of bare spots, salt-tolerant plants, and uneven crop growth are used as indicators of salinity and high electrical conductivity. When keyed to measurements, these observations help to estimate the amount of salts.

F. Entries.—Enter the high, low, and representative values for the range of electrolytic conductivity of the saturation extract during the growing season for each horizon. If laboratory measurements or accurate field estimates are available, the high and low values do not need to correspond with salinity class limits. However, if data is limited, use the following ranges to represent the high and low values of the salinity classes: 0-2, 2-4, 4-8, 8-16, and 16-32 (or a reasonable high value for the strongly saline class) or use a combination of classes (for example, 2- 8 for the high and low values). The range of valid entries is from 0 to 15000 mmhos cm^{-1} , and tenths (one decimal place) are allowed.

618.22 Electrical Conductivity 1:5 (volume)

A. Definition.—“Electrical conductivity 1:5 (volume)” is the electrolytic conductivity of a diluted, unfiltered supernatant of 1 part soil to 5 parts distilled water as measured by volume. The measurement is only used for subaqueous soils.

B. Classes.—See the salinity classes described above in “Electrical Conductivity” (section 618.21). The traditional salinity classes were designed as phase criteria for terrestrial soils and are not applicable to subaqueous soils.

C. Significance.—Electrical conductivity (EC) 1:5 (volume) is a measure of the concentration of water-soluble salts in soils. It is used to indicate the threshold between freshwater and salt and brackish water subaqueous soils. Measuring EC in this manner is the best approach for

subaqueous soils as samples containing reduced sulfide must be kept moist to avoid oxidation and production of sulfate salts that can increase the electrical conductivity. Salinity tolerance in plants is a measure of diminished plant growth at a threshold of 10-percent reduction in biomass. This is not the same as the maximum salinity tolerance which is an LD50 response. Electrical conductivity 1:5 (volume) is used for soil classification in the criteria for the Frasiwassents and Frasiwassists great groups.

D. Measurement.—EC 1:5 (volume) measured in an unfiltered supernatant is the standard measure used to express salinity in subaqueous soils. EC 1:5 (volume) must be measured in a fresh, field wet sample (moisture content at sample collection) that has been refrigerated or even frozen because sulfides may oxidize during drying and form sulfate salts, which can increase the EC value. This method assumes that the salts in subaqueous soils are highly soluble chloride and sulfate salts, in a dissolved state, with no important contributions from minerals such as gypsum. Units of measure are decisiemens per meter (dS m^{-1}), at 25 degrees C. The laboratory procedure used to measure electrical conductivity is described in an addendum to the Soil Survey Investigations Report No. 51, Soil Survey Field and Laboratory Methods Manual, Version 2.0, 2014, USDA, NRCS.

E. Estimates.—Field estimates of salinity are made for subaqueous soils from observations of the presence of native plant indicator species and from measuring the water column with field salinity refractometers. Caution should be used in comparing water column salinity to soil salinity. Ground water discharge can decrease soil salinity, and seasonal evaporation of seawater in barrier salt marshes can produce brine that sinks through the ground water to collect in subsurface coarse-textured lenses. Salinity distributions in mainland-associated soils tend to have a systematic decrease with depth while salinity in other subaqueous soils remain high with depth.

F. Entries.—Enter the high, low, and representative values for the range of electrolytic conductivity 1:5 (volume) of the unfiltered supernatant for each horizon. The range of valid entries is from 0 to 100 dS m^{-1} , and tenths (one decimal place) are allowed.

618.23 Elevation

A. Definition.—“Elevation” is the vertical distance from mean sea level to a point on the Earth’s surface.

B. Significance.—Elevation, or local relief, influences the genesis of natural soil bodies. Elevation also may affect soil drainage within a landscape, salinity or sodicity within a climatic area, or soil temperature.

C. Estimates.—Elevation is normally obtained from U.S. Geological Survey topographic maps or measured using altimeters or global positioning systems.

D. Entries.—Enter the high, low, and representative values for elevation in meters for each map unit component. The range of valid entries is from -300 to 8550 meters, and tenths (one decimal place) are allowed.

618.24 Engineering Classification

A. AASHTO Group Classification

- (1) Definition.—“AASHTO group classification” is a system that classifies soils specifically for geotechnical engineering purposes that are related to highway and airfield construction. It is based on particle-size distribution and Atterberg limits, such as liquid limit and plasticity index. This classification system is covered in Standard No. M 145-82, published by the American Association of State Highway and Transportation Officials (AASHTO), and consists of a symbol and a group index. The classification is based on that portion of the soil that is smaller than 3 inches in diameter.
- (2) Classes.—The AASHTO classification system identifies two general classifications: granular materials having 35 percent or less, by weight, particles smaller than 0.074 mm in diameter and silt-clay materials having more than 35 percent, by weight, particles smaller than 0.074 mm in diameter. These two divisions are further subdivided into seven main group classifications. Part 618, subpart B, section 618.83, shows the criteria for classifying soil in the AASHTO classification system. The group and subgroup classifications are based on estimated or measured grain-size distribution and on liquid limit and plasticity index values.
- (3) Significance.—The group and subgroup classifications of this system aid in the evaluation of soils for highway and airfield construction. The classifications can help to make general interpretations relating to performance of the soil for engineering uses, such as highways and local roads and streets.
- (4) Measurements.—Measurements involve sieve analyses for the determination of grain-size distribution of that portion of the soil between a 3 inch and 0.074 mm particle size. ASTM Designations D 422, C 136, and C 117 have applicable procedures for the determination of grain-size distribution. The liquid limit and plasticity index values (ASTM Designation D 4318) are determined for that portion of the soil having particles smaller than 0.425 mm in diameter (no. 40 sieve). Measurements, such as laboratory tests, are made on most benchmark soils and on other representative soils in survey areas.
- (5) Estimates.—During soil survey investigations and field mapping activities, the soil is classified by field methods. This classification involves making estimates of particle-size fractions by a percentage of the total soil, minus the greater-than-3-inch fraction. Estimates of liquid limit and plasticity index are based on clay content and mineralogy relationships. Estimates are expressed in ranges that include the estimating accuracy as well as the range of values for the taxon.
- (6) Entries.—Enter classes and separate them by commas for each horizon, for example, A-7, A-6. The acceptable entries for AASHTO group are A-1, A-1-a, A-1-b, A-2, A-2-4, A-2-5, A-2-6, A-2-7, A-3, A-4, A-5, A-6, A-7, A-7-5, A-7-6, and A-8.

B. AASHTO Group Index

- (1) Definition.—The AASHTO group and subgroup classifications may be further modified by the addition of a group index value. The empirical group index formula was devised for approximate within-group evaluation of the “clayey granular” materials and the “silty-clay” materials.

- (2) Significance.—The group index aids in the evaluation of the soils for highway and airfield construction. The index can help to make general interpretations relating to performance of the soil for engineering uses, such as highways and local roads and streets.

- (3) Measurement.—The group index (GI) is calculated from an empirical

formula: $GI = (F-35) [0.2 + 0.005 (LL-40)] + 0.01 (F-15) (PI-10)$

Where—

F = percentage passing sieve No. 200 (75 micrometer), expressed as a whole number LL = liquid limit

PI = plasticity index

In calculating the group index of A-2-6 and A-2-7 subgroups, only the PI portion of the formula is used.

- (4) Entries.—The group index is reported to the nearest integer. If the calculated group index is negative, the group index value is zero. The minimum group index value is 0, and the maximum is 120. A NASIS calculation is available and can be viewed in part 618, subpart B, section 618.98.

C. Unified Soil Classification

- (1) Definition.—The Unified soil classification is a system that classifies mineral and organic mineral soils for engineering purposes based on particle-size characteristics, liquid limit, and plasticity index.

- (2) Classes

- (i) The Unified soil classification system identifies three major soil divisions:

- Coarse-grained soils having less than 50 percent, by weight, particles smaller than 0.074 mm in diameter.
 - Fine-grained soils having 50 percent or more, by weight, particles smaller than 0.074 mm in diameter.
 - Highly organic soils that demonstrate certain organic characteristics.
- These divisions are further subdivided into a total of 15 basic soil groups.

- (ii) The major soil divisions and basic soil groups are determined on the basis of estimated or measured values for grain-size distribution and Atterberg limits. ASTM

Designation D 2487 shows the criteria chart used for classifying soil in the Unified system, the 15 basic soil groups of the system, and the plasticity chart for the system.

- (3) Significance.—The various groupings of this classification have been devised to correlate in a general way with the engineering behavior of soils. This correlation provides a useful first step in any field or laboratory investigation for engineering purposes. It can be used to make some general interpretations relating to probable performance of the soil for engineering uses.

- (4) Measurement.—The methods for measurement are provided in ASTM Designation D 2487. Measurements involve sieve analysis for the determination of grain-size distribution of that portion of the soil between 3 inches and 0.074 mm in diameter (no.

- 200 sieve). ASTM Designations D 422, C 136, and C 117 have applicable procedures that are used, where appropriate, for the determination of grain-size distribution. Values for the Atterberg limits (liquid limit and plasticity index) are also used. Specific tests are made for that portion of the soil having particles smaller than 0.425 mm in diameter (no. 40 sieve) according to ASTM Designations D 423 and D 424. Measurements, such as laboratory tests, are made on most benchmark soils and on other representative soils in survey areas.
- (5) Entries for Measured Data.—For measured Unified data, enter up to four classes for each horizon. ASTM Designation D 2487 provides flow charts for classifying the soils. Separate the classes by commas, for example, CL-ML, ML. Acceptable entries are: GW, GP, GM, GC, SW, SP, SM, SC, CL, ML, OL, CH, MH, OH, PT, CL-ML, GW-GM, GW-GC, GP-GM, GP-GC, GC-GM, SW-SM, SW-SC, SP-SM, SP-SC, and SC-SM.
 - (6) Estimates.—The methods for estimating are provided in ASTM Designation D 2488. During all soil survey investigations and field mapping activities, the soil is classified by field methods. The methods include making estimates of particle-size fractions by a percentage of the total soil. The Atterberg limits are also estimated based on the wet consistency, ribbon or thread toughness, and other simple field tests. These tests and procedures are explained in ASTM Designation D 2488. If samples are later tested in the laboratory, adjustments are made to field procedures as needed. Estimates are expressed in ranges that include the estimating accuracy as well as the range of values from one location to another within the map unit. If an identification is based on visual-manual procedures, it must be clearly stated so in reporting.
 - (7) Entries for Estimated Soils.—For estimated visual-manual Unified data, enter up to four classes for each horizon. ASTM Designation D 2488 provides flow charts for classifying the soils. Separate the classes by commas, for example, CL, ML, SC. Acceptable entries are: GW, GP, GM, GC, SW, SP, SM, SC, CL, ML, OL, CH, MH, OH, PT, CL-ML, GW-GM, GW-GC, GP-GM, GP-GC, GC-GM, SW-SM, SW-SC, SP-SM, SP-SC, and SC-SM.

618.25 Erosion Accelerated, Kind

- A. Definition.—“Erosion accelerated, kind” is the type of detachment and removal of surface soil particles that is largely affected by human activity.
- B. Significance.—The type of accelerated erosion is important in assessing the current health of the soil and in assessing its potential for different uses. Erosion, whether natural or induced by humans, is an important process that affects soil formation and may remove all or parts of the soils formed in the natural landscape.
- C. Classes.—There are five kinds of accelerated erosion:
 - (1) Water erosion, sheet
 - (2) Water erosion, rill
 - (3) Water erosion, gully
 - (4) Water erosion, tunnel
 - (5) Wind erosion

D. Entries.—Enter the appropriate class for each map unit component. Multiple entries are allowable, but a representative value should be indicated.

618.26 Erosion Class

A. Definition.—“Erosion class” is the class of accelerated erosion.

B. Significance

- (1) The degree of erosion that has taken place is important in assessing the health of the soil and in assessing the soil’s potential for different uses. Erosion is an important process that affects soil formation and may remove all or parts of the soils formed in natural landscapes.
- (2) Removal of increasing amounts of soil increasingly alters various properties and capabilities of the soil. Properties and qualities affected include bulk density, organic matter content, tilth, and water infiltration. Altering these properties affects the productivity of the soil.

C. Estimates.—During soil examinations, estimate the degree to which soils have been altered by accelerated erosion. The *Soil Survey Manual* describes the procedures involved.

D. Classes.—There are five erosion classes:

- (1) None – deposition
- (2) Class 1
- (3) Class 2
- (4) Class 3
- (5) Class 4

E. Entries.—Enter the appropriate class for each map unit component.

618.27 Excavation Difficulty Classes

A. Definition.—“Excavation difficulty classes” are used for soil layers, horizons, pedons, or geologic layers and estimate the difficulty of making an excavation into them. Excavation difficulty, in most instances, is strongly controlled by water state, which should be specified.

B. Classes.—The excavation difficulty classes are defined below:

Figure 618-A7

Class	Definition
Low	Excavations can be made with a spade using arm-applied pressure only. Neither application of impact energy nor application of pressure with the foot to a spade is necessary.
Moderate	Arm-applied pressure to a spade is insufficient. Excavation can be accomplished quite easily by application of impact energy with a spade or by foot pressure on a spade.
High	Excavation with a spade can be accomplished with difficulty. Excavation is easily possible with a full-length pick, using an over-the-head swing.
Very high	Excavation with a full-length pick, using an over-the-head swing, is moderately to markedly difficult. Excavation is possible in a reasonable period of time with a backhoe mounted on a 40 to 60 kW (50-80 hp) tractor.
Extremely high	Excavation is nearly impossible with a full-length pick using an over-the-head arm swing. Excavation cannot be accomplished in a reasonable time period with a backhoe mounted on a 40 to 60 kW (50-80 hp) tractor.

C. Significance.—Excavation difficulty classes are important for evaluating the cost and time needed to prepare shallow excavations.

D. Estimates.—Estimates of excavation difficulty classes are made from field observations.

E. Entries.—Enter the appropriate class for each horizon. The allowable entries are: low, moderate, high, very high, and extremely high.

618.28 Exchangeable Sodium

A. Definition.—“Exchangeable sodium” is a measure of soil exchangeable sodium ions that may become active by cation exchange. It is the fraction of the cation-exchange capacity of a soil that is occupied by sodium ions, expressed as a percentage.

B. Significance.—Exchangeable sodium percentage (ESP) is used for soil classification in the required characteristics for the natric horizon, in the key to soil orders and key to suborders of Inceptisols and Mollisols, and in criteria for certain taxa such as Sodic subgroups. Soils that have values for exchangeable sodium of 15 percent or more may have an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

C. Measurement.—The ESP is calculated by several methods which use the results of separate procedures to measure the sodium extractable by NH_4OAc and the cation-exchange capacity by NH_4OAc , pH 7.0 (CEC-7) as outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS. Units of measure for extractable sodium and cation-exchange capacity are centimoles per kilogram ($\text{cmol}(+) \text{ kg}^{-1}$) of soil, which are equivalent to milliequivalents per 100 grams (meq

100 g⁻¹) of soil. In some soils with high salt content (i.e., >20 dS m⁻¹) the ESP is calculated using the sodium extractable by NH₄OAc, the cation-exchange capacity by NH₄OAc, pH 7.0 (CEC-7), the water saturation percentage, and the water-soluble sodium (mmol (+) L⁻¹).

D. Entries.—Enter high, low, and representative values as percentages for each horizon for which data is available. The range of valid entries is from 0 to 100 percent, and only whole numbers (integers) are allowed.

618.29 Extractable Acidity

A. Definition.—“Extractable acidity” is a measure of soil exchangeable hydrogen ions that may become active by cation exchange.

B. Significance.—Extractable acidity is important for certain evaluations of soil nutrient availability or of the effect of waste additions to the soil. Extractable acidity is indirectly important data for soil classification because it is needed to calculate cation-exchange capacity by sum of cations (at pH 8.2). The cation-exchange capacity by the sum of cations method is used to calculate percent base saturation by sum of cations.

C. Measurement.—Extractable acidity is determined by a method using a solution of barium chloride-triethanolamine buffered at pH 8.2, as outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS. Units of measure are centimoles per kilogram (cmol(+) kg⁻¹) of soil, which are equivalent to milliequivalents per 100 grams (meq 100 g⁻¹) of soil.

D. Entries.—Enter the range of extractable acidity in milliequivalents per 100 grams (meq 100 g⁻¹) of soil for the horizon. The range of valid entries is from 0 to 250 meq 100 g⁻¹, and tenths (one decimal place) are allowed. A NASIS calculation is available and can be viewed in part 618, subpart B, section 618.101.

618.30 Extractable Aluminum

A. Definition.—“Extractable aluminum” is the amount of aluminum that approximates the aluminum considered exchangeable. It is a measure of the “active” acidity present in soils with a 1:1 water pH ≤5.5.

B. Significance.—Extractable aluminum is important for certain evaluations of soil nutrient availability and of toxicities. An aluminum saturation of about 60 percent is usually regarded as toxic to most plants. It may be a useful measurement for assessing potential lime needs for acid soils. Extractable aluminum is used for soil classification in the criteria for Alic and some Eutric subgroups of Andisols.

C. Measurement.—Extractable aluminum is determined by a method using a solution of one normal potassium chloride, as outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS. Units of measure are centimoles per kilogram ($\text{cmol}(+) \text{ kg}^{-1}$) of soil, which are equivalent to milliequivalents per 100 grams ($\text{meq } 100 \text{ g}^{-1}$) of soil.

D. Entries.—Enter the range of extractable aluminum as milliequivalents per 100 grams ($\text{meq } 100 \text{ g}^{-1}$) of soil for the horizon. The range of valid entries is from 0 to 150 $\text{meq } 100 \text{ g}^{-1}$, and hundredths (two decimal places) are allowed.

618.31 Flooding Frequency Class, Duration Class, Inundation Type, and Month

A. Free water may occur above the soil. Inundation is the condition when the soil area is covered by liquid, free water.

B. Definition.—“Flooding” is the temporary inundation by flowing water from any source, such as streams overflowing their banks, runoff from adjacent or surrounding slopes, inflow from high tides, or any combination of sources. Chapter 3 of the *Soil Survey Manual* provides additional information. Standing water (ponding) or water that forms a permanent covering is excluded from the definition.

C. Classes.—Estimates of flooding class are based on the interpretation of soil properties and other evidence gathered during soil survey fieldwork. Flooding hazard is expressed by flooding frequency class, flooding duration class, flooding inundation type, and time of year that flooding occurs. Not considered here, but nevertheless important, are velocity and depth of floodwater. Frequencies used to define classes are generally estimated from evidence related to the soil and vegetation. They are expressed in wide ranges that do not indicate a high degree of accuracy. Flooding frequencies that are more precise can be calculated by performing complex analyses used by engineers. The class “very frequent” is used for areas subject to daily and monthly high tides.

- (1) Flooding Frequency Class.—“Flooding frequency class” indicates the number of times flooding occurs over a period of time. The classes of flooding are defined as follows:

Figure 618-A8

Flooding Frequency Class	Definition
None	No reasonable possibility of flooding; less than 0.2 percent chance of flooding in any year or less than 1 time in 500 years.
Very rare	Flooding is very unlikely but is possible; 0.2 to less than 1 percent chance of flooding in any year, or 1 time or more in 500 years but less than 1 time in 100 years.

Flooding Frequency Class	Definition
Rare	Flooding is unlikely but is possible; 1 to less than 5 percent chance of flooding in any year, or 1 time or more in 100 years but less than 5 times in 100 years.
Occasional	Flooding is expected infrequently; 5 to less than 50 percent chance of flooding in any year, or 5 times or more in 100 years but less than 50 times in 100 years.
Frequent	Flooding is likely to occur often; 50 percent or more chance of flooding in any year, or 50 times or more in 100 years but less than 50 percent in all months of any year.
Very frequent	Flooding is likely to occur very often; more than 50 percent chance of flooding in all months of any year.

- (2) **Flooding Duration Class.**—The average duration of inundation per flood occurrence is given only for the occasional, frequent, and very frequent classes (defined above).

Figure 618-A9

Flooding Duration Class	Duration
Extremely brief	0.1 to < 4 hours
Very brief	4 hours to < 2 days
Brief	2 days to < 7 days
Long	7 days to < 30 days
Very long	≥ 30 days

- (3) **Flooding Inundation Type.**—The type of water flow or flooding event that causes inundation of the soil. The three inundation types that are populated in the NASIS database are defined below. Definitions of terms follow.

Figure 618-A10

Flooding Inundation Type	Definition
Overbank flow	Inundation by a stream flowing above and outside of its normal channel.
Overland flow	Inundation by runoff water coming from surrounding or adjacent slopes; water flow is not concentrated in any form of stream channel.
Tidal flow	Inundation as a result of flows from astronomical tides, such as solar and lunar tides, storm surges, storm tides, wind tides, and tsunami waves.

(4) Terms

- (i) Overbank flow and overland flow.—Flooding that originates on the land and inundates terrestrial soils, subaqueous soils, and water bodies.
- (ii) Tidal flow.—Flooding that originates in water bodies, such as bays, estuaries, seas, and lakes, and inundates terrestrial soils, subaqueous soils, and water; it includes tidal flow, solar tide, lunar tide, storm surge, storm tide, wind tide, and tsunami.
- (iii) Solar tide.—Normal rise in water level produced by the gravitational pull of the sun.
- (iv) Lunar tide.—Normal rise in water level produced by the gravitational pull of the moon.
- (v) Storm surge.—An abnormal rise in water level during a storm, measured as the height of the water above the normal predicted astronomical tide.
- (vi) Storm tide.—An abnormal rise in water level during a storm, resulting from the combination of storm surge and the astronomical tides.
- (vii) Wind tide.—An abnormal rise in water level produced by the wind.
- (viii) Tsunami.—An abnormal rise in water level or a wave caused by seismic activity, including underwater earthquakes, volcanic eruptions, and landslides.

D. Assignment

- (1) Yearly flooding frequency classes are assigned to months and indicate the months of likely occurrence in the year and not the frequency of the flooding during the month, except for the very frequent class. The time period expressed includes 70 percent of the occurrences. Only in the very frequent and none classes are all 12 months populated with a frequency.
- (2) Only the dominant flooding inundation type and the highest frequency are populated for soils that have more than one type of flooding. For example, some soils that are flooded by overbank flow from rivers are also subject to storm tides. The three types populated in the NASIS database are overbank flow, overland flow, and tidal flow, as defined above.
- (3) Flooding duration classes are assigned to months. Time period and duration of flooding are the most critical factors that determine the growth and survival of a given plant species. Flooding during the dormant season has few if any harmful effects on plant growth or mortality and may improve the growth of some species. If inundation from floodwater occurs for long periods during the growing season, the soil becomes oxygen deficient and plants may be damaged or killed.

E. Significance.—The susceptibility of soils to flooding is an important consideration for building sites, sanitary facilities, and other uses. Floods may be less costly per unit area of farmland as compared to that of urban land, but the loss of crops and livestock can be disastrous.

F. Estimates.—The most precise evaluation of flood-prone areas for stream systems is based on hydrologic studies. The area subject to inundation during a flood of a given frequency, such as one with a 1 percent or 2 percent chance of occurrence, is generally determined by one of two basic methods.

- (1) The first method is used if stream flow data are available. In this method, the data are analyzed to determine the magnitude of floods of different frequencies. Engineering studies are made to determine existing channel capacities and flow on the flood plain by the use of valley cross sections and water-surface profiles.

- (2) The second method is used if stream flow data are not available. In this method, hydrologists make an estimate of flood potential from recorded data on rainfall. They consider such factors as—
Size, slope, and shape of the contributing watershed.
- (3) Hydrologic characteristics of the soil.
- (4) Land use and treatment.
- (5) Hydraulic characteristics of the valley and channel system.
- (6) With the use of either method, soil surveys can aid in the delineation of flood-prone areas. Possible sources of flooding information are—
 - NRCS project-type studies, such as those arising from Public Law 556, flood protection, river basin, or resource conservation and development projects.
 - Flood hazard analyses.
 - Corps of Engineers (COE) flood plain information reports.
 - Special flood reports.
 - Local flood-protection and flood-control project reports.
 - Department of Housing and Urban Development flood-insurance study reports.
 - Maps by the U.S. Geological Survey (USGS), NRCS, Tennessee Valley Authority, COE, or National Oceanic and Atmospheric Administration.
 - Studies by private firms and other units of Government.
 - USGS quadrangle sheets and hydrologic atlases of flood-prone areas and stream gauge data.
 - The online FEMA Flood Map Service Center: <http://msc.fema.gov/portal>.
- (7) General estimates of flooding frequency and duration are made for each soil. However, in intensively used areas where construction has materially altered the natural water flow, flood studies are needed to adequately reflect present flooding characteristics.
- (8) Soil scientists collect and record evidence of flood events during the course of the soil survey. The extent of flooded areas, flood debris in trees, damage to fences and bridges, and other signs of maximum water height are recorded. Information that is helpful in delineating soils that have a flood hazard is also obtained. Hydrologists may have flood stage predictions that can be related to kinds of soil or landscape features. Conservationists and engineers may have recorded elevations of high flood marks. Local residents may have recollections of floods that can help to relate the events to kinds of soil, topography, and geomorphology.
- (9) Certain landscape features have developed as the result of past and present flooding and include former river channels, oxbows, point bars, alluvial fans, meander scrolls, sloughs, natural levees, backswamps, sand splays, and terraces. Most of these features are easily recognizable on aerial photographs when the photo image is compared to on-the-ground observations. Different kinds of vegetation and soils are normally associated with these geomorphic features.
- (10) The vegetation that grows in flood areas may furnish clues to past flooding. In the central and southeastern United States, the survival of trees in flood-prone areas depends on the frequency, duration, depth, and time of flooding and on the age of the tree.
- (11) Past flooding may sometimes leave clues in the soil, such as—
 - (i) Thin strata of material of contrasting color, texture, or both.

- (ii) An irregular decrease in organic matter content, not due to human-alteration by mixing or transportation of material, which is an indication of a buried genetic surface horizon.
- (iii) Soil layers that have abrupt boundaries to contrasting kinds of material, which indicate that the materials were laid down suddenly at different times and were from different sources or were deposited from stream flows of different velocities.
- (iv) Artifacts which are easily moved and deposited by flood waters (e.g., plastic bottles).
- (12) Laboratory analyses of properly sampled layers are often helpful in verifying these observations. Organic carbon and particle-size analyses are particularly useful in verifying flood deposits. Microscopic observations may detect preferential horizontal orientation of plate-like particles; microlayering, which indicates water-laid deposits; or mineralogical differences between layers.

G. Entries.—If a map unit component floods, then the annual flooding frequency and duration are populated, as stated above in section 618.31B, for the specific months in which the flooding events most commonly occur. All other months have records in the “Component Month” table but the data elements for frequency and duration are left as “NULL.” Flooding entries reflect the current existing and mapped condition with consideration for dams, levees, and other human-induced changes affecting flooding frequency and duration. Only in very frequent and none classes are all 12 months populated with a frequency.

- (1) Enter the flooding frequency class name: none, very rare, rare, occasional, frequent, or very frequent.
- (2) Enter the flooding duration class name that most nearly represents the soil component: extremely brief, very brief, brief, long, or very long.

618.32 Fragments in the Soil

A. Definition.—“Fragments” are unattached, cemented pieces of bedrock, bedrock-like material, durinodes, concretions, nodules, or pedogenic horizons (e.g., petrocalcic fragments) 2 mm or larger in diameter and unprocessed woody material 20 mm or larger in diameter in organic soils. Fragments are separated into three types: rock fragments, pararock fragments (which are distinguished by coherence class), and wood fragments. The words “rock” and “pararock” are used here in the broad sense and do not connote only natural fragments of geologic material. Some artifacts behave in a similar manner to fragments in the soil. See section 618.5 for detailed information on the measurement, classes, and data entries for artifacts.

- (1) Rock fragments are unattached pieces of geologic or pedogenic material 2 mm in diameter or larger that are strongly coherent or more resistant to rupture. Rock fragments ≥ 2 mm to < 75 mm (3 inches)* are considered when estimating the percent passing sieves, as discussed in section 618.48.
- (2) Pararock fragments are unattached, coherent pieces of geologic or pedogenic material 2 mm in diameter or larger that are extremely weakly coherent to moderately coherent. These fragments are not retained on sieves because they are crushed by grinding during sample preparation.

- (3) Wood fragments are unprocessed (i.e., naturally occurring) woody materials that cannot be crushed between the fingers when moist or wet and are 20 mm or larger in size. Wood fragments are only used in organic soils. They are comparable to rock and pararock fragments in mineral soils. Processed wood products, whether treated or untreated, are considered artifacts and not wood fragments.

B. Significance

- (1) The fraction of the soil 2 mm or larger in diameter has an impact on the behavior of the whole soil. Soil properties, such as available water capacity, cation-exchange capacity, saturated hydraulic conductivity, structure, and porosity, are affected by the volume, composition, and size distribution of rock fragments in the soil. Fragments also affect the management of the soil and are used as interpretation and classification criteria (e.g., particle-size and substitute classes). Terms related to volume, size, and hardness of fragments are used as texture modifier terms.
- (2) Generally, the fraction of soil ≥ 75 mm (3 inches) in diameter is not included in the engineering classification systems. However, it can be added as a descriptive term to the group name, for example, poorly graded gravel with silt, sand, cobbles, and boulders. Estimates of the percent of cobbles and boulders are presented in the soil descriptions for a group name (see ASTM Designation D 2487, Appendix X1.1). A small amount of these larger particles generally has little effect on soil properties. The particles may, however, have an effect on the use of a soil in certain types of construction. Often, the larger portions of a soil must be removed before the material can be spread in thin layers, graded, or compacted and graded to a smooth surface. As the quantity of this “oversized” fraction increases, the properties of the soil can be affected. If the larger particles are in contact with each other, the strength of the soil is very high and the compressibility very low. If voids exist between the larger particles, the soil will likely have high saturated hydraulic conductivity and may undergo some internal erosion as a result of the movement of water through the voids. Most of the smaller and more rapid construction equipment normally used in excavating and earthmoving cannot be used if the oversize fraction of a soil is significant.

C. Measurement.—The fraction from ≥ 2 to < 75 mm in diameter may be measured in the field. However, 50 to 60 kg of sample material may be necessary if there is an appreciable amount of fragments near 75 mm. An alternative means of measuring is to visually estimate the volume of the 20- to 75-mm fraction, then sieve and weigh the ≥ 2 - to < 20 -mm fraction. The fraction ≥ 75 mm (3 inches) or greater is usually not included in soil samples taken in the field for laboratory testing. Measurements can be made in the field by weighing the dry sample and the portion retained on a

3-inch screen. The quantity is expressed as a weight percentage of the total soil. A sample as large as 200 pounds to more than a ton may be needed to assure that the results are representative.

Measurements of the fraction from ≥ 75 to < 250 mm (3 to 10 inches) and the fraction greater than or equal to 250 mm (10 inches) in diameter are usually obtained from volume estimates.

D. Estimates

- (1) Estimates are usually made by visual means and are on the basis of percent by

volume. The percent by volume is converted to percent by weight by using the average bulk unit weights for soil and rock. These estimates are made during investigation and mapping activities in the field. They are expressed as ranges that include the estimating accuracy as well as the range of values for a component.

- (2) Measurements or estimates of fragments less than strongly coherent are made prior to any rolling or crushing of the sample.

E. Rock Fragments Greater Than 10 Inches (250 mm)

- (1) Definition.—“Rock fragments greater than 10 inches” is the percent by weight of the horizon occupied by rock fragments greater than or equal to 10 inches (250 mm) in diameter. Although the upper limit is undefined, for practical purposes it generally is no larger than a pedon, up to 10 meters square. For flat rock fragments, the intermediate dimension is used for the 250 mm (10 inch) measurement. For example, a flat-shaped rock fragment that is 100 mm × 250 mm × 380 mm has an intermediate dimension of 250 mm and is not counted as greater than 250 mm. A flat-shaped rock fragment that is 100 mm × 275 mm × 380 mm has an intermediate dimension of 275 mm and is counted as greater than 250 mm.
- (2) Entries.—Enter the high, low, and representative values in the “Component Horizon” table in the NASIS database as whole number percentages for each horizon, as appropriate.

F. Rock Fragments ≥ 3 to <10 Inches (75 to 250 mm)

- (1) Definition.—“Rock fragments 3 to 10 inches” is the percent by weight of the horizon occupied by rock fragments ≥ 3 to <10 inches (75 to 250 mm) in diameter.
- (2) Entries.—Enter the high, low, and representative values in the “Component Horizon” table in the NASIS database as whole number percentages for each horizon, as appropriate.

G. Fragment Kind

- (1) Definition.—“Fragment kind” is the lithology or composition of the 2 mm or larger fraction of the soil (20 mm or larger for wood fragments).
- (2) Entries.—Enter the appropriate fragment kind name for the record of fragments populated in the “Component Horizon Fragments” tables in the NASIS database. The class names appear in a choice list and can also be viewed in the NASIS data dictionary.

H. Fragment Roundness

- (1) Definition.—“Fragment roundness” is an expression of the sharpness of edges and corners of fragments.
- (2) Significance.—The roundness of fragments impacts water infiltration, root penetration, and macropore space.
- (3) Classes.—The fragment roundness classes are given below:

Figure 618-A11

Roundness Class	Definition
Very angular	Strongly developed faces with very sharp, broken edges.
Angular	Strongly developed faces with sharp edges (SSM).
Subangular	Detectable flat faces with slightly rounded corners.
Subrounded	Detectable flat faces with well rounded corners (SSM).
Rounded	Flat faces absent or nearly absent with all corners rounded (SSM).
Well rounded	Flat faces absent with all corners rounded.

- (4) Entries.—Enter the appropriate fragment roundness class name for the record of fragments populated in the “Component Horizon Fragments” table in the NASIS database.

I. Fragment Hardness

- (1) Definition.—“Fragment hardness” is equivalent to the “rupture resistance coherence” of a fragment of specified size that has been air dried and then submerged in water.
- (2) Measurements.—Measurements are made using the procedures and classes of coherence that are listed with the rupture resistance classes in the *Soil Survey Manual*. Classes are described for block-like specimens about 25-30 mm on edge, which are air dried and then submerged in water for at least 1 hour. The specimen is compressed between an extended thumb and forefinger, between both hands, or between a foot and a nonresilient flat surface. If the specimen resists compression, a weight is dropped onto it from progressively greater heights until it ruptures. Failure is considered at the initial detection of deformation or rupture. Stress applied in the hand should be over a 1-second period. The tactile sense of the class limits may be learned by applying force to top-loading scales and sensing the pressure through the tips of the fingers or through the ball of the foot. Postal scales may be used for the resistance range that is testable with the fingers. A bathroom scale may be used for the higher rupture resistance range.
- (3) Significance.—The hardness of a fragment is significant where the rupture resistance class is strongly coherent or greater. These classes can impede or restrict the movement of soil water vertically through the soil profile and have a direct impact on the quality and quantity of ground water and surface water.
- (4) Classes.—The fragment hardness (rupture resistance) classes are—
 - (i) Extremely weakly coherent
 - (ii) Very weakly coherent
 - (iii) Weakly coherent
 - (iv) Moderately coherent
 - (v) Strongly coherent

- (vi) Very strongly coherent
- (vii) Indurated
- (5) Entries.—Enter the appropriate class name for each record of fragments populated in the “Component Horizon Fragments” table in the NASIS database. Choose the term without the word “coherent” (i.e., choose “moderately” to represent the moderately coherent class).

J. Fragment Shape

- (1) Definition.—“Fragment shape” is a description of the overall shape of the fragment.
- (2) Significance.—Fragment shape is important for fragments that are too large to be called channers or flagstones.
- (3) Classes.—The fragment shape classes are: flat and nonflat.
- (4) Entries.—Enter the appropriate fragment shape class name for each record of fragments populated in the “Component Horizon Fragments” table in the NASIS database.

K. Fragment Size

- (1) Definition.—“Fragment size” is based on the multiaxial dimensions of the fragment.
- (2) Significance.—The size of fragments is significant to the use and management of the soil. Fragment size is used as a criterion in naming map units. It affects equipment use, excavation, construction, and recreational uses.
- (3) Classes.—Classes of fragment size are subdivided as flat or nonflat, based on the shape of the fragments (described above).
 - (i) Flat fragment classes are given below:

Figure 618-A12

Flat Fragment Class	Length of Fragment (mm)
Channers	≥ 2 to < 150
Flagstones	≥ 150 to < 380
Stones	≥ 380 to < 600
Boulders	≥ 600

- (ii) Nonflat fragment classes are given below:

Figure 618-A13

Nonflat Fragment Class	Diameter (mm)
Gravel	≥ 2 to < 75
fine gravel	≥ 2 to < 5
medium gravel	≥ 5 to < 20

coarse gravel	≥ 20 to < 75
Cobbles	≥ 75 to < 250
Stones	≥ 250 to < 600
Boulders	≥ 600

- (iii) Gravel is a collection of fragments having a diameter ranging from ≥ 2 to < 75 mm. Individual fragments in this size range are properly referred to as “pebbles,” not “gravels.” For fragments that are less than strongly coherent, “para” is used as a prefix to the above terms (e.g., paracobbles).
- (4) Entries.—Enter the high, low, and representative values of each size class populated in the “Component Horizon Fragments” table in the NASIS database. The range of valid entries is from 2 to 3,000 millimeters, and only whole numbers (integers) are allowed.

L. Fragment Volume

- (1) Definition.—“Fragment volume” is the volume percentage of the horizon occupied by the 2 mm or larger fraction (20 mm or larger for wood fragments) on a whole soil base.
- (2) Significance.—The volume occupied by the 2 mm or larger fraction is important in selecting texture modifiers (i.e., gravelly, very gravelly, extremely paragravelly).
- (3) Entries.—Enter the high, low, and representative values for the percent volume present of each size class and kind of fragment populated in the “Component Horizon Fragments” table in the NASIS database. The range of valid entries is from 0 to 100 percent, and only whole numbers (integers) are allowed.

618.33 Free Iron Oxides

A. Definition.—“Free iron oxides” are secondary iron oxides, such as goethite, hematite, ferrihydrite, lepidocrocite, and maghemite. These forms of iron may occur as discrete particles, as coatings on other soil particles, or as cementing agents between soil mineral grains. They consist of iron extracted by dithionite-citrate from the fine-earth fraction.

B. Significance.—The amount of iron that is extractable by dithionite-citrate is used in the ferritic, ferruginous, parasesquic, and sesquic mineralogy classes defined in Soil Taxonomy. The ratio of dithionite-citrate (free) iron to total iron in a soil is a measure of the degree of soil weathering. Free iron oxides are important in the soil processes of podzolization and laterization and play a significant role in the phosphorous fixation ability of soils.

C. Measurement.—Free iron oxides are measured as the amount extracted by a solution of sodium dithionite and sodium citrate using a method outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

D. Entries.—Enter high, low, and representative values as percentages for each horizon for which data is available. The range of valid entries is from 0 to 100 percent, and hundredths (two decimal places) are allowed.

618.34 Frost Action, Potential

A. Definition.—“Potential frost action” is a rating of the susceptibility of the soil to upward or lateral movement by the formation of segregated ice lenses. It rates the potential for frost heave and the subsequent loss of soil strength when the ground thaws.

B. Classes.—Classes are used in regions where frost action is a potential problem. Refer to part 618, subpart B, section 618.84, for more information. The classes are: low, moderate, and high. They are defined below:

Figure 618-A14

Potential Frost Action Class	Definition
Low	Soils are rarely susceptible to the formation of ice lenses.
Moderate	Soils are susceptible to the formation of ice lenses, which results in frost heave and subsequent loss of soil strength.
High	Soils are highly susceptible to the formation of ice lenses, which results in frost heave and subsequent loss of soil strength.

C. Significance.—Damage from frost action results from the formation of segregated ice crystals and ice lenses in the soil and the subsequent loss of soil strength when the ground thaws. Frost heave damages highway and airfield pavements. It is less of a problem for dwellings and buildings that have footings which extend below the depth of frost penetration. In cold climates, unheated structures that have concrete or asphalt floors can be damaged by frost heave. Driveways, patios, and sidewalks can heave and crack. The thawing of the ice causes a collapse of surface elevation and produces free-water perches on the still-frozen soil below. Soil strength is reduced. Backslopes and side slopes of cuts and fills can slough during thawing. Seedlings and young plants of clover, alfalfa, wheat, and oats can be raised out of the soil or have their root systems damaged by frost heave.

D. Estimates

- (1) Freezing temperatures, soil moisture, and susceptible soils are needed for the formation of segregated ice lenses. Ice crystals begin to form in the large pores first. Water in small pores or water that was adsorbed on soil particles freezes at lower temperatures. This supercooled water is strongly attracted to the ice crystals, moves toward them, and freezes on contact with them. The resulting ice lens continues to grow in width and thickness until all available water that can be transported by capillary has been added to the ice lens and a further supply cannot be made available because of the energy requirements.
- (2) Soil temperatures must drop below 0° C for frost action to occur. Generally, the more slowly and deeply the frost penetrates, the thicker the ice lenses are and the greater the resulting frost heave is. Part 618, subpart B, section 618.85, is a map that shows the design freezing index values in the continental United States. The values are the number of degree days below 0° C for the coldest year in a period of 10 years. The

- values indicate duration and intensity of freezing temperatures. The 250 isoline is the approximate boundary below which frost action ceases to be a problem. Except on the West Coast, the frost action boundary corresponds closely to the functional boundary between the mesic and thermic soil temperature regimes as defined in *Soil Taxonomy*. More information is provided in the U.S. Army Engineer School, Student Reference, 1967, *Soil Engineering*, Section I, Volume II, Chapters VI-IX, Fort Belvoir, VA.
- (3) Water necessary for the formation of ice lenses may come from a high water table or from infiltration at the surface. Capillary water in voids and adsorbed water on particles also contribute to ice lens formation but, unless this water is connected to a source of free water, the amount generally is insufficient to produce significant ice segregation and frost heave.
 - (4) The potential intensity of ice segregation is dependent to a large degree on the effective soil pore size and soil saturated hydraulic conductivity, which are related to soil texture. Ice lenses form in soils in which the pores are fine enough to hold quantities of water under tension but coarse enough to transmit water to the freezing front. Soils that have a high content of silt and very fine sand have this capacity to the greatest degree and hence have the highest potential for ice segregation. Clayey soils hold large quantities of water but have such slow saturated hydraulic conductivity that segregated ice lenses are not formed unless the freezing front is slow moving. However, sandy soils have large pores and hold less water under lower tension. As a result, freezing is more rapid and the large pores permit ice masses to grow from pore to pore, entombing the soil particles. Thus, in coarse grained soils, segregated ice lenses are not formed and less displacement can be expected.
 - (5) Estimates of potential frost action generally are made for soils in mesic or colder temperature regimes. Exceptions are on the West Coast, where the mesic-thermic temperature line crosses below the 250 isoline, as displayed in part 618, subpart B, section 618.85, and along the East Coast, where the soil climate is moderated by the ocean. Mesic soils that have a design freezing index of less than 250 degree days should not be rated because frost action is not likely to occur. The estimates are based on bare soil that is not covered by insulating vegetation or snow. They are also based on the moisture regime of the natural soil. The ratings can be related to manmade modifications of drainage or to irrigation systems on an onsite basis. Frost action estimates are made for the whole soil to the depth of frost penetration, to bedrock, or to a depth of 2 meters (6.6 feet), whichever is shallowest. Part 618, subpart B, section 618.84, is a guide for making potential frost action estimates. It uses the soil moisture regimes and taxonomic family particle-size classes as defined in *Soil Taxonomy*.

E. Entries.—Enter one of the following classes for the whole soil: low, moderate, or high. If frost action is not a problem, enter “none.”

618.35 Gypsum

A. Definition.—“Gypsum” is the percent, by weight, of hydrated calcium sulfates in the <20 mm fraction of soil.

B. Significance.—Gypsum is partially soluble in water and can be dissolved and removed by water. Soils with more than 10 percent gypsum may collapse if the gypsum is removed by

percolating water. Gypsum is corrosive to concrete. Corrosion of concrete is most likely to occur in soils that are more than about 1 percent gypsum when wetting and drying occurs. Gypsum percentage is used for soil classification in the required characteristics for gypsic and petrogypsic horizons, the gypseous substitute classes, several strongly contrasting particle-size classes, and the hypergypsic, gypsic, and carbonatic mineralogy classes.

C. Measurement.—Gypsum percentage is measured by a method that uses precipitation in acetone, as outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

D. Entries.—Enter the high, low, and representative values to represent the range in gypsum content as a weight percent of the soil fraction less than 20 mm in size. Round values to the nearest 5 percent for layers that are more than 5 percent gypsum and to the nearest 1 percent for layers that are less than 5 percent gypsum (for example, 0-1, 1-5, 5-10). If the horizon does not have gypsum, enter “0.” The range of valid entries is from 0 to 120 percent, and only whole numbers (integers) are allowed.

618.36 Horizon Depth to Bottom

A. Definition.—“Horizon depth to bottom” is the distance from the top of the soil to the base of the soil horizon.

B. Measurement.—Distance is measured from the top of the soil, which is defined as the top of the mineral soil, or, for soil with “O” horizons, the top of any organic layer that is at least slightly decomposed. For soils that are covered by 80 percent or more rock or pararock fragments, the top of the soil is the mean height of the top of the fragments. See chapter 3 in the *Soil Survey Manual* for a complete discussion. Measurement should be estimated to a depth of 200 cm for most soils and to a depth at least 25 cm below a lithic contact if the contact is above 175 cm. For soils, including those that have a root-restricting contact such as a paralithic contact, the lowest horizon bottom should extend to a depth of at least 25 cm below the contact or to a depth of 200 cm, whichever is shallower.

C. Entries.—Values for horizon depth to bottom that are used to populate component data in NASIS are not specific to any one point but rather are a reflection of commonly observed values based on field observations and are intended to model the component as it occurs throughout the map unit. Enter the high, low, and representative values in whole centimeters. The high value represents either the greatest depth to which the base of the horizon extends or, for horizons extending beyond the limit of field observation, is the depth to which observation was made (usually no more than 200 cm but at least 150 cm).

618.37 Horizon Depth to Top

A. Definition.—“Horizon depth to top” is the distance from the top of the soil to the upper boundary of the soil horizon.

B. Measurement.—Distance is measured from the top of the soil, which is defined as the top of the mineral soil, or, for soils with “O” horizons, the top of any organic layer that is at least slightly decomposed. For soils that are covered by 80 percent or more rock or pararock

fragments, the top of the soil is the mean height of the top of the fragments. See chapter 3 in the *Soil Survey Manual* for a complete discussion.

E. Entries.—Values for depth to top that are used to populate component data in NASIS are not specific to any one point but rather are a reflection of commonly observed values based on field observations and are intended to model the component as it occurs throughout the map unit. Enter the high, low, and representative values in whole centimeters. See section 618.38, “Horizon Designation,” for a discussion on how to list E/B and E and Bt type horizons.

618.38 Horizon Designation

A. Definition.—“Horizon designation” is a concatenation of three kinds of symbols used in various combinations to identify layers of soil that reflect the investigator's interpretations of genetic relationships among layers within a soil.

B. Significance.—Soils vary widely in the degree to which horizons are expressed. The range is from little or no expression to strong expression. Layers of different kinds are identified by symbols. Designations are provided for layers that have been changed by soil formation and for those that have not. Designations are assigned after comparison of the observed properties of the layer with properties inferred for the material before it was affected by soil formation.

Designations of genetic horizons express a qualitative judgment about the kind of changes that are believed to have taken place. A more detailed discussion can be reviewed in the latest edition of the Keys to Soil Taxonomy and in the *Soil Survey Manual*, chapter 3. Horizon designations shown in field pedon descriptions (point data) represent a specific location on the landscape. Horizon designations used to populate component data in NASIS are not specific to any one point but rather are a reflection of commonly observed horizon sequences based on field observations and are intended to model the component as it occurs throughout the map unit so that accurate interpretations can be derived.

C. Entries.—Enter combinations of symbols to reflect master horizons and their vertical subdivisions. Commonly occurring master horizon sequences, identified in field pedon descriptions (e.g., A-Bt1-Bt2-Btk-2Bk-2C), are used for soil components in NASIS. Generalized horizon layer designations (e.g., H1-H2-H3) may be used instead of genetic horizon designations. Users of generalized horizon layer designations must be cognizant of the fact that certain master horizon designations, such as O, Cr, and R, are still required entries in NASIS for proper soil interpretations.

- (1) It is not possible to include all master horizon sequences observed in individual pedon descriptions when populating the interpretive horizons of soil components. For example, if an Ap horizon is present and the former E horizon is incorporated into the Ap horizon, a sequence of Ap-E should not be used because the horizons would not normally occur together. Judgment is required when determining how much detail is required to represent the component adequately for interpretations. Care must be taken to maintain important differences between genetic horizons whose range in properties are specified separately on the official series descriptions. Some general guidance follows. Master horizons (i.e., O, A, E, B) represent unique sets of pedogenic

- processes and therefore should not be combined when aggregating data, even if their basic properties are similar.
- (2) Transitional horizons, such as EB and BC, should be recorded if they are commonly more than about 10 cm thick. After applying careful judgment, some horizons may be combined in order to avoid overly complex horizon sequences representing map unit components. Keep in mind, however, that once combined, any useful information gained by their separation is lost. Transitional horizons thinner than about 10 cm may be combined with an adjacent master horizon if they are not considered important to the interpretation of the component. Master horizon subdivisions showing genetic variations not deemed significant to interpretations may be combined. For example, a horizon sequence of Bt1-Bt2-Bt3, based solely on color variation and having no other significant differences, may be combined and shown simply as Bt. Master horizon subdivisions showing genetic variations that are deemed significant to interpretations should not be combined. For example, a horizon sequence of Bt-Btx-BC should not be combined. Do not combine horizons that straddle the criteria break to a diagnostic horizon. For example, a Bk1 with insufficient calcium carbonate content to qualify as a calcic horizon should not be combined with a Bk2 that is a calcic horizon. Enter only what the documentation can support.
 - (3) Combination horizons (E and Bt, Btn/E, E/Bt, etc.) should be entered as two separate horizon records, such as one for the E part of the horizon and the second for the Bt part of the horizon. Both records must have the same horizon designations assigned (e.g., E/Bt). But these separate horizon records must have different RV depth values for the top and bottom depths. The RV horizon depths must be completely in sync with no duplication, overlaps, or gaps. For example, the E part of a E/Bt horizon could have RV depths of 20 to 35 cm and the Bt part of the E/Bt horizon could have RV depths of 35 to 50 cm. The depth values for the “Low” and “High” columns of the horizon top and bottom depths may be populated to identify the overlapping nature of the horizon (e.g., both records may have the same low value for the top depth of 10 cm). Soil property data elements would be populated for each part to describe the characteristics of that separate part of the combination horizon.
 - (4) Allowable codes are listed in the NASIS data dictionary (https://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=stelprdb1247050&ext=pdf). The rules for use of horizon designations are in the latest edition of the *Keys to Soil Taxonomy* and in the *Soil Survey Manual*, chapter 3.

618.39 Horizon Thickness

- A. Definition.—“Horizon thickness” is a measurement from the top to bottom of a soil horizon throughout its areal extent.
- B. Measurement.—Soil horizon thickness varies on a cyclical basis. Measurements should be made to record the range in thickness as it normally occurs in the soil.
- C. Entries.—Horizon thickness values used to populate component data in NASIS are not specific to any one point but rather are a reflection of commonly observed values based on field observations and are intended to model the component as it occurs throughout the map

unit. Enter the high, low, and representative values in whole centimeters. The minimum allowable entry is 1 cm. For horizons extending beyond the limit of field observation, thickness is only populated to the depth at which an observation was made.

618.40 Hydrologic Group

A. Definition

- (1) The complete definition and official criteria for hydrologic soil groups are available online at (Title 210, National Engineering Handbook, part 630, chapter 7, “Hydrologic Soil Groups”).
- (2) “Hydrologic group” is a group of soils having similar runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently.

B. Classes.—The soils in the United States are placed into four groups, A, B, C, and D, and three dual classes, A/D, B/D, and C/D.

C. Significance.—Hydrologic groups are used in equations that estimate runoff from rainfall. These estimates are needed for solving hydrologic problems that arise in planning watershed-protection and flood-prevention projects and for planning or designing structures for the use, control, and disposal of water.

D. Measurements.—The original classifications assigned to soils were based on the use of rainfall-runoff data from small watersheds and infiltrometer plots. From these data, relationships between soil properties and hydrologic groups were established.

E. Estimates.—Assignment of soils to hydrologic groups is based on the relationship between soil properties and hydrologic groups. Wetness characteristics, water transmission after prolonged wetting, and depth to very slowly permeable layers are properties used in estimating hydrologic groups.

F. Entries.—Enter the soil hydrologic group, such as A, B, C, D, A/D, B/D, or C/D.

618.41 Landscape, Landform, Microfeature, Anthroscape, Anthropogenic Landform, and Anthropogenic Microfeature

A. Definition.— the geomorphic description is nested to describe largest to smallest setting.

- (1) “Landscape” is a broad or unique land area comprised of a collection of related landforms that define a general geomorphic form or setting.
- (2) “Landform” is any physical, recognizable form or feature of the Earth’s surface

having a characteristic shape, internal composition, and produced by natural causes; a distinct individual produced by a set of processes.

- (3) “Microfeatures” are small, local, natural forms on the land surface that are too small to delineate on a topographic or soils map at commonly used map scales.
- (4) “Anthrosapes” are human-modified landscapes of substantial and permanent alterations formed by the removal, addition, or reorganization of the physical shape and/or internal stratigraphy of the land, associated with management for habitation, commerce, food or fiber production, recreation, or other human activities that have permanently and substantively altered water flow and sediment transport across or within the regolith.
- (5) “Anthropogenic landforms” are discrete, human-made landforms on the Earth’s surface or in shallow water that have characteristic shape and range of internal composition of unconsolidated earthy, organic, human-transported materials, or rock that is the direct result of human manipulation or activities and are mappable at common soil survey scales (e.g., Order 2: $> 1:10,000$ and $< 1:24,000$). Anthropogenic landforms can be either constructional (accumulations; e.g., artificial levee) or destructional (voids; e.g., quarry) in origin.
- (6) “Anthropogenic microfeatures” are discrete, individual, human-derived forms on the Earth’s surface or in shallow water that have a characteristic shape and range in composition of unconsolidated earthy, organic, human-transported materials, or rock, and are too small to delineate on a topographic or soils map at commonly used map scales. Anthropogenic microfeatures can be either constructional accumulations (e.g., railroad bed) or destructional voids (e.g., ditch) in origin.

B. Significance.— Geographic patterns suggests natural relationships. Running water, with weathering and gravitation, commonly sculpts landforms within a landscape. Over the ages, earthy material is removed from some landforms and deposited on others. Landforms are interrelated. An entire area has unity through the interrelationships of its landform. Typically, microfeatures and anthropogenic microfeatures are nested within landforms or anthropogenic landforms. In turn, landforms and anthropogenic landforms are nested within landscapes or anthrosapes.

- (1) Each landform or anthropogenic landform may have one kind of soil present or several. Climate, vegetation, and time of exposure to weathering of the parent materials are commonly about the same throughout the extent of the landform, depending on the relief of the area. Position on the landform may have influenced the soil-water relationships, microclimate, and vegetation.
- (2) The anthropogenic landform typically has straight-line boundaries or geometric shape and is the result of human deposition or removal activities.
- (3) The proper identification of the geomorphic setting is an important part of understanding the formative history of the soil and the materials from which the soil formed and dictate the dynamics operating in a given area. Understanding these geoforms, materials, and interactions aid in the development of the soil mapping model and in the consistent transfer of information between areas.
- (4) Landform terms are also used as local phase criteria for separating components or uniquely naming soil map units. See part 627 of this handbook for more information on naming physiographic phases, features, and materials.
- (5) A term should only be used once in a geomorphic descriptive string (e.g., microfeature/landform/landscape, or anthropogenic microfeature/anthropogenic

landform/anthroscape). If a term is used at one level, it should not be repeated at another level in the same string (e.g., an outwash plain on an outwash plain is not acceptable). A different term that conveys additional information should be used at each level (e.g., an outwash plain on a till plain is more informative).

- (6) Describe and record what you see. Not all levels are present at all sites. If there are no microfeatures present, none should be recorded for that site. If anthropogenic landforms are found, but are not part of a larger anthropogenically modified area (no anthroscape), then a natural landscape should be identified.

C. Classes.—The allowable list of terms is included in the NASIS data dictionary. Definitions of the terms are included in part 629 of this handbook.

D. Entries.—Enter the appropriate class name for the landforms on which each map unit component occurs. A representative value (term) may be indicated. It is possible to indicate the presence of one landform occurring on another landform (e.g., a dune on a flood plain).

618.42 Linear Extensibility Percent

A. Definition.—“Linear extensibility percent” is the linear expression of the volume difference of natural soil fabric at 1/3-bar or 1/10-bar water content and oven dryness. The volume change is reported as percent change for the whole soil.

B. Classes.—Shrink-swell classes are based on the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. If this change is expressed as a percent, the value used is LEP, linear extensibility percent. If it is expressed as a fraction, the value used is COLE, coefficient of linear extensibility. The shrink-swell classes are defined as follows:

Figure 618-A15

Shrink-Swell Class	LEP	COLE
Low	<3.0	<0.03
Moderate	3.0– 5.9	0.03– 0.06
High	6.0– 8.9	0.06– 0.09
Very High	≥9.0	≥0.09

C. Significance.—If the shrink-swell class is rated moderate to very high, shrinking and swelling can damage buildings, roads, and other structures. The high degree of shrinkage associated with high and very high shrink-swell classes can damage plant roots. Linear extensibility (expressed as cm of extension per meter of soil) is used for soil classification in the required characteristics for Vertic subgroups. Such soils will typically have LEP values of 6 or more.

D. Measurement.—Coefficient of linear extensibility is measured directly as the change in clod dimension from moist to dry conditions and is expressed as a percentage of the volume change to the dry length:

$$\text{COLE} = \frac{\text{moist length} - \text{dry length}}{\text{dry length}}$$

When expressed as LEP (linear extensibility percent): $\text{LEP} = \text{COLE} \times 100$

Linear extensibility may be determined by any of the following methods:

- (1) For the core method of measurement, select a sample core from a wet or moist soil. Carefully measure the wet length of the core and set the core upright in a dry place. If the core shrinks in a symmetrical shape without excessive cracking or crumbling, its length can be measured and linear extensibility percent calculated. If the core crumbles or cracks, measurements cannot be accurately determined by this method.
- (2) In the coated clod method of measurement, shrink-swell potential can be estimated from the bulk density of soil measured when moist and when dry. The coated clod method is widely used and is the most versatile procedure for determining the bulk density of coherent soils. Procedures and calculations are given in Soil Survey Investigations Report No. 42, *Soil Survey Laboratory Methods Manual*, Version 4.0, November 2004, USDA, NRCS.
- (3) Linear extensibility percent can be calculated from bulk density moist (Dbm) and bulk density dry (Dbd) using the following formula:

$$\text{LEP} = 100 [(\text{Dbd}/\text{Dbm})^{1/3} - 1] [1 - (\text{Volume \%} > 2 \text{ mm}/100)]$$

This equation is used to simplify the determination of shrink-swell potential classes. The classes are as follows:

Figure 618-A16

Dbd/Dbm	Shrink-Swell Potential
<1.10	Low
1.10 - 1.20	Moderate
1.20 - 1.30	High
≥ 1.30	Very high

E. Estimates.—Field estimates of shrink-swell potential can be made by observing desiccation cracks, slickensides, gilgai, soil creep, and leaning utility poles. Shrink-swell potential correlates closely with the kind and amount of clay. The greatest shrink-swell potential occurs in soils that have high amounts of 2:1 lattice clays, such as clay minerals in the smectite group. Illitic clays are intermediate, and kaolinitic clays are least affected by volume change as the content in moisture changes.

F. Entries.—Enter the low, high, and representative linear extensibility percent values. If laboratory measurements or accurate field estimates are available, the high and low values do not need to correspond with shrink-swell class limits. However, if data is limited, the high and low values may correspond to the high and low limits of the appropriate shrink-swell class.

The range of valid entries is from 0 to 30 percent, and tenths (one decimal place) are allowed.

618.43 Liquid Limit

A. Definition.—“Liquid limit” is the water content of the soil material, which passes a no. 40 sieve, at the change between the liquid and plastic states.

B. Significance.—The plasticity chart, given in ASTM Designation D 2487, is a plot of liquid limit (LL) versus plasticity index (PI) and is used in classifying soil in the Unified soil classification system. The liquid limit is also a criterion for classifying soil in the AASHTO classification system, as shown in part 618, subpart B, section 618.83. Generally, the amount of clay- and silt-sized particles, the organic matter content, and the type of minerals determine the liquid limit. Soils that have a high liquid limit have the capacity to hold a lot of water while maintaining a plastic or semisolid state.

C. Measurement.—Tests are made on thoroughly puddled soil material that has passed a no. 40 (.425 mm) sieve. The measurement is expressed on a dry weight basis, according to ASTM Designation D 4318. This procedure requires the use of a liquid limit device, a special tool designed to standardize the arbitrary boundary between a liquid and plastic state of a soil. Estimates of liquid limit are made on soils during soil survey investigations and mapping activities. The liquid limit is usually inferred from clay mineralogy and clay content. If soils are tested later in the laboratory, adjustments are made to the field estimates as needed. Generally, experienced personnel can estimate these values with a reasonable degree of accuracy.

D. Estimates.—The formula in part 618, subpart B, section 618.86, is used in the NASIS database to provide default calculated values if no measurements are available.

E. Entries.—Enter the high, low, and representative values as a range for each horizon. The range of valid entries is from 0 to 400 percent, and tenths (one decimal place) are allowed. However, entries should be rounded to the nearest 5 percent unless they represent measured values or a calculation is used. Enter “0” for nonplastic soils. The liquid limit for organic soil material is not defined and is assigned “null.” A NASIS calculation is available and can be viewed in part 618, subpart B, section 618.102.

618.44 Organic Matter

A. Definition.—“Organic matter percent” is the weight of decomposed plant and animal residue and expressed as a weight percentage of the soil material less than 2 mm in diameter.

B. Significance

- (1) Organic matter influences the physical and chemical properties of soils far more than the proportion to the small quantities present would suggest. The organic fraction

- influences plant growth through its influence on soil properties. It encourages granulation and good tilth, increases porosity and lowers bulk density, promotes water infiltration, reduces plasticity and cohesion, and increases the available water capacity. It has a high capacity to adsorb and exchange cations and is important to pesticide binding. It furnishes energy to micro-organisms in the soil. As it decomposes, it releases nitrogen, phosphorous, and sulfur. The distribution of organic carbon according to depth indicates different episodes of soil deposition or soil formation.
- (2) Soils that are very high in organic matter have poor engineering properties and subside upon drying.

C. Measurement.—Laboratory measurements are made using a dry combustion method to determine percent total carbon. For an estimate of organic carbon in calcareous soils, the carbon present in carbonate compounds, such as CaCO_3 , must be calculated and then subtracted from the total carbon. This is done using the equation:

$$\text{percent organic carbon} = \text{percent total carbon} - [\% < 2 \text{ mm } \text{CaCO}_3 \times 0.12].$$

The results are given as the percent of organic carbon in dry soil. To convert the figures for organic carbon to those for organic matter, multiply the organic carbon percentage by 1.724. The detailed procedures are outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

D. Estimates.—Color and “feel” are the major properties used to estimate the amount of organic matter. Color comparisons in areas of similar materials can be made against laboratory data so that a soil scientist can make estimates. In general, black or dark colors indicate high amounts of organic matter. The contrast of color between the A horizon and subsurface horizons is also a good indicator.

E. Entries.—Enter the high, low, and representative values for the range in organic matter in each horizon. The range of valid entries is from 0 to 100 percent, and hundredths (two decimal places) are allowed.

618.45 Parent Material, Kind, Modifier, and Origin

A. Definition.—Parent material is the unconsolidated material, mineral or organic, from which the soil develops. The soil surveyor considers parent material in developing a model to be used for soil mapping. Soil scientists and specialists in other disciplines use parent material data to help interpret soil boundaries and project performance of the material below the soil. Many soil properties relate to parent material. Among these properties are proportions of sand, silt, and clay; chemical content; bulk density; structure; and the kinds and amounts of fragments. These properties affect interpretations and may be criteria used to separate soil series. Soil properties and landscape information infer parent material. Three data elements—parent material kind, parent material modifier, and parent material origin—describe parent material.

B. Parent Material Kind

- (1) Definition.—“Parent material kind” is a term describing the general physical, chemical, and mineralogical composition of the material, mineral or organic, from

- which the soil develops. Mode of deposition, weathering, or both may be implied or implicit.
- (2) Classes.—The list of allowable entries is included in the NASIS data dictionary. Definitions of many of these terms are included in part 629 of this handbook.
 - (3) Entries.—Enter the applicable class names for each map unit component. Multiple entries are permissible. Multiple rows of parent materials may also be indicated for a single component, such as loess over till over residuum.

C. Parent Material Modifier

- (1) Definition.—“Parent material modifier” is the general description of the texture of the parent material. Class limits correspond to those of the general texture groupings defined in the *Soil Survey Manual* and the family category particle-size classes defined in Soil Taxonomy.
- (2) Classes.—The classes of parent material modifiers are as follows:
 - (i) Clayey
 - (ii) Coarse-loamy
 - (iii) Coarse-silty
 - (iv) Fine-loamy
 - (v) Fine-silty
 - (vi) Gravelly
 - (vii) Loamy
 - (viii) Sandy
 - (ix) Sandy and gravelly
 - (x) Sandy and silty
 - (xi) Silty
 - (xii) Silty and clayey
- (3) Entries.—Enter the appropriate class name to modify the corresponding row of parent material kind.

D. Parent Material Origin

- (1) Definition.—“Parent material origin” is the type of bedrock from which the parent material is derived.
- (2) Classes.—The allowable class names are included in the NASIS data dictionary and are the same as for the “bedrock kind” data element.
- (3) Entries.—Enter the appropriate parent material origin class names that correspond to each parent material kind. Although this data element is intended to be used when “residuum” is the chosen parent material kind, it may also be used with other kinds of parent material.

618.46 Particle Density

A. Definition.—“Particle density” is the mass per unit of volume of the solid soil particle, either mineral or organic. It is also known as specific gravity.

B. Significance.—Particle density is used in the calculation of weight and volume for soil (porosity). The relationship between bulk density, percent pore space, and the rate of sedimentation of solid particles in a liquid depends on particle density. The term “particle density” indicates wet particle density or specific gravity.

C. Measurement.—The standard methods of measurement for particle density are: the ASTM standard test method for specific gravity of soils, ASTM Designation D 854-92, which uses soil materials passing a no. 4 sieve; the method described by Blake and Hartge in Methods of Soil Analysis, Part 1, Agronomy 9; or the method for volcanic soils described by Biielders and others in Soil Science Society of America Journal 54, pages 822-826.

D. Estimates

- (1) Particle density is often assumed to be 2.65 g cm^{-3} ; however, many minerals and material of various origins have particle densities less than or greater than this standard. Particle density (Dp) may be calculated using the extractable iron and the organic carbon percentages in the following formula:

Dp =

$$\frac{100}{\frac{(1.7 \times \text{OC})}{\text{Dp1}} + \frac{(1.6 \times \text{Fe})}{\text{Dp2}} + \frac{100 - [(1.7 \times \text{OC}) + (1.6 \times \text{Fe})]}{\text{Dp3}}}$$

- (2) OC is the organic carbon percentage and Fe is the percent extractable iron determined by dithionite-citrate extraction, or by an equivalent method. The particle density of the organic matter (Dp1) is assumed to be 1.4 g cm^{-3} , that of the minerals from which the extractable iron originates (Dp2) is assumed to be 4.2 g cm^{-3} , and that of the material exclusive of the organic matter and the minerals contributing to the extractable Fe (Dp3) is assumed to be 2.65 g cm^{-3} .

E. Entries.—Enter the representative value for the horizon. The range of valid entries is from 0.01 to 5 g cm^{-3} , and hundredths (two decimal places) are allowed.

618.47 Particle Size

A. Definition.—“Particle size” is the effective diameter of a particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are clay, silt, and sand, ranging from the smaller to the larger of the less than 2 mm mineral soil fraction. It includes fragments of weathered or poorly consolidated fragments that disperse to particles less than 2 mm in diameter.

B. Significance.—The physical behavior of a soil is influenced by the size and percentage composition of the size classes. Particle size is important for most soil interpretations, for determination of soil hydrologic qualities, and for soil classification.

C. Measurement.—Particle size is measured by sieving and sedimentation. The method used is method 3A1, which is outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS. A NASIS calculation is available and can be viewed in part 618, subpart B, section 618.103.

D. Classes.—The USDA uses the following size separates for the <2 mm mineral material:

Figure 618-A17

USDA Particle Size Separates	Size (mm)
Clay, total	<0.002
Silt, total	≥0.002 to <0.05
Silt, fine	≥0.002 to <0.02
Silt, coarse	≥0.02 to <0.05
Sand total	≥0.05 to <2.00
Very fine sand	≥0.05 to <0.10
Fine sand	≥0.10 to <0.25
Medium sand	≥0.25 to <0.50
Coarse sand	≥0.50 to <1.00
Very coarse sand	≥1.00 to <2.00

Part 618, subpart B, section 618.87, compares the USDA system with the AASHTO and Unified soil classification systems and shows the U.S. standard sieve sizes.

E. Clay Percentage

- (1) Definition.—“Total clay percentage” is the weight percentage of the mineral particles less than 0.002 mm in equivalent diameter in the less-than-2-mm soil fraction. Most of the material is in one of three groups of clay minerals or in a mixture of these clay minerals. The groups are kaolinite, smectite, and hydrous mica, the best-known member of which is illite.
- (2) Significance.—Physical and chemical activities of a soil are related to the kind and amount of clay minerals. Clay particles may have thousands of times more surface area per gram than silt particles and nearly a million times more surface area than very coarse sand particles. Thus, clay particles are the most chemically and physically active part of mineral soil.

- (i) Clay mineralogy and clay percentage have a strong influence on engineering properties and the behavior of soil material when it is used as construction or foundation material. They influence linear extensibility, compressibility, bearing strength, and saturated hydraulic conductivity.
- (ii) The kind and amount of clay influence plant growth indirectly by affecting available water capacity, water intake rate, aeration, cation-exchange capacity, saturated hydraulic conductivity, erodibility, and workability. Up to a certain point, an increase in the amount of clay in the subsoil is desirable. Clay can increase the amount of water and nutrients stored in that zone. By slightly slowing the rate of water movement, it can reduce the rate of nutrient loss through leaching. If the amount of clay is great, it can impede water and air movement, restrict root penetration, increase runoff, and, on sloping land, result in increased erosion.
- (iii) Clay particles are removed by percolating water from surface and subsurface horizons and deposited in the subsoil horizons. The amount of clay accumulation and its location in the profile provide clues for the soil scientist about soil genesis. Irregular clay distribution as related to depth may indicate lithologic discontinuities, especially if accompanied by irregular sand distribution.
- (3) Measurement.—Clay content is measured in the laboratory by the pipette or hydrometer methods after the air-dry soil is pretreated to remove organic matter and soluble salts. Field estimates of clay content are made by manual methods. The way a wet soil ribbons (develops a long continuous ribbon) when pressed between the thumb and fingers gives a good idea of the amount of clay present. Excessive amounts of sodium can toughen the soil, making the soil feel more clayey. Care should be taken not to overestimate the amount of clay in sodic soils. Accuracy depends largely on frequent and attentive observation. Texture reference samples determined in the laboratory are used by soil scientists to calibrate the feel of soils with various percentages of clay.
- (4) Entries.—Enter the high, low, and representative values of the clay total separate as a percent of the material less than 2 mm in size for each horizon. Enter a “0” if the amount is not significant, as in organic layers or in some andic soil materials. The range of valid entries is from 0 to 100 percent, and tenths (one decimal place) are allowed. The representative value chosen should equate to a valid clay total content for the representative texture class posted for each horizon.

F. Sand Percentage

- (1) Definition.—“Sand percentage” is the weight percentage of the mineral particles less than 2 mm and greater than or equal to 0.05 mm in equivalent diameter in the less than 2 mm soil fraction. The sand separates recognized are very coarse, coarse, medium, fine, very fine, and total. Respective size limits are shown in section 618.47D above. Much of the sand fraction is composed of fragments of rocks and primary minerals, especially quartz. Therefore, the sand fraction is quite chemically inactive.
- (2) Significance.—Physical properties of the soil are influenced by the amounts of total sand and of the various sand fractions present in the soil. Sand particles, because of their size, have a direct impact on the porosity of the soil. This impact influences other properties, such as saturated hydraulic conductivity, available water capacity, water intake rates, aeration, and compressibility related to plant growth and

engineering uses.

- (3) **Measurement.**—Sand content is measured in the laboratory by the wet sieving method and then fractionated by dry sieving. Field estimates are made by manual methods. The degree of grittiness in a wet soil sample, when worked between the thumb and forefinger, gives an estimate of the sand content. The size of sand grains may be observed with the naked eye or with the aid of a hand lens.
- (4) **Entries.**—Enter the high, low, and representative value of the sand total separate and each sand size separate (sand very coarse separate, sand coarse separate, sand medium separate, sand fine separate, and sand very fine separate) as a percent of the material less than 2 mm in size for each horizon. The sum of the representative values for the five sand size fractions must equal the representative value for the sand total separate. The range of valid entries is from 0 to 100 percent, and tenths (one decimal place) are allowed. Enter a “0” if the amount is not significant, as in organic layers or in some andic soil materials. The representative values chosen should equate to a valid sand total content and sand size fraction content for the representative texture class posted for each horizon.

G. Silt Percentage

- (1) **Definition.**—“Silt percentage” is the weight percentage of the mineral particles greater than or equal to 0.002 mm but less than 0.05 mm in the less than 2 mm soil fraction. The silt separates recognized are fine, coarse, and total. The respective size limits are listed in paragraph 618.46D above. The silt separate is dominated by primary minerals, especially quartz, and therefore has a low chemical activity.
- (2) **Significance.**—The silt separate possesses some plasticity, cohesiveness, and absorption, but to a much lesser degree than the clay separate. Silt particles act to slow water and air movement through the soil by filling voids between sand grains. A very high content of silt in a soil may be physically undesirable for some uses unless supplemented by adequate amounts of sand, clay, and organic matter.
- (3) **Measurement**
 - (i) The silt content is measured in the laboratory in two phases. The fine silt is measured using the pipette method on the suspension remaining from the wet sieving process. Aliquots of the diluted suspension are removed at predetermined intervals based on Stokes Law. The aliquots are then dried and weighed. The coarse silt fraction is the difference between 100 percent and the sum of the sand, clay, and fine silt percentages.
 - (ii) The silt content may be estimated in the field using the ribbon test as described for clay. The content of silt is usually estimated by first estimating the clay and sand portions and then subtracting that number from 100 percent. Silt tends to give the soil a smooth feel.
- (4) **Entries.**—Enter the high, low, and representative value of the silt total separate and each silt size separate (silt coarse separate and silt fine separate) as a percent of the material less than 2 mm in size for each horizon. The sum of the representative values for the two silt size fractions must equal the representative value for the silt total separate. The range of valid entries is from 0 to 100 percent, and tenths (one decimal place) are allowed. Enter a “0” if the amount is not significant, as in organic layers or

Title 430 – National Soil Survey Handbook
in some andic soil materials. The representative value chosen should equate to a valid
silt total content for the representative texture class posted for each horizon.

618.48 Percent Passing Sieves

A. Definition.—The percent passing sieve numbers 4, 10, 40, and 200 is the weight of material that passes through these sieves, based on the material less than 3 inches (75 mm)* in size and expressed as a percentage.

B. Significance.—Data for the percent passing sieves are used to classify the soil in the engineering classifications and to make judgments on soil properties and performance. Many soil characteristics are influenced by the depth distribution of grain sizes for the soil as well as the soil's mode of deposition, stress history, density, and other features.

C. Measurement.—Measurements involve sieve analysis for the determination of grain size distribution of that portion of the soil having particle diameters between 3 inches and 0.074 mm (no. 200 sieve). ASTM Designations D 422, C 136, and C 117 are applicable procedures. Measurements are made on most benchmark soils and other representative soils in survey areas.

D. Estimates

(1) Estimates of the content of sand, silt, clay, and rock fragments that are made for soils during soil survey investigations and mapping activities are used to estimate percent passing sieves. If samples are tested later in a laboratory, adjustments are made to the field estimates as needed. Generally, experienced personnel can estimate these values with a high degree of accuracy. Estimates for percent passing sieves can be made from soil texture using the following general guidance:

(i) Percent passing #200 = clay + silt + 1/2 very fine sand.

(ii) Percent passing #40 = 1/2 very fine sand + fine sand + 1/2 medium sand + percent passing #200.

(2) The percent passing #10 equals the less-than-2-mm fraction, and soil texture is based on the less-than-2-mm fraction. Since sieves represent the less-than-3-inch fraction, the #40 and #200 sieve estimates must be adjusted when the percent passing #10 is less than 100 percent. The percent passing #40 and #200 that is determined by texture must be adjusted by multiplying the percent passing #40 and percent passing #200 by the percent passing #10. Pararock fragments are not coherent strongly enough to be retained on sieves. They are crushed and estimated into percent passing sieves. ASTM procedures use a roller crusher as a pretreatment of the soil material prior to sieving. Field estimates should try to replicate this procedure. Discrete artifacts which are either noncohesive or nonpersistent (e.g., paper) are not considered in estimating sieve values.

E. Entries.—Enter the high, low, and representative values to represent the range of percent passing each sieve size for each horizon. The range includes the estimating accuracy as well as the range of values for a soil. The range of valid entries is from 0 to 100 percent, and tenths (one decimal place) are allowed. A NASIS calculation is available and can be viewed in part 618, subpart B, section 618.104.

618.49 Plasticity Index

A. Definition.—“Plasticity index” is the numerical difference between the liquid limit and the plastic limit. It is the range of water content in which a soil exhibits the characteristics of a plastic solid. The plastic limit is the water content that corresponds to an arbitrary limit between the plastic and semisolid states of a soil.

B. Significance.—The plasticity index, when used in connection with the liquid limit, serves as a measure of the plasticity characteristics of a soil. The plasticity chart, given in ASTM Designation D 2487, is a plot of the liquid limit (LL) versus the plasticity index (PI) and is used in classifying soil in the Unified soil classification system. The plasticity index is also a criterion for classifying soil in the AASHTO classification system, as shown in part 618, subpart B, section 618.83. Soils that have a high plasticity index have a wide range of moisture content in which the soil performs as a plastic material. Highly and moderately plastic clays have large PI values.

C. Measurements.—Tests are made on that portion of the soil having particles passing the no. 40, (425 micrometer) sieve, according to ASTM Designation D 423. Measurements are made on most benchmark soils and on other representative soils in survey areas. Estimates of plasticity index are made on all soils during soil survey investigations and mapping activities. The plasticity index is usually not estimated directly: a position on the plasticity chart in ASTM Designation D 2487 is estimated and the plasticity index is determined from the chart. If soils are later tested in the laboratory, adjustments are made to the field procedures as needed. Generally, experienced personnel can estimate these values with a reasonable degree of accuracy. Estimates are expressed in ranges that include the estimating accuracy as well as the range of values from one location to another within the map unit.

D. Estimates.—The formula in part 618, subpart B, section 618.86, is used in the NASIS database to provide default calculated values if no measurements are available.

E. Entries.—Enter the high, low, and representative values to represent the range of plasticity index for each horizon. The range of valid entries is from 0 to 130 percent, and tenths (one decimal place) are allowed. However, entries should be rounded to the nearest 5 percent unless they represent measured values or a calculation is used. Enter “0” for nonplastic soils. The plasticity index for organic soil material is not defined and is assigned “null.” A NASIS calculation is available and can be viewed in part 618, subpart B, section 618.102.

618.50 Ponding Depth, Duration Class, Frequency Class, and Month

A. Free water may occur above the soil. Inundation is the condition when the soil is covered by liquid, free water.

B. Definition.—Ponding is the temporary inundation by standing water in a closed depression, including potholes, sloughs, backswamps, playas, and ponds. The water is removed only by deep percolation, transpiration, evaporation, or by a combination of these processes. Ponding of soils is classified according to depth, frequency, duration, and the months in which standing water is most likely to occur.

C. Ponding Depth

- (1) Definition.—“Ponding depth” is the depth of the surface water that is ponding inundation on the soil.
- (2) Entries.—Enter the high, low, and representative values for the ponding depth, in centimeters, for the map unit component. The range of valid entries is from 0 to 185 cm, and only whole numbers (integers) are allowed.

D. Ponding Duration Class

- (1) Definition.—“Ponding duration class” is the average duration, or length of time, of the ponding occurrence.
- (2) Classes.—The ponding duration classes are listed below:

Figure 618-A18

Ponding Duration Class	Duration of the Ponding Occurrence
Very brief	0.1 hour to < 48 hours
Brief	48 hours to < 7 days
Long	7 to < 30 days
Very long	≥ 30 days

- (3) Entries.—Enter “very brief,” “brief,” “long,” or “very long” for the map unit component. Only use entries if ponding frequency (defined below) occurs more often than “rare.” Ponding duration classes are assigned to months.

E. Ponding Frequency Class

- (1) Definition.—“Ponding frequency class” indicates the range in the number of times ponding occurs over a period of time, or the range in the percent probability of a ponding event in any year.
- (2) Classes.—The ponding frequency classes are listed below:

Figure 618-A19

Ponding Frequency Class	Definition
None	No reasonable possibility of ponding; less than 0.2 percent chance of ponding in any year or less than 1 time in 500 years.
Rare	Ponding is unlikely but possible; 0.2 percent to less than 5 percent chance of ponding in any year; or 1 time or more in 500 years but less than 5 times in 100 years.
Occasional	Ponding is expected infrequently; 5 to less than 50 percent chance of ponding in any year, or 5 times or more in 100 years but less than 50 times in 100 years.
Frequent	Ponding is likely to occur often; 50 percent or more chance in any year; 50 times or more in 100 years but less than a 100 percent chance of ponding in all months of any year.

- (3) Entries.—Enter “none,” “rare,” “occasional,” or “frequent” as appropriate for the mapunit component. Yearly ponding frequency classes are assigned to months, indicating the months of most likely occurrence and not the frequency of the ponding during the month. The time period expressed includes 70 percent of the occurrences.

F. Ponding Month

- (1) Definition.—“Ponding month” is the calendar months in which ponding is expected.
- (2) Classes.—The time of year when ponding is likely to occur is expressed in months for the expected beginning to expected end of the ponding period. The time period expressed includes 70 percent of the occurrences.
- (3) Entries.—Yearly ponding frequency classes are assigned to months and indicate the months of occurrence and not the frequency of the ponding during the month. Enter annual frequency in each month of the year in which ponding is expected, as defined above.

G. Significance.—The susceptibility of soils to ponding is important for homes, building sites, and sanitary facilities. Time and duration of the ponding are critical factors in determining plant species. Ponding during the dormant season has few if any harmful effects on plant growth or mortality and may even improve growth.

H. Estimates.—Generally, estimates of ponding frequency and duration can be made for each soil. Where the natural infiltration, saturated hydraulic conductivity, and surface and subsurface drainage of soils is altered, ponding studies are needed to reflect present ponding characteristics.

- (1) Evidence of ponding events should be gathered during soil survey fieldwork. High water lines and other signs of maximum water height are recorded. Other records may also exist.

- (2) Certain landform features are subject to ponding. These features are characteristics of closed drainage systems with concave, concave slope shape and include potholes, playas, sloughs, and backswamps. Most of these features are recognizable when correlating features on aerial photographs with ground observations. Different kinds of vegetation and soils are normally associated with these geomorphic features.
- (3) The vegetation that grows in ponded areas may furnish clues to past ponding and indicate the potential for ponding in the future. Generally, native vegetation in ponded areas consists of obligate and facultative wet hydrophytes. Some plant species are intolerant of ponding and do not grow in areas that are ponded.
- (4) The soil provides clues to past ponding, but characteristics vary according to climate and soil conditions. Some of the clues (alone or in any combination) are—
 - (i) A dark surface horizon or layer overlying a gleyed subsoil.
 - (ii) Many prominent redoximorphic features that have low value and chroma.
 - (iii) Capillary transport and concentrations of carbonates or sulfates, or both, in the upper soil horizons.
 - (iv) Dark colors and high levels of organic matter throughout the profile.

618.51 Pores

A. Definition.—Pores are small openings or voids (“pore space”) between soil particles and aggregates in the soil material. The term includes matrix, nonmatrix, and interstructural pore space. For water movement at low suction and conditions of saturation, the nonmatrix and interstructural porosity have particular importance.

- (1) Matrix Pores.—Matrix pores are formed by the agents that control the packing of the primary soil particles (i.e., primary packing voids). These pores are usually smaller than nonmatrix pores. Additionally, their aggregate volume and size can change markedly according to water state for soil horizons or layers with high extensibility.
- (2) Nonmatrix Pores.—Nonmatrix pores are relatively large voids that are expected to be present both when the soil is moderately moist or wetter as well as in drier states. The voids are not bounded by the planes that delimit structural units. Nonmatrix pores may be formed by roots, animals, the action of compressed air, and other agents. The size of the distribution of nonmatrix pores usually bears no relationship to the particle-size distribution and the related matrix pore-size distribution.
- (3) Interstructural Pores.—Interstructural pores are delimited by structural units. Inferences as to the interstructural porosity may be obtained from the structure description. Commonly, interstructural pores are at least crudely planar.

B. Description of Pores.—Nonmatrix pores are described by quantity, size, shape, and vertical continuity (generally in that order).

- (1) Pore Quantity
 - (i) Definition.—“Pore quantity” is defined by classes that pertain to the number of a selected size of pores per unit area of undisturbed soils. The unit area that is evaluated varies according to the size class of the pores: 1 cm² for very fine and fine pores, 1 dm² for medium and coarse pores, and 1 m² for very coarse pores.
 - (ii) Classes.—The pore quantity classes are described below:

Figure 618-A20

Pore Quantity Class	Number of Pores per Unit Area
Few	<1
Common	≥1-5
Many	≥5

(iii) Entries.—Enter pore quantity as pores/area. Enter the high, low, and representative values as whole numbers between 0 and 99 for the horizon.

(2) Pore Size

(i) Definition.—“Pore size” is the average diameter of the pore.

(ii) Classes.—The pore size classes are described below:

Figure 618-A21

Pore Size Class	Pore Size (mm)
Very fine	<1
Fine	≥1 to <2
Medium	≥2 to <5
Coarse	≥5 to <10
Very Coarse	≥10

(iii) Entries.—Enter a single class or classes for the horizon.

(3) Pore Shape

(i) Definition.—“Pore shape” is a description of the multi-areal shape of the pore. The shapes of nonmatrix pores are dendritic tubular (approximately cylindrical, elongated, and branching), irregular (nonconnected cavities or chambers), tubular (approximately cylindrical and elongated), or vesicular (approximately spherical or elliptical). The primary packing voids between soil particles or rock fragments are referred to as interstitial pores.

(ii) Classes.—The pore shape classes are:

- Dendritic tubular
- Interstitial
- Irregular
- Tubular
- Vesicular

(iii) Entries.—Enter one of the classes from the pore shape list for the horizon.

(4) Vertical Continuity

(i) Definition.—“Vertical continuity” is the average vertical distance through which the minimum pore diameter exceeds 0.5 mm when the soil layer is moist or wetter.

(ii) Classes.—The vertical continuity classes are described below:

Figure 618-A22

Vertical Continuity Class	Vertical Distance (cm)
Low	<1
Moderate	≥1 to <10
High	≥10

(iii) Entries.—Enter one of the vertical continuity classes.

618.52 Reaction

A. Acid Volatile Sulfides (Whiff Test)

- (1) Definition.—“Acid Volatile Sulfides” (AVS) is an odor test using 10% HCl. The smell of H₂S (hydrogen sulfide) gas is a positive indicator for monosulfides.
- (2) Classes.—The descriptive terms for odor include the kind and intensity. Odor kinds for AVS would be “none” or “sulfurous.” Odor intensity ranges from slight to strong.
- (3) Significance.—A positive reaction (detected H₂S odor) indicates the presence of monosulfides (FeS). If present, the “se” suffix symbol should be added to the soil horizon description.
- (4) Measurement.—Place a pinch of soil in a sealable plastic bag and add a few drops of 10% HCl. Close the bag and allow several seconds for a reaction. Open the bag and apply the “whiff test.” Caution: H₂S is a toxic gas and care should be taken when applying this test. A broad sweep of the hand to the nose in the open air is sufficient to sense any H₂S odor.
- (5) Entries.—Enter the odor kind and intensity of reaction to 10% HCl in the pedon horizon table.

B. Hydrogen Peroxide (Sulfidic Materials)

- (1) Definition.—“Reaction to Hydrogen Peroxide” is a color change and sometimes an effervescence class that helps identify the presence of sulfidic materials in coastal and subaqueous soils.
- (2) Classes.—The descriptive terms for effervescence class range from “none” to “violent.”
- (3) Significance.—A positive reaction (color change) indicates the presence of monosulfides (FeS), and the “se” suffix symbol should be added to the soil horizon description. Two concentrations of H₂O₂ (hydrogen peroxide) can be used: 3 percent and 30 percent.

A positive color response/reaction to application of 3% H₂O₂ indicates the presence of monosulfides (FeS), which quickly oxidize and change color (within 10 seconds) upon application of H₂O₂. Soils are considered potential acid sulfate soils if they contain

monosulfides.

A positive color response/reaction to application of 30% H₂O₂ indicates the presence of monosulfides (FeS), which quickly oxidize and change color (within 10 seconds) upon application of H₂O₂ within 10 seconds. The color change is usually an increase in value by 2 or more units. A color change indicates monosulfide detection ONLY and is not applicable to other sulfides (e.g., pyrite, marcasite, FeS₂).

Effervescence and a positive color response/reaction to application of 30% H₂O₂ can detect the type of monosulfides (FeS). A very slight through violent effervescence class combined with a positive color change indicates the presence of pyrite (sulfide mineral). An incubation pH test should be conducted to determine the type of sulfidic materials present. When only an effervescence class is observed with no color change, these soils are not considered to be monosulfidic soil materials.

- (4) Entries.—Enter the presence or absence of reaction to 3% H₂O₂ and 30% H₂O₂ in the pedon horizon table.

C. Soil Reaction (pH)

- (1) Definition.—“Soil reaction” is a numerical expression of the relative acidity or alkalinity of a soil.
- (2) Classes.—The descriptive terms for reaction and their respective ranges in pH are:

Reaction Class	Range in pH
Ultra acid	1.8-3.4
Extremely acid	3.5-4.4
Very strongly acid	4.5-5.0
Strongly acid	5.1-5.5
Moderately acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3
Slightly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0
Very strongly alkaline	9.1-11.0

(3) Significance

- (i) A principal value of soil pH is the information it provides about associated soil characteristics. Two examples are phosphorus availability and base saturation. Soils that have a pH of approximately 6 or 7 generally have the most ready availability of plant nutrients. Strongly acid or more acid soils have low extractable calcium and magnesium; a high solubility of aluminum, iron, and boron, and a low solubility of molybdenum. In addition, these soils may possibly have organic toxins and generally have a low availability of nitrogen and phosphorus. At the other extreme are alkaline soils. Calcium, magnesium, and molybdenum are abundant where there is little or no toxic aluminum and nitrogen is readily available. If pH is above 7.9, the soils may

have an inadequate availability of iron, manganese, copper, zinc, and especially phosphorus and boron.

- (ii) Soil reaction is one of several properties used as a general indicator of soil corrosivity or the soil's susceptibility to dispersion. In general, soils that are either highly alkaline or highly acid are likely to be corrosive to steel. Soils that have pH <5.5 are likely to be corrosive to concrete. Soils that have pH >8.5 are likely to be highly dispersible and may have a piping problem.
 - (iii) Soil reaction is used for soil classification in the required characteristics for sulfidic materials, in the key to calcareous and reaction classes for mineral soils, in the key to reaction classes for Histosols and Histels, and in criteria for certain taxa such as Sulfic subgroups.
- (4) Measurement.—The most common soil laboratory measurement of pH is the 1:1 water method. In this method, a crushed and sieved soil sample is mixed with an equal amount of water and a measurement is made of the suspension using a pH meter. Another common method, used for mineral and organic soils, is the 0.01M calcium chloride method. A new method to indicate the possible presence of sulfidic materials is the hydrogen peroxide test, delta pH for acid sulfate soils. This method uses hydrogen peroxide to rapidly oxidize sulphur compounds which releases elemental sulphur and quickly decreases the pH. In NASIS, the pH values derived from these three methods are populated in separate data elements.
- (i) The pH values derived from water suspension are affected by field applications of fertilizer or other salts in the soil, the content of carbon dioxide in the soil, and the moisture content at the time of sampling. The 0.01M calcium chloride method reduces these influences.
 - (ii) The laboratory procedure for measuring pH by the 1:1 water and 0.01 M calcium chloride methods are described in Soil Survey Investigations Report No. 42, *Soil Survey Laboratory Methods Manual*, Version 4.0, November 2004, USDA, NRCS.
 - (iii) The procedure for measuring pH by the hydrogen peroxide test, delta pH for acid sulphate soils method is described in Soil Survey Investigations Report No. 51, *Soil Survey Field and Laboratory Methods Manual*, Version 2.0, 2014, USDA, NRCS.
- (5) Estimates.—A variety of field test kits are available for determination of pH in the field. The methods include a water-soluble dye, which is mixed with soil and thus produces a color that is compared with a chart; a dye-impregnated paper, which changes color according to differences in pH; and portable glass electrodes. Each State office can recommend a suitable pH method for the soils in the State. If requested, the NSSC Kellogg Soil Survey Laboratory makes suggestions for suitable methods for field measurements and furnishes NRCS soil scientists with the proper chemicals.
- (6) Entries.—Soil reaction (pH) is time and moisture dependent, and water pH can vary up to a whole unit during the growing season. The range of pH should reflect the variations. The 1:1 water method generally is used with mineral soils. Mineral and organic soils are measured in a 1:2 0.01M calcium chloride solution and with the hydrogen

peroxide test, delta pH method. Separate entries are made by horizon for pH 1:1 water, pH 1:2 0.01M calcium chloride, and final pH oxidized, as needed. Enter the high, low, and representative values of the appropriate estimated pH range for each horizon. If laboratory measurements or accurate field estimates are available, the high and low values do not need to correspond with reaction class limits. However, if data is limited, then pH values may reflect reaction class limits such as 1.8-3.4, 3.5-4.4, etc., or a combination of reaction classes, such as 4.5-5.5, can be entered.

618.53 Restriction Kind, Depth, Thickness, and Hardness

A. Restriction Kind

- (1) Definition.—“Restriction kind” is the type of nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly reduce the movement of water and air through the soil or that otherwise provide an unfavorable root environment. Bedrock (e.g., limestone), cemented horizons (e.g., duripan), densic material (e.g., dense till), frozen horizons or layers (e.g., permanent ground ice), and horizontally oriented, human-manufactured materials (e.g., concrete) are examples of subsurface layers that are kinds of restrictions.
- (2) Significance.—Restrictive layers limit plant growth by restricting the limits of the rooting zone. They also impede or restrict the movement of soil water vertically through the soil profile and have a direct impact on the quality and quantity of ground water and surface water. Restrictions are important for both soil interpretations and soil classification.
- (3) Measurement.—Identify and describe restrictive soil layers in the field. Observe, measure, and record the restriction kind along with their depth, thickness, and hardness (defined below). When describing pedons, identify types or kinds of restrictions by suffix symbols, such as “d,” “f,” “m,” “r,” “v,” or “x,” or by the master layers “M” or “R.” Use measurements or observations made throughout the extent of occurrence of a soil as a basis for estimates of restriction kind.
- (4) Entries.—Enter the appropriate choice for the kind of restrictive horizon or layer from the following list:
 - (i) Abrupt textural change
 - (ii) Bedrock, densic
 - (iii) Bedrock, lithic
 - (iv) Bedrock, paralithic
 - (v) Cemented horizon
 - (vi) Densic material
 - (vii) Duripan
 - (viii) Fragipan
 - (ix) Manufactured layer
 - (x) Natric
 - (xi) Ortstein
 - (xii) Permafrost
 - (xiii) Petrocalcic
 - (xiv) Petroferic

- (xv) Petrogypsic
- (xvi) Placic
- (xvii) Plinthite
- (xviii) Salic
- (xix) Strongly contrasting textural stratification
- (xx) Sulfuric

B. Restriction Depth

- (1) Definition.—“Restriction depth” is the vertical distance from the soil surface to the upper and lower boundaries of the restriction.
- (2) Measurement.—Use measurements or observations made throughout the extent of occurrence of a soil as a basis for estimates of restriction depth.
- (3) Entries.—Restriction depth values used to populate component data in NASIS are not specific to any one point. They are a reflection of commonly observed values based on field observations and are intended to model the component as it occurs throughout the map unit. Enter the high, low, and representative values for the top and bottom restriction depths in centimeters using whole numbers (integers).

C. Restriction Thickness

- (1) Definition.—“Restriction thickness” is the distance from the top to the bottom of a restrictive layer.
- (2) Significance.—Restriction thickness has a significant impact on the ease of mechanical excavation.
- (3) Measurement.—Use observations made throughout the extent of occurrence of a soil as a basis for estimates of restriction thickness.
 - (iv) Entries.—Restriction thickness values used to populate component data in NASIS are not specific to any one point. They are a reflection of commonly observed values based on field observations and are intended to model the component as it occurs throughout the map unit. Enter the high, low, and representative values for the thickness in centimeters. The range of valid entries is from 1 to 999, and only whole numbers (integers) are allowed.

D. Restriction Hardness

- (1) Definition.—“Restriction hardness” is the rupture resistance coherence of an air-dried, then submerged block-like specimen of mineral material. Ice is not applicable.
- (2) Significance.—Restriction hardness has a significant impact on the ease of mechanical excavation. Use excavation difficulty classes (defined above) to evaluate the relationships of restriction layers to excavations.
- (3) Measurement.—Use observations made throughout the extent of occurrence of a soil as a basis for estimates of restriction hardness. For measurements of the restriction hardness, use the procedures and classes of coherence listed with the rupture resistance classes. Classes are described for like specimens about 25-30 mm on edge that are air-dried and then submerged in water for at least 1 hour. Compress the specimen between extended thumb and forefinger, between both hands, or between the foot and a nonresilient flat surface. If the specimen resists compression, drop a weight onto it from progressively greater heights until it ruptures. Failure is the point of the initial detection of deformation or rupture. Stress applied in the hand should be over a 1-second period. Learn the tactile sense of the class limits by applying force to top-

loading scales and sensing the pressure through the tips of the fingers or through the ball of the foot. Use postal scales for the resistance range that is testable with the fingers. Use a bathroom scale for the higher rupture resistance range.

- (4) Classes.—Restriction hardness is rated using the classes and operation descriptions listed below:

Figure 618-A24

Restriction Hardness (Rupture Resistance) Class	Operation Description*
Noncoherent	Fails under very slight force applied slowly between thumb and forefinger (<8N).
Extremely weakly coherent	Fails under slight force applied slowly between thumb and forefinger (8 to 20N).
Very weakly coherent	Fails under moderate force applied slowly between thumb and forefinger (20 to 40N).
Weakly coherent	Fails under strong force applied slowly between thumb and forefinger (about 80N maximum force can be applied) (40 to 80N).
Moderately coherent	Cannot be failed between thumb and forefinger but can be failed between both hands or by placing specimen on a nonresilient surface and applying gentle force underfoot (80 to 160N).
Strongly coherent	Cannot be failed in hands but can be failed underfoot by full body weight (about 800N) applied slowly (160 to 800N).
Very strongly coherent	Cannot be failed underfoot by full body weight but can be failed by <3J blow (800N to 3J).
Indurated	Cannot be failed by blow of 3J (> 3J).

* Both force (Newtons, N) and energy (joules, J) are employed. The number of Newtons is 10 times the kilograms of force. One joule is the energy delivered by dropping a 1 kg weight a distance of 10 cm.

618.54 Saturated Hydraulic Conductivity

A. Definition.—“Saturated hydraulic conductivity” is the ease with which pores of a saturated soil transmit water. Formally, it is the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy’s Law (a law that describes the rate of water movement through porous media). It is expressed in micrometers per second. To convert micrometers per second to inches per hour, multiply micrometers per second by 0.1417. The historical definition of “saturated hydraulic conductivity” is the amount of water that would move vertically through a unit area of saturated soil in unit time under unit hydraulic gradient.

B. Significance.—Saturated hydraulic conductivity is used in soil interpretations. It is also known as K_{sat}. Saturated hydraulic conductivity is used for soil classification in criteria for certain taxa, such as the Albaqualfs and Albaquults great groups.

C. Measurement.—Means of measurement, such as the Amoozemeter and double-ring infiltrometers, provide some basis for estimation of saturated hydraulic conductivity. No method has been accepted as a standard. Since measurements are difficult to make and are only available for relatively few soils, estimates of saturated hydraulic conductivity are based on soil properties.

D. Estimates.—The soil properties that affect saturated hydraulic conductivity are distribution, continuity, size, and shape of pores. Since the pore geometry of a soil is not readily observable or measurable, observable properties related to pore geometry are used to make estimates of saturated hydraulic conductivity. These properties are texture, structure, pore size, density, organic matter content, and mineralogy. Part 618, subpart B, section 618.88, provides a guide for estimating saturated hydraulic conductivity according to soil texture and bulk density or according to specified overriding conditions.

- (1) In making estimates, the soil characteristic that exerts the greatest control for many soils is texture.
- (2) The general relationships shown in part 618, subpart B, section 618.88, are adjusted up or down depending on bulk density. Structure, pore size, organic matter content, clay mineralogy, and other features observed within the soil profile, such as consistency, dry layers in wet seasons, root mats or absence of roots, and evidence of perched water levels or standing water, are good field indicators for adjusting estimates.
- (3) Water movement through bedrock for layers designated as R and Cr can be estimated from the guide in part 618, subpart B, section 618.89, of this handbook.

E. Entries.—Enter the high, low, and representative values of saturated hydraulic conductivity for each horizon. The range of valid entries is from 0 to 705 $\mu\text{m s}^{-1}$, and four decimal places are allowed.

618.55 Slope Aspect

A. Definition.—“Slope aspect” is the direction toward which the surface of the soil faces.

B. Significance.—Slope aspect may affect soil temperature, evapotranspiration, winds received, and snow accumulation.

C. Measurement.—Slope aspect is measured clockwise from true north as an angle between 0 and 360 degrees. Tools such as geographic information systems (GIS) can be used to consistently predict and identify slope aspect.

D. Entries.—For map unit components that are aspect dependent, enter the slope aspect counterclockwise, slope aspect clockwise, and slope aspect representative. The range of valid entries is from a minimum of 0 degrees to a maximum of 360 degrees. Record values to the nearest whole number (integer). The fields may be left NULL for those components that are not aspect dependent.

- (1) “Slope aspect counterclockwise” is one end of the range in characteristics for the slope aspect of a component. This end of the range is expressed in degrees measured clockwise from true north, but in the direction counterclockwise from the representative

slope aspect.

- (2) “Slope aspect clockwise” is one end of the range in characteristics for the slope aspect of a component. This end of the range is expressed in degrees measured clockwise from true north, but in the direction clockwise from the representative slope aspect.
- (3) “Slope aspect representative” is the common, typical, or expected direction toward which the surface of the soil faces, measured in degrees clockwise from true north.

618.56 Slope Gradient

A. Definition.—“Slope gradient” is the difference in elevation between two points and is expressed as a percentage of the distance between those points. For example, a difference in elevation of 1 meter over a horizontal distance of 100 meters is a slope of 1 percent.

B. Significance.—Slope gradient influences the retention and movement of water, the potential for soil slippage and accelerated erosion, the ease with which machinery can be used, soil-water states, and the engineering uses of the soil. Slope is used for soil classification in criteria for certain taxa, such as the Fluvents suborder, Fluvaquents great group, Fluvaquentic and Fluventic subgroups, and several Cumulic subgroups.

C. Measurement.—Slope gradient is usually measured in the field with a hand level or clinometer. The range is determined by summarizing data from several sightings. Slope gradient may also be determined through the use of a digital elevation model (DEM) and geospatial software. A DEM is a digital file format that is the representation of the elevation values over a topographic surface by a regular array of z-values.

- (1) DEMs are available in many resolutions and sources. Resolution refers to the smallest measurement unit represented by the data. A resolution is selected to capture and represent the soil resource of concern for the project area. Resolution will typically be 5 or 10 meters to a side. Resolutions larger than 10 meters are not used except in special circumstances, such as remote, wildland surveys where higher resolution data is unavailable.
- (2) DEM sources are developed using light detection and ranging (LiDAR), interferometric synthetic aperture radar (IFSAR) and older methods, including electronic image correlation, manual profiling on stereoplotters, and contour-to-grid interpolation. USGS is the largest provider of DEMs with sources derived from all methods except IFSAR. DEMs produced using older methods may have artifacts that preclude it from use.
- (3) A project area may have DEMs of multiple resolutions with overlapping extents. This process is resampling and should proceed from finer to coarser resolutions. In these cases, a seamless DEM is developed at a common resolution that meets the objectives of the project. For example, data at 3-meter and 5-meter resolution is resampled to match adjacent 10-meter DEMs. Two common methods are available, resample and aggregate. Resample will convert from an input resolution to any output resolution with elevation values assigned using bilinear or cubic convolution. Aggregate will convert to output resolutions that are evenly divisible by the input resolution with output values assigned using the mean or median of the aggregation. There is no practical difference in the output produced from these methods.

- (4) Slope gradient is calculated from a DEM using geospatial software based on two common algorithms, Evans and Young (see Evans, 1979, in subpart B, section 618.106) and Zevenbergen and Thorne (1987) (see subpart B, section 618.106). The Evans and Young algorithm is often the sole method available. The output unit for slope gradient is percent for soil survey purposes. Differences in the output between these methods is not of practical significance for soil survey purposes.
- (5) Slope gradient is determined based on a neighborhood. Neighborhood size may be thought of as analogous to the length parameter in a conventional slope measurement. The common implementation in geospatial software uses a 3 x 3 neighborhood, typically a range of 10 to 40 meters. This neighborhood works well for larger cell resolutions like 10 or 30 meters, but results in noisy slope gradients when using small cell resolutions like 1 or 3 meters. Software that allows setting neighborhood size as a parameter is an important option for derivation of slope gradient as resampling is not required. Smaller neighborhoods emphasize local variation, while larger neighborhoods emphasize broad trends. Neighborhood size is based on the terrain and soil mapping objectives.
- (6) Neighborhood shape is a parameter available with some software. Most implementations of slope gradient use a square neighborhood explicitly defined by the cell resolution. A circular neighborhood has been shown to provide a more accurate representation of slope gradient (see Shi et.al., 2007, 2012, in subpart B, section 618.106).
- (7) The slope gradient calculation will produce a layer containing floating point data type. Converting the original slope gradient layer to an integer data type is acceptable. Integer data types result in smaller file sizes and quicker processing operations. Statistical parameters like majority and median are available automatically from some geospatial software when integer data types are used as inputs.

D. Entries.—Enter the high, low, and representative values to represent the range of slope gradient as a percentage for the map unit component. The range of valid entries is to the nearest integer from 0 to 99 percent. Tenths (one decimal place) are allowed but are only used for representative values less than 1 percent. These values may be determined by a statistical summary of the slope gradient layer for a given map unit layer. Slope gradient distributions are seldom normal, eliminating the use of conventional statistical parameters like mean and standard deviation as tools for determining the high, low and representative values. These values should be based on the robust parameters of percentiles. The representative value is based on the median. The low and high should be based on ranges that capture a majority of the area represented in a map unit. Using the 10th and 90th percentiles as the low and high represents 80 percent of the area.

618.57 Slope Length, USLE

A. Definition.—“Slope length” is the horizontal distance from the origin of overland flow to the point where either the slope gradient decreases enough that deposition begins or runoff becomes concentrated in a defined channel. Refer to Agriculture Handbook 703.

B. Significance.—Slope length has considerable control over runoff and potential accelerated water erosion. Slope length is combined with slope gradient in erosion prediction equations to account for the effect of topography on erosion.

C. Measurement

- (1) Slope length is measured from the point of origin of overland flow to the point where the slope gradient decreases enough that deposition begins or runoff becomes concentrated in a defined channel. In cropland, defined channels are usually ephemeral gullies or, in rare cases where they are near a field edge, are a classic gully or stream. Surface runoff will usually concentrate in less than 400 feet (120 meters), although longer slope lengths of up to 1000 feet are occasionally found. The maximum distance allowed in erosion equations is 1000 feet (305 meters). Conversion to the horizontal distance is made in the conversion process within the equation model.
- (2) Assume no support practices. Ignore practices such as terraces or diversions. Slope length is best determined by pacing or measuring in the field. Do not use contour maps to estimate slope lengths unless contour intervals are 1 foot or less. Slope lengths estimated from contour maps are usually too long because most maps do not have the detail needed to indicate all ephemeral gullies and concentrated flow areas that end the slope lengths. Refer to figures 4-1 through 4-10 within Agriculture Handbook 703 for more landscape guidance.

D. Entries.—Enter the high, low, and representative values for the range for each map unit component. Enter a whole number that represents the slope length in meters, from the point of origin of overland flow to the point of deposition or concentrated flow, of the slope on which the component lies. The slope length may be fully encompassed within one map unit or may cross several map units. The minimum value is 0, and the maximum value used in erosion equations is 305 meters. The NASIS database allows valid entries from 0 to 4000 meters.

618.58 Sodium Adsorption Ratio

A. Definition.—“Sodium adsorption ratio” (SAR) is a measure of the amount of sodium (Na^+) relative to calcium (Ca^{2+}) and magnesium (Mg^{2+}) in the water extracted from a saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. SAR is calculated from the following equation:

$$\text{SAR} = \text{Na}^+ / [(\text{Ca}^{2+} + \text{Mg}^{2+})/2]^{0.5}$$

B. Significance.—Sodium adsorption ratio is used for soil classification in the required characteristics for the natric horizon, in the key to soil orders and key to suborders of Inceptisols and Mollisols, and in criteria for certain taxa such as Sodic subgroups. Soils that have values for sodium adsorption ratio of 13 or more may have an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

C. Measurement.—The concentration of Na, Ca, and Mg ions is measured in a water extract from a saturated soil paste. The method is described in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS. The sodium adsorption ratio is then calculated from the molar concentrations of the three cations using the equation shown above in section 618.58A.

D. Entries.—Enter the high, low, and representative values for the range of sodium adsorption ratio for each horizon. Enter “0” where SAR is negligible. The range of valid entries is from 0 to 9999, and tenths (one decimal place) are allowed.

618.59 Soil Erodibility Factors, USLE, RUSLE2

A. Definition.—Soil erodibility factors K_w and K_f quantify soil detachment by runoff and raindrop impact. These erodibility factors are indexes used to predict the long-term average soil loss from sheet and rill erosion under crop systems and conservation techniques. Factor K_w applies to the whole soil, and factor K_f applies only to the fine-earth (less than 2.0 mm) fraction.

The procedure for determining the K_f factor is outlined in Agriculture Handbook 703, “Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE),” USDA, Agricultural Research Service, 1997. The K factors for soils in Hawaii and the Pacific Basin were extrapolated from local research. The nomograph, shown in part 618, subpart B, section 618.91, was not used to determine K factors for soils in Hawaii.

B. Classes.—Experimentally measured K_w factors vary from 0.02 to 0.69. For soil interpretations, the factors are grouped into 14 classes. The classes are identified by a representative class value as follows: 0.02, 0.05, 0.10, 0.15, 0.17, 0.20, 0.24, 0.28, 0.32, 0.37, 0.43, 0.49, 0.55, and 0.64.

C. Significance.—Soil erodibility factors K_w or K_f are used in the erosion prediction equations USLE and RUSLE.

- (1) Soil properties that influence rainfall erosion are those that affect—
 - (i) Infiltration rate, movement of water through the soil, and water storage capacity.
 - (ii) Dispersion, detachability, abrasion, and mobility by rainfall and runoff.
- (2) Some of the most important properties are texture, organic matter content, structure size class, and the saturated hydraulic conductivity of the subsoil.

D. Estimates

- (1) The K_w factor is measured by applying a series of simulated rainstorms on freshly tilled plots. Direct measurement of K factors is both costly and time consuming and is conducted only for a few selected soils.
- (2) Reliable estimates of K_f factor are obtained from the soil erodibility nomograph, which is presented on page 11 of Agriculture Handbook 537 and reproduced in part 618, subpart B, section 618.91, or by using the soil erodibility equation. The nomograph integrates the relationship between the K_f factor and the following five soil properties:

- (3) Percent silt plus very fine sand
- (i) Percent sand greater than or equal to 0.10 mm
 - (ii) Organic matter content
 - (iii) Soil structure
 - (iv) Saturated hydraulic conductivity
- (4) The soil erodibility equation which follows also provides an estimate of
- $$K_f \text{ K factor} = \{2.1 \times M^{1.14} \times 10^{-4} \times (12-a) + 3.25 \times (b-2) + 2.5 \times (c-3)\} / 100$$

where: $M = (\text{percent si} + \text{percent vfs}) \times (100 - \text{percent clay})$

Example: For a soil with 29.0% silt, 12.3% very fine sand, and 36%

$$\text{clay } M = (29.0 + 12.3) \times (100 - 36) = 2,643.20.$$

a = percent organic matter (0, 1, 2, 3, or 4).

b = soil structure code (1, = very fine granular, 2, = fine granular, 3, = med or coarse granular, or 4 = blocky, platy, or massive)

c = profile saturated hydraulic conductivity code (1, 2, 3, 4, 5, or 6).

Use the layer with the lowest K_{sat} RV (representative value) in the permeability control section. The permeability control section is the zone from the top of the mineral soil layer being evaluated to a depth of 50 cm below the top of that soil layer but should not exceed a profile depth of 200 cm. The permeability control section guarantees that a specific zone is only considered relative to the mineral soil layer being evaluated. Include the permeability of any bedrock or other nonsoil layers in the permeability control section.

Note that the codes were initially established using the 1951 edition of the *Soil Survey Manual*. The codes correspond to the following saturated hydraulic conductivity ranges.

Figure 618-A25

Profile permeability class code	Permeability class of 1951	Saturated hydraulic conductivity range $\mu\text{m/sec}$	Saturated hydraulic conductivity classes (1993)
6	Very slow	<0.30	very low or mod. low
5	Slow	≥ 0.30 to <1.20	mod. low
4	Slow or mod.	≥ 1.20 to <4.80	mod. high
3	Moderate	≥ 4.80 to <15.00	mod. high or high
2	Mod. or rapid	≥ 15.00 to <30.00	high
1	Rapid	≥ 30.00	high or very high

- (5) The accuracy of the nomograph and equation has been demonstrated for a large number of soils in the United States. However, the nomograph and the equation may not be applicable to some soils having properties that are uniquely different from those used in developing the nomograph. For example, the nomograph does not accurately predict K_f factors for certain Oxisols in Puerto Rico or the Hawaiian Islands; some

- soils with andic soil properties, organic soil materials, or low activity clays; and some calcareous or micaceous soils. In these cases, Kf factors are estimated using the best information at hand and knowledge of the potential for rainfall erosion. See Agriculture Handbook 703 for more information.
- (6) When using the nomograph and the equation, care should be taken to select an organic matter percentage that is most representative of the horizon being considered, assuming long-term cultivation. It is acceptable to use linear interpolations between plotted lines on the nomograph and values in hundredths (two decimal places) for organic matter content in the equation. For horizons that have organic matter content greater than 4 percent, use the 4-percent curve in the nomograph and exactly 4 percent in the equation.
 - (7) Rock or pararock fragments are not taken into account in the nomograph or the soil erodibility equation. If fragments are substantial, they have an armoring effect. Pararock fragments are assumed to break down with cultivation or other manipulation and so are not used in determining Kw factors. If a soil has mixtures of rock and pararock fragments, the Kw factor should reflect the degree of protection afforded only by the rock fragments. Guidelines for determining Kw factors are as follows:
 - (i) First, use the soil erodibility nomograph shown in part 618, subpart B, section 618.91, or the soil erodibility equation shown above to determine the Kf factor for the soil material less than 2 mm in diameter.
 - (ii) Then use the table in part 618, subpart B, section 618.92, to convert the Kf value of the soil fraction less than 2 mm in diameter, which is derived from either the nomograph in part 618, subpart B, section 618.91, or from the soil erodibility equation, to a Kw factor adjusted for the total volume of rock fragments. The Kw factor is adjusted only when the total content of rock fragment values in the layer, by volume, is equal to or greater than 15 percent. If total rock fragment content, by volume, is less than 15 percent, the Kw factor equals the Kf factor. In practice, the representative values (RVs) for rock fragment volume, as populated in the NASIS “Horizon Fragments” table, are summed for each size fraction to compute the total rock fragment content for the layer.
 - (iii) If the soil on site contains more or less rock fragments than the mean of the range reported, adjustments can be made in Kf by using part 618, subpart B, section 618.92. Select the estimates of total rock fragment volume percentages, then use part 618, subpart B, section 618.92. In part 618, subpart B, section 618.92, go to the line with the rock fragment volume percentage and find, in the appropriate line, the nearest value to the Kf factor. Within that column, read the Kw factor on the line with the percentage of rock fragments of the soil for which you are making the estimate. Round the K factor displayed in the table to the closest acceptable K factor class entry, as shown below. This is the new Kw factor adjusted for rock fragments on site.

E. Entries.—Enter the coordinated values for Kw and Kf factor classes for each horizon posted, except organic horizons.

- (1) The acceptable entries for Kw and Kf classes are: 0.02, 0.05, 0.10, 0.15, 0.17, 0.20, 0.24, 0.28, 0.32, 0.37, 0.43, 0.49, 0.55, and 0.64. Use the comparison reports and calculation script in NASIS for help in populating Kf and Kw factors. Use the reports

to print or export the currently stored values for Kf and Kw factor classes for each component in a selected set for comparison with the computed Kf and Kw factor classes using the calculation script formulas. The comparison reports give a preview of the results of the K factor calculations and should be used before the decision is made to run the calculation and save the new data.

- (2) Soil horizons that do not have rock fragments are assigned equal Kw and Kf factors. In horizons where total rock fragments are 15 percent or more, by volume, the Kw factor is always less than the Kf factor. For example:

Figure 618-A26

Depth (in)	USDA Texture	Kw	Kf
0-5	GR-L	0.20	0.32
0-5	L	0.32	0.32
0-5	GRV-L	0.10	0.32
0-46	CL	0.28	0.28
46-60	SL	0.20	0.20

- (3) Soils that have similar properties and erosivity should be grouped in similar K factor classes.

618.60 Soil Erodibility Factors for WEPP

A. Definition.—Soil erodibility factors for WEPP include interrill erodibility (Ki), rill erodibility (Kr), and critical shear stress (Tc). These erodibility factors for the WEPP erosion model quantify the susceptibility of soil detachment by water. They predict the long-term average soil loss which results from sheet and rill erosion under various alternative combinations of crop systems and conservation techniques.

B. The Ki, Kr, and Tc factors are used in a continuous simulation computer model that predicts soil loss and deposition on a hillslope. Reference NSERL Report No. 9, USDA, Agricultural Research Service, National Erosion Research Laboratory, August 1994, documentation version

94.7. This procedure does not include data for soils with highly weathered material (e.g., oxic horizons) and those with andic soil properties. These factors are quantitative and calculated using experimental equations. They are different from the soil erodibility factors used in USLE and RUSLE.

(1) Interrill Erodibility (Ki)

- (i) Definition.—“Interrill erodibility (Ki)” is the susceptibility of detachment and transport of soil particles by water. It is the susceptibility of the soil to movement to a rill carrying runoff.
- (ii) Significance.—Interrill erodibility (Ki) is a measure of sediment delivery rate to rills as a function of rainfall intensity. The Ki values for soil need to be adjusted if factors that influence the resistance of soil to detachment occur. These factors include live and dead root biomass, soil freezing and thawing, and mechanical and livestock compaction.

- (iii) Measurement.—Interrill erodibility (K_i) measurements are determined from rainfall simulation experiments. These experiments require the use of specialized equipment and specialized measurement techniques in a research setting.
 - (iv) Calculations.—Use the following equations:
 - For cropland soils with 30 percent or more sand:

$$K_i = 2,728,000 + 192,100 \times (\% \text{ very fine sand})$$

Where very fine sand must be less than or equal to 40 percent; if very fine sand is greater, use 40 percent.
 - For cropland soils with less than 30 percent sand:

$$K_i = 6,054,000 - 55,130 \times (\% \text{ clay})$$

Where clay must not exceed 50 percent; if clay is greater, use 50 percent.
 - (v) Entries.—The computer generates entry values using the above formulas. Allowable K_i values range from 2,000,000 to 11,000,000.
- (2) Rill Erodibility (K_r)
- (i) Definition.—“Rill erodibility (K_r)” is a measure of the susceptibility of a soil to detachment by flowing water. As rill erodibility (K_r) increases, rill erosion rates increase.
 - (ii) Significance.—Rill erodibility (K_r) is often defined as the soil detachment per unit increase in shear stress of clear water flow. The rate of soil detachment in rills varies because of a number of factors, including soil disturbance by tillage, living root biomass, incorporated residue, fragments, soil consolidation, freezing and thawing, and wheel and livestock compaction.
 - (iii) Measurement.—Rill erodibility (K_r) measurements are determined by rainfall simulation and flow simulation experiments. These experiments require the use of specialized equipment and specialized measurement techniques in a research setting.
 - (iv) Calculations.—Use the following equations:
 - For cropland soils with 30 percent or more sand:

$$K_r = 0.00197 + 0.00030 \times (\% \text{ very fine sand}) + 0.03863 \times \text{EXP}(-1.84 \times \text{ORGMAT})$$

Where—

 - Organic matter (ORGMAT) is the organic matter in the surface soil (assuming that organic matter equals 1.724 times organic carbon content). Organic matter must exceed 0.35 percent; if less, use 0.35 percent.
 - Very fine sand must be less than or equal to 40 percent; if greater, use 40 percent.
 - For cropland soils with less than 30 percent sand:

$$K_r = 0.0069 + 0.134 \times \text{EXP}(-0.20 \times \% \text{ Clay})$$

- Where clay must be 10 percent or greater; if less, use 10 percent.
- (v) Entries.—The computer generates the value by using the above formulas. Allowable K_r values range from 0.002 to 0.045 s/m.
- (3) Critical Shear Stress (T_c)
- (i) Definition.—“Critical shear stress (T_c)” is the hydraulic shear that must be exceeded before rill erosion can occur.
- (ii) Significance.—Critical shear stress (T_c) is important in the rill detachment equation. It is the shear stress below which no soil detachment occurs. Critical shear stress (T_c) is the shear intercept on a plot of detachment by clear water versus shear stress in rills.
- (iii) Measurements.—Critical shear stress (T_c) is derived from a specialized research project.
- (iv) Calculations.—Use the following equations:
- For cropland soils with 30 percent or more sand:

$$T_c = 2.67 + 0.065 \times (\% \text{ clay}) - 0.058 \times (\% \text{ very fine sand})$$

Where very fine sand must be less than or equal to 40 percent; if greater, use 40 percent.
 - For cropland soils with less than 30 percent sand:

$$T_c = 3.5$$
- (v) Entries.—No manual entry is needed. The value is computer generated using the above formulas. Allowable T_c values range from 1 to 6 N/m².

618.61 Soil Moisture Status

A. Definition.—“Soil moisture status” is the mean monthly soil water state at a specified depth.

B. Classes.—The water state classes used in soil moisture status are: dry, moist, and wet. These classes are defined as follows:

Figure 618-A27

Water State Class	Definition
Dry	≥ 15 bar suction
Moist	< 15 bar to ≥ 0.0 bar (moist plus nonsatiated wet)
Wet	< 0.0 bar; free water present (satiated wet)

C. Significance.—Soil moisture status is a recording of the generalized water states for a soil component. Soil moisture greatly influences vegetation response, root growth, excavation difficulty, albedo, trafficability, construction, conductivity, soil chemical interactions, workability, chemical transport, strength, shrinking and swelling, frost action, seed germination, and many other properties, qualities, and interpretations. Soil moisture states are significant to soil taxonomic classification, wetland classification, and other classification systems. The recording of soil moisture states helps to document the soil classification as well

as convey information useful for crop and land management models.

D. Measurement

- (1) Soil water status can be measured using tensiometers or moisture tension plates. Soil water status also can be field estimated. Chapter 3 of the *Soil Survey Manual* provides more information. It is important to note that the three water state classes and eight subclasses described in the *Soil Survey Manual* are used to describe the moisture state at a point in time for individual pedons (spatial and temporal point data), while the water state classes discussed here are used to estimate the mean monthly aggregated moisture conditions for a map unit component. As a consequence, only three classes are used and the definitions for the moist and wet classes are modified from the definitions in the *Soil Survey Manual*. The wet class used here includes only the satiated wet class and corresponds to a free water table. The moist class is expanded to include the nonsatiated wet class given in the *Soil Survey Manual*.
- (2) Dry is separated from moist at 15 bar suction. Wet satiated has a tension of 0.0 bar or less (zero or positive pore pressure).
- (3) Changes in natural patterns of water movement from dams and levees are considered in evaluating and entering soil moisture status. Infiltration, saturated hydraulic conductivity, and organic matter, which affect soil moisture movement, are strongly impacted by land cover and land use. Land use and land cover should be considered as a mapping tool for separating map units or map unit components. The difference in soil moisture status resulting from differences in land use and land cover constitute a difference in soil properties. However, conservation practices, such as irrigating and fallowing the land, alter the soil moisture status but are not considered in the map unit component data. Use-dependent databases may allow entries for these altered states in the future. Permanent installations, such as drainage ditches and tile, affect soil moisture status, and the drained condition should be reflected in the soil moisture status entries for map unit components that are mapped as “drained.” Undrained areas are mapped as “undrained” components, and the entries for soil moisture status reflect the undrained condition.
- (4) Irrigation and drainage canals are shown on soil maps; their effects on the soil should be shown in the properties of the soils in mapping and in the property records. Soils that are now wet because of excessive irrigation and leaking canals should be mapped, and their properties should reflect the current soil moisture status.

E. Guiding Concepts

- (1) The intent is to describe a mean moisture condition, by month, for a soil component. Layer depths may or may not be the same as horizon depths in the “Component Horizon” table. Layers define the zone having a specific soil moisture state. If the soil is wet throughout 0 to 200 cm, then one entry (“wet”) is made for 0 to 200 cm for that month.
- (2) For frozen soils, enter the appropriate soil moisture state that the soil would have if thawed. For example, if the soil is frozen and then determined to be wet when thawed, enter “wet.”
- (3) The horizons can be subdivided or combined, as appropriate, into layers for the various soil moisture states as needed. Remember that these are monthly averages for the extent of the component across the landscape.

- (4) The entries are expected to come from the best estimates that local knowledge can provide. When possible, use documented measurements. The information as aggregated data is not expected to be exact but should be generalized and reflect an average condition.
- (5) Entries for the representative values (RV) on distance to the upper and lower boundary of the moisture layer should reflect the soil moisture conditions expected in a normal year, as defined in the latest edition of the Keys to Soil Taxonomy.
- (6) Make entries for each month by layer. Enter the dominant condition for the month. This is the condition that exists for more than 15 days on the long-term average. The low and high values represent the depth range within the component for the normal year; they should not represent the extremes, such as years of drought.
- (7) If the depth to free water fluctuates during the month, use the depth for the average between the high and low levels.

F. Entries.—Enter the soil moisture status as “dry,” “moist,” or “wet” for each soil layer for each month. Enter only one soil moisture state for a given layer. The number of layers depends upon the number of changes of soil moisture status in the profile. Enter the values for component soil moisture depth to top and depth to bottom that represents the distance, in whole centimeters, from the soil surface to the top and bottom respectively, of each soil layer for each month. Part 618, subpart B, section 618.97, contains examples of entries in a worksheet format that graphs soil moisture status by month and depth.

618.62 Soil Slippage Potential

A. Definition.—“Soil slippage potential” is the hazard that a mass of soil will slip when vegetation is removed, soil water is at or near saturation, and other normal practices are applied. Conditions that increase the hazard of slippage but are not considered in this rating are undercutting lower portions or loading the upper parts of a slope or altering the drainage or offsite water contribution to the site, such as through irrigation. The publication “Landslides Investigation and Mitigation Special Report 247” (Transportation Research Board, National Research Council, 1996) provides additional information on landscape slippage.

B. Significance.—Slippage is an important consideration for engineering practices, such as constructing roads and buildings, and for forestry practices.

C. Estimates.—Soil slippage potential classes are estimated by observing slope; lithology, including contrasting lithologies; strike and dip; surface drainage patterns; and occurrences of such features as slip scars and slumps.

D. Guides.—Use part 618, subpart B, section 618.96, “Key Landforms and Their Susceptibility to Slippage,” as a guide for rating the hazard of slippage.

E. Entries.—Enter one of the following soil slippage potential classes for the component:

- (1) High (unstable)
- (2) Medium (moderately unstable)
- (3) Low (slightly unstable to stable)

618.63 Soil Temperature

- A. Definition.—“Soil temperature” is the temperature calculated as both the mean annual temperature at a single depth in the soil and the mean monthly temperature calculated at a specified depth range for each month of the year.
- B. Significance.—Soil temperature is important to many biological and physical processes that occur in the soil. Plant germination and growth are closely related to soil temperature. Cold soil temperatures effectively create a thermal pan in the soil. Roots cannot uptake moisture or nutrients below the threshold temperatures specific to plant species. Chemical reactions are temperature sensitive. Pesticide breakdown, residue breakdown, microbiological activity in the soil, and nutrient conversions relate to soil temperature. Soil temperature gradients affect soil moisture and salt movement. Soil temperatures below freezing especially affect soil saturated hydraulic conductivity, excavation difficulty, and construction techniques. Soil temperature is used in soil classification and hydric soil determinations. Additional information on soil temperature is provided in chapter 3 of the *Soil Survey Manual* and chapter 4 of *Soil Taxonomy*.
- C. Estimates.—Soil temperature according to depth can be estimated from measured soil temperatures of the vicinity. Air temperature fluctuations, soil moisture, aspect, slope, color, snow cover, plant cover, and residue cover affect soil temperature. Estimates of soil temperature should take these factors into account when soil temperatures are extrapolated from one soil map unit component to another.
- D. Measurement.—Soil temperature can be measured by many types of thermometers, including mercury, bimetallic, thermistors, and thermocouples. Many types of thermometers can be configured for remote, unattended operation.
- E. Mean Annual Soil Temperature (MAST)
- (1) Definition.—“Mean annual soil temperature (MAST)” is the temperature generally determined at a depth of 50 cm below the soil surface or at the upper boundary of a root-limiting layer as defined in *Soil Taxonomy*, whichever is shallower.
 - (2) Entries.—Enter the high, low, and representative values for the range of mean annual soil temperature for the component as the long-term average of the mean monthly soil temperatures in the “Component” table. The long-term average is generally considered to be a 30-year average. The range of valid entries is from -40 to 50 degrees Celsius, and tenths (one decimal place) are allowed.
- F. Mean Monthly Soil Temperature
- (1) Definition.—“Mean monthly soil temperature” is the long-term monthly average of the mean daily high and daily low soil temperatures at a specified depth for the month in question. Long-term is generally considered to be a 30-year average.
 - (2) Entries.—Enter soil temperature for the component as the long-term monthly average of the mean daily soil temperature at a specified depth for the month in question in the “Component Soil Temperature” table. The long-term average is generally considered to be a 30-year average. The range of valid entries is from -25 to 50 degrees Celsius, and only whole numbers (integers) are allowed. The number of layers populated depends

upon the number of changes of soil temperature status in the profile.

G. Soil Temperature, Depth to Top

- (1) Definition.—“Soil temperature, depth to top” is the distance from the top of the soil to the upper boundary of the soil temperature layer.
- (2) Entries.—Enter the value for “soil temperature, depth to top” that represents the distance, in centimeters, from the soil surface to the top of each soil temperature layer for each month in the “Component Soil Temperature” table.

H. Soil Temperature, Depth to Bottom

- (1) Definition.—“Soil temperature, depth to bottom” is the distance from the top of the soil to the lower boundary of the soil temperature layer.
- (2) Entries.—Enter the value for “soil temperature, depth to bottom” that represents the distance, in centimeters, from the soil surface to the bottom of each soil temperature layer for each month in the “Component Soil Temperature” table.

618.64 Subsidence, Initial and Total

A. Definition.—“Subsidence” is the decrease in surface elevation as a result of the drainage of wet soils that have organic layers or semifluid, mineral layers. Initial subsidence is the decrease of surface elevation that occurs within the first 3 years of the drainage of these wet soils. Total subsidence is the potential decrease of surface elevation as a result of the drainage of these wet soils.

B. Significance

- (2) The susceptibility of soils to subsidence is an important consideration for organic soils that are drained. If these soils are drained for community development, special foundations are needed for buildings. Utility lines, sidewalks, and roads that lack special foundations may settle at different rates, thus causing breakage, high maintenance costs, and inconvenience. If the soils are drained for farming, the long-term effects of subsidence, the possible destruction of land if it subsides below the water table, and possible legal implications where the soils are in wetlands must be considered.
- (3) Subsidence as a result of drainage is attributed to the factors in the following list. The first three factors are responsible for the initial subsidence that occurs rapidly, specifically within about 3 years after the water table is lowered.
 - (i) Shrinkage from drying
 - (ii) Consolidation because of the loss of ground-water buoyancy
 - (iii) Compaction from tillage or manipulation
 - (iv) Wind erosion
 - (v) Burning
 - (vi) Biochemical oxidation
- (4) After the initial subsidence, a degree of stability is reached and the loss of elevation declines to a steady rate, primarily because of oxidation. The oxidation and subsidence continue at this slower rate until stopped by the water table or underlying mineral material.

- (i) The rate of subsidence depends on—
- (ii) Ground-water depth
- (iii) Amount of organic matter
- (iv) Kind of organic matter
- (v) Soil temperature
- (vi) pH
- (vii) Biochemical activity

C. Estimates

- (1) A number of studies have been made to measure actual subsidence. Other useful studies have measured the bulk density of organic soils after drainage. Based on these studies, some general guidelines can be given for initial and total subsidence.
- (2) Initial subsidence generally is about half of the depth to the lowered water table or to mineral soil, whichever is shallower. It occurs within about 3 years after drainage. Total subsidence is the total depth to the water table or the thickness of the organic layer, whichever is shallower. It is rarely reached, except where organic layers are thin or where drainage systems have been installed for a long time.

D. Measurement.—After organic soils have been drained and cultivated for a number of years, they reach a nearly steady rate of subsidence that is reflected by the rather stable bulk density. Unpublished studies by the NSSC Kellogg Soil Survey Laboratory have shown that the bulk density of the organic component, such as that with the percent mineral calculated out, stabilizes at around 0.27 g/cc for surface layers and 0.18 g/cc for subsurface layers. These values can be used to calculate the amount of subsidence at some time in the future as compared to the thickness of soil at the time of observation or measurement. The procedure is as follows:

- (1) Sample the surface and subsurface layers for field state bulk density. Methods are described in the Handbook of Soil Survey Investigations Field Procedures, I 4-2, 1971, USDA, Soil Conservation Service, and in Soil Survey Investigations Report No. 42, *Soil Survey Laboratory Methods Manual*, Version 4.0, November 2004, USDA, NRCS.
- (2) Calculate out the weight contribution of the mineral component to obtain the bulk density of the organic component (DbOM). This manipulation allows bulk densities to be on a common base so that various layers can be compared. The formula for the computation is as follows: $DbOM = Db (1 - \text{percent mineral}/100)$, where Db is the field state bulk density.
- (3) Calculate the subsidence percent (SP) for surface and subsoil horizons as follows:
 - (i) For surface horizons:

$$SP = 100 - [(DbOM/0.27) \times 100]$$
 - (ii) For subsurface horizons:

$$SP = 100 - [(DbOM/0.18) \times 100]$$

Where DbOM is obtained from step (2).
- (4) Convert initial subsidence percent to depth of subsidence in inches as follows: $S = SP_{sur} \times T_{sur} + SP_{sub} \times T_{sub}$

Where—

S = depth of subsidence in inches

SP_{sur} = subsidence percent of the surface

horizon T_{sur} = thickness of the surface horizon

SP_{sub} = subsidence percent of the subsurface horizon

T_{sub} = thickness of the subsurface horizon above the water table or the mineral soil, whichever is shallower

E. Entries.—Enter the high, low, and representative values that represent the range for initial and total subsidence, in centimeters, for the map unit component. The range of valid entries is from 0 to 999, and only whole numbers (integers) are allowed. If subsidence is not a concern, enter “0.”

618.65 Sum of Bases

A. Definition.—“Sum of bases” is the sum of the basic cations calcium, magnesium, potassium, and sodium that are extractable from the <2 mm soil fraction using a solution of ammonium acetate (NH₄OAc, pH 7).

B. Significance.—Sum of bases is important for certain evaluations of soil nutrient availability or of the effect of waste additions to the soil. Sum of extractable bases is used directly in soil classification as a criterion to classify soils in most of the Eutric subgroups of Andisols. It is also used indirectly in soil classification to calculate percent base saturation by the sum of cations method. Base saturation by sum of cations is used as a criterion for Ultisols; Ultic subgroups of Alfisols, Andisols, and Mollisols; Alfic and Dystric subgroups of Inceptisols; and Alfic subgroups of Spodosols.

C. Measurement.—Sum of bases is calculated from the results of methods outlined in Soil Survey Investigations Report No. 42, *Soil Survey Laboratory Methods Manual*, Version 4.0, November 2004, USDA, NRCS. Sum of bases is reported in centimoles per kilogram (cmol(+)
kg⁻¹), which are equivalent to milliequivalents per 100 grams (meq 100 g⁻¹) of soil.

D. Entries.—Enter the range of sum of bases as milliequivalents per 100 grams (meq 100 g⁻¹) of soil for the horizon. The range of valid entries is from 0 to 300, and tenths (one decimal place) are allowed.

618.66 Surface Fragments

A. Definition.—“Surface fragments” are unattached, cemented pieces of bedrock, bedrocklike material, durinodes, concretions, nodules, or pedogenic horizons (e.g., petrocalcic fragments) 2 mm or larger in diameter and woody material 20 mm or larger in diameter that are exposed at the surface of the soil. Surface fragments can be rock fragments, pararock fragments, or

wood fragments, as defined in section 618.32. Vegetal material other than wood fragments, whether live or dead, is not included.

B. Surface Fragment Cover Percent

- (1) Definition.—“Surface fragment cover percent” is the percent of ground covered by fragments 2 mm or larger in diameter (20 mm or larger in diameter for wood fragments).
- (2) Significance.—Fragments on the soil surface are used as map unit phase criteria and greatly affect the use and management of the soil. They affect equipment use, erosion, excavation, and construction. They act as mulch, slowing evaporation and armoring the soil against rainfall impact. They also affect the heating and cooling of soils.
- (3) Estimates.—An estimation of cover by surface fragments can be made visually without quantitative measurement, by transect techniques, or by some combination of visual and quantitative measures. Chapter 3 of the *Soil Survey Manual* provides more information.
- (4) Entries.—Enter the high, low, and representative values for the percent of the surface covered by each size class and kind of fragment populated in the “Component Surface Fragments” table in the NASIS database. The range of valid entries is from 0 to 100 percent, and hundredths (two decimal places) are allowed.

C. Surface Fragment Kind

- (1) Definition.—“Surface fragment kind” is the lithology or composition of the surface fragments 2 mm or larger in diameter (20 mm or larger in diameter for wood fragments).
- (2) Significance.—Fragments vary according to their resistance to weathering. Consequently, fragments of some lithologies are more suited than others for use as building stone, road building material, or riprap to face dams and stream channels.
- (3) Entries.—Enter the appropriate fragment kind name for the record of fragments populated in the “Component Surface Fragments” table in the NASIS database. The class names are present in a choice list and can also be viewed in the NASIS data dictionary.

D. Surface Fragment Size

- (1) Definition.—“Surface fragment size” is the size based on the multiaxial dimensions of the surface fragments.
- (2) Significance.—The size of surface fragments is significant to the use and management of the soil. The adjective form of fragment size is used as phase criteria for naming map units. The size affects equipment use, excavation, construction, and recreational uses.
- (3) Classes
Classes of surface fragment size are subdivided based on the shape of the fragments (described below).

- Flat fragment classes are described below:

Figure 618-A28

Flat Fragment Class	Length of Fragment (mm)
Channers	≥ 2 to <150
Flagstones	≥ 150 to <380
Stones	≥ 380 to <600
Boulders	≥ 600

- Nonflat fragment classes are described below:

Figure 618-A29

Nonflat Fragment Class	Diameter (mm)
Gravel	≥ 2 to $<75^*$
Fine gravel	≥ 2 to <5
Medium gravel	≥ 5 to <20
Coarse gravel	≥ 20 to <75
Cobbles	≥ 75 to <250
Stones	≥ 250 to <600
Boulders	≥ 600

- (4) Gravel is a collection of fragments having a diameter ranging from ≥ 2 to <75 mm. Individual fragments in this size range are properly referred to as pebbles, not “gravels.” For fragments that are less than strongly cemented, “para” is used as a prefix to the above terms (e.g., paracobbles).
- (5) Entries.—Enter the high, low, and representative values for each size class populated in the “Component Surface Fragments” table in the NASIS database. Valid entries are values of 2 millimeters (mm) or larger, and only whole numbers (integers) are allowed.

E. Mean Distance Between Rocks

- (1) Definition.—“Mean distance between rocks” is the average distance between surface stones, boulders, or both, measured between edges.
- (2) Significance.—The mean distance between rocks is a field clue for naming stony or bouldery map units. The closer the distance, the more equipment limitations there are for harvesting forestland or soil cultivation.

- (3) Estimates.—Table 3-12 of the *Soil Survey Manual* shows the distance between stones and boulders if the diameter is 0.25 m, 0.6 m, or 1.2 m. This table should be used with caution because stones and boulders are rarely equally spaced or have the same diameter.
- (4) Entries.—Enter the high, low, and representative values for the mean distance between rocks. The range of valid entries is from 0 to 50 meters, and hundredths (two decimal places) are allowed.

F. Surface Fragment Roundness

- (1) Definition.—“Surface fragment roundness” is an expression of the sharpness of edges and corners of surface fragments.
- (2) Classes.—The surface fragment roundness classes are described below:

Figure 618-A30

Roundness Class	Definition
Very angular	Strongly developed faces with very sharp, broken edges
Angular	Strongly developed faces with sharp edges (SSM)
Subangular	Detectable flat faces with slightly rounded corners
Subrounded	Detectable flat faces with well rounded corners (SSM)
Rounded	Flat faces absent or nearly absent with all corners rounded (SSM)
Well rounded	Flat faces absent with all corners rounded

- (3) Entries.—Enter the appropriate surface fragment roundness class name for the record of surface fragments populated in the “Component Surface Fragments” table in the NASIS database.

G. Surface Fragment Hardness

- (1) Definition.—“Surface fragment hardness” is equivalent to the rupture resistance cemented of a surface fragment of specified size that has been air-dried and then submerged in water.
- (2) Measurements.—Procedures and classes of coherence are listed with the rupture resistance classes in the *Soil Survey Manual*. Classes are described for similar specimens about 25-30 mm on edge which are air-dried and then submerged in water for at least 1 hour. The specimen is compressed between extended thumb and forefinger, between both hands, or between the foot and a hard flat surface. If the specimen resists compression, a weight is dropped onto it from progressively greater heights until it ruptures. Failure is considered at the initial detection of deformation or rupture. Stress applied in the hand should be over a 1-second period. The tactile sense of the class limits may be learned by applying force to top-loading scales and sensing the pressure through the tips of the fingers or through the ball of the foot. Postal scales may be used for the resistance range that is testable with the fingers. A bathroom scale may be

- used for the higher rupture resistance range.
- (3) Significance.—The hardness of a surface fragment is significant where the rupture resistance class is strongly coherent or greater. These classes can impede or restrict the movement of soil water vertically through the soil profile and have a direct impact on the quality and quantity of ground water and surface water.
 - (4) Classes.—The surface fragment hardness (rupture resistance) classes are the following:
 - (ii) Extremely weakly coherent
 - (iii) Very weakly coherent
 - (iv) Weakly coherent
 - (v) Moderately coherent
 - (vi) Strongly coherent
 - (vii) Very strongly coherent
 - (viii) Indurated
 - (5) Entries.—Enter the appropriate class name for each record of surface fragments populated in the “Component Surface Fragments” table in the NASIS database. Choose the term without the word “coherent” (e.g., choose the “moderately” class to represent the moderately coherent class).

H. Surface Fragment Shape

- (1) Definition.—“Surface fragment shape” is a description of the overall shape of the surface fragment.
- (2) Classes.—The surface fragment shape classes are “flat” and “nonflat.”
- (3) Entries.—Enter the appropriate surface fragment shape class name for each record of surface fragments populated in the “Component Surface Fragments” table in the NASIS database.

618.67 T Factor

A. Definition.—The “T factor” is the soil loss tolerance (in tons per acre). It is defined as the maximum amount of erosion at which the quality of a soil as a medium for plant growth can be maintained. This quality of the soil to be maintained is threefold in focus. It includes maintaining the surface soil as a seedbed for plants, the atmosphere-soil interface to allow the entry of air and water into the soil and still protect the underlying soil from wind and water erosion, and the total soil volume as a reservoir for water and plant nutrients, which is preserved by minimizing soil loss. Erosion losses are estimated by USLE and RUSLE2.

A. Classes.—The classes of T factors are: 1, 2, 3, 4, and 5.

B. Significance.—Soil loss tolerances commonly serve as objectives for conservation planning on farms. These objectives assist in the identification of cropping sequences and management systems that can maximize production and also sustain long-term productivity. T factors represent the goal for maximum annual soil loss.

C. Guidelines.—Conservation objectives for soil loss tolerance include maintaining a suitable seedbed and nutrient supply in the surface soil, maintaining an adequate depth and quality of the rooting zone, and minimizing unfavorable changes in water status throughout the soil. A single T factor is assigned to each map unit component.

D. Estimates.—The T factor is assigned to soils without respect to land use or cover. T factors are assigned to compare soils and do not imply differences to vegetation response directly. Many of the factors used to assign a T factor are also important to vegetation response, but the T factor is not assigned to imply vegetation sensitivity to all vegetation. The general guideline given in part 618, subpart B, section 618.93, is used to assign T factors but more specific criteria are used to select limiting soil properties.

E. Entries.—The estimated soil loss tolerance should be calculated from the soil properties and qualities posted in the database for each map unit component based generally on the guideline given in part 618, subpart B, section 618.93. Acceptable values are: 1, 2, 3, 4, and 5.

618.68 Taxonomic Family Temperature Class

A. Definition

- (1) The soil temperature classes are part of the family categorical level as defined in Soil Taxonomy. They differ from “soil temperature regimes” (Data Element: taxonomic temp regime) in that the cryic temperature regime is divided between the frigid and isofrigid classes based on differences in mean winter and mean summer soil temperatures. Soil temperature classes are based on mean annual and mean seasonal soil temperatures using the Celsius (centigrade) scale and taken either at a depth of 50 cm from the soil surface or at a lithic or paralithic contact, whichever is shallower.
- (2) For soil families in Gelisols, Gelic suborders, and Gelic great groups, the soil temperature classes, defined in terms of the mean annual soil temperature, are as follows:
 - (i) Hypergelic: -10 °C or lower
 - (ii) Pergelic: -4 to -10 °C
 - (iii) Subgelic: +1 to -4 °C
- (3) For soil families that have a difference of 6 °C or more between mean summer (June, July, and August in the Northern Hemisphere) temperature and mean winter (December, January, and February in the Northern Hemisphere) temperature, the soil temperature classes, defined in terms of the mean annual soil temperature, are as follows:
 - (i) Frigid: Lower than 8 °C
 - (ii) Mesic: 8 to 15 °C
 - (iii) Thermic: 15 to 22 °C
 - (iv) Hyperthermic: 22 °C or higher
- (4) For soil families that have a difference of less than 6 °C between the mean summer and mean winter soil temperatures, the soil temperature classes, defined in terms of the mean annual soil temperature, are as follows:
 - (i) Isofrigid: Lower than 8 °C
 - (ii) Isomesic: 8 to 15 °C
 - (iii) Isothermic: 15 to 22 °C
 - (iv) Isohyperthermic: 22 °C or higher

B. Significance.—All soils have a taxonomic soil temperature class. Soil temperature classes are used as family differentiae in all the orders defined in *Soil Taxonomy*. The names are used as part of the family name unless the criteria for a higher taxon carry the same limitation. The frigid or isofrigid class is implied in all cryic suborders and great groups, but the class is not used as part of the family name because it would be redundant.

C. Estimates.—Estimates of soil temperature classes are made with models that use climatic data including mean annual and mean seasonal air temperatures, precipitation, and evapotranspiration. Some models include snow cover, topographic, and vegetative inputs.

D. Measurement.—The Celsius (centigrade) scale is the standard. It is assumed that the temperature is that of a nonirrigated soil. The soil temperature classes are based on long-term averages of mean annual and mean seasonal soil temperatures taken either at a depth of 50 cm from the soil surface or at a lithic or paralithic contact, whichever is shallower.

E. Entries.—Enter the appropriate soil temperature class from the following list:

- (1) Frigid
- (2) Hypergelic
- (3) Hyperthermic
- (4) Isofrigid
- (5) Isohyperthermic
- (6) Isomesic
- (7) Isothermic
- (8) Mesic
- (9) Pergelic
- (10) Subgelic
- (11) Thermic
- (12) Not used

618.69 Taxonomic Moisture Class

A. Definition.—Soil moisture classes refer to the soil moisture regimes defined in *Soil Taxonomy*. Soil moisture regimes are defined by the presence or absence either of ground water or of water held at a tension of less than 1500 kPa, in the soil or in specific horizons, by periods of the year.

B. Significance.—All soils have a soil moisture regime. Soil moisture regimes are used as differentiae in all the orders defined in *Soil Taxonomy*. Data on the moisture regime are used for making interpretations for cropland agriculture, correlating soils to ecological sites, and determining suitability for wildlife habitat. The moisture regime of some soils is not apparent in the classification given in *Soil Taxonomy*. Ustolls and Xerolls, for example, can have an aridic moisture regime. Some soils have more than one moisture regime. An example is a soil that meets the requirements of the aquic moisture regime in the wet season and also meets the requirements of the ustic regime.

C. Estimates.—Estimates of soil moisture regimes are made with models that use climatic

data, including mean annual and mean seasonal air temperatures, precipitation, and evapotranspiration. Some models include topographic and vegetative inputs. The soil moisture control section, also defined in *Soil Taxonomy*, is used to facilitate the estimation of soil moisture regimes. For more guidance, see Soil Survey Technical Note 9, available online at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_053566.

D. Measurement.—The soil moisture regimes are based on annual and seasonal soil moisture measurements taken in the soil moisture control section. The soil should not be irrigated, fallowed, or influenced by other moisture-altering practices.

E. Entries.—Enter the appropriate soil moisture regimes from the following list:

- (1) Aquic
- (2) Aridic (torric)
- (3) Peraquic
- (4) Perudic
- (5) Udic
- (6) Ustic
- (7) Xeric

618.70 Taxonomic Moisture Subclass (Subclasses of Soil Moisture Regimes)

A. Definition.—“Subclasses of soil moisture regimes” are defined at the subgroup categorical level in Soil Taxonomy. The criteria differ among the great groups. For example, aquic, aridic, and udic are subclasses of the soil moisture regime in Haplustalfs. A subclass is entered for all soils in a great group that meet the subclass criteria, even if the subclass is not part of the taxonomic classification. For example, aquic, aridic, udic, or typic should be used as a subclass of the soil moisture regime in Lithic Haplustalfs if the criteria are met.

B. Significance.—Subclasses of soil moisture regimes are used at the subgroup categorical level in all orders in Soil Taxonomy except Histosols. They typically indicate an intergrade between two moisture regimes that affect the use and management of the soil. The subclasses of soil moisture regimes are used for making interpretations for cropland agriculture, correlating soils to ecological sites, and determining suitability for wildlife habitat.

C. Estimates.—Estimates of subclasses of soil moisture regimes are made with models that use climatic data, including mean annual and mean seasonal air temperatures, precipitation, and evapotranspiration. Some models include topographic and vegetative inputs. The soil moisture control section, also defined in Soil Taxonomy, is used to facilitate estimation of some subclasses of soil moisture regimes. For more guidance, see Soil Survey Technical Note 9, available online at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_053566.

D. Measurement.—The subclasses of soil moisture regimes are based on annual and seasonal soil moisture measurements taken in the soil moisture control section. The soil should not be irrigated, fallowed, or influenced by other moisture-altering practices.

E. Entries.—Enter the appropriate subclass of soil moisture regimes from the following list:

- (1) Aeric
- (2) Anthraquic
- (3) Aquic
- (4) Aridic (torric)
- (5) Oxyaquic
- (6) Typic
- (7) Udic
- (8) Ustic
- (9) Xeric

618.71 Taxonomic Temperature Regime (Soil Temperature Regimes)

A. Definition.—“Soil temperature regimes” refer to the temperature regimes as defined in *Soil Taxonomy*.

B. Significance.—Soil temperature regimes are used as differentiae above the family categorical level in all orders in Soil Taxonomy. (Soil temperature classes, defined above, are used as family differentiae.) Soil temperature regimes greatly affect the use and management of soils, particularly the selection of adapted plants. Temperature regimes are used for making interpretations for cropland agriculture, correlating soils to ecological sites, and determining suitability for wildlife habitat.

C. Estimates.—Estimates of soil temperature regimes are made with models that use climatic data, including mean annual and mean seasonal air temperatures, precipitation, and evapotranspiration. Some models include topographic and vegetative inputs.

D. Measurement.—The soil temperature regime is based on mean annual and seasonal soil temperatures using the Celsius (centigrade) scale and taken either at a depth of 50 cm from the soil surface or at a lithic or paralithic contact, whichever is shallower.

E. Entries.—Enter the appropriate soil temperature regimes from the following list:

- (1) Gelic
- (2) Cryic
- (3) Frigid
- (4) Mesic
- (5) Thermic
- (6) Hyperthermic
- (7) Isofrigid
- (8) Isomesic
- (9) Isothermic
- (10) Isohyperthermic

618.72 Texture Class, Texture Modifier, and Terms Used in Lieu of Texture

A. Definition.—“Texture class” refers to the soil texture classification used by the USDA as defined in the Soil Survey Manual.

B. Significance.—Soil texture influences engineering works and plant growth and indicates how soils have formed. Soil texture has a strong influence on soil mechanics and the behavior of soil when it is used as construction or foundation material. It influences such engineering properties as bearing strength, compressibility, saturated hydraulic conductivity, shrink-swell potential, and compaction. Soil texture influences plant growth by its effect on aeration, water intake rate, available water capacity, cation-exchange capacity, saturated hydraulic conductivity, erodibility, and workability. Changes in texture as related to depth are indicators of how soils formed. When texture is plotted with depth, smooth curves indicate translocation and accumulation. Irregular changes in particle-size distribution, especially in the sand fraction, may indicate lithologic discontinuities, specifically differences in parent material. Soil texture is used for soil classification in criteria for certain taxa such as the Psammets suborder, “Psamm” great groups, and Arenic, Grossarenic, and Psammentic subgroups. Soil texture is also used in the family category of Soil Taxonomy for differentiae such as particle-size class.

C. Measurement.—USDA texture can be measured in the laboratory by determining the proportion of the various size particles in a soil sample. The analytical procedure is called particle-size analysis or mechanical analysis. Stone, gravel, and other material 2 mm or larger are sieved out of the sample and thus are not considered in the analysis of the sample. Their amounts are measured separately. Of the remaining material smaller than 2 mm, the amount of the various sizes of sand is determined by sieving. The amount of silt and clay is determined by a differential rate of settling in water. Either the pipette or hydrometer method is used for the silt and clay analysis. Organic matter and dissolved mineral matter are removed in the pipette procedure but not in the hydrometer procedure. The two procedures are generally very similar, but a few samples, especially those with high organic matter or high soluble salts, exhibit wide discrepancies. The detailed procedures are outlined in Soil Survey Investigations Report No. 42, *Kellogg Soil Survey Laboratory Methods Manual*, Version 6.0, 2022, USDA, NRCS.

D. Estimates

- (1) The determination of soil texture for the less-than-2-mm material is made in the field mainly by feeling the soil with the fingers. The soil must be well moistened and rubbed vigorously between the fingers for a proper determination of texture class by feel. This method requires skill and experience, but good accuracy can be obtained if the field soil scientist frequently checks his or her estimates against laboratory results. Many NRCS offices collect reference samples for this purpose. The content of particles ≥ 2 mm cannot be evaluated by feel. The content of the fragments is determined by estimating the proportion of the soil volume they occupy. Fragments in the soil are discussed in section 618.32.
- (2) Each soil scientist must develop the ability to determine soil texture by feel for each genetic soil group according to the standards established by particle-size analysis. Soil scientists must remember that soil horizons in the same texture class but in different subgroups or families may have a different feel. For example, natric horizons generally feel higher in clay than non-natric horizons. Laboratory analysis generally shows the clay in natric horizons is less than the amount estimated from the field method. The soil scientist needs to adjust judgment and not the size distribution standards.

E. Entries.—Texture is displayed using six data elements in the NASIS database: texture class, texture modifier, texture modifier and class, stratified texture flag, representative value indicator, and terms used in lieu of texture. Only use multiple textures if they interpret the same for the horizon. Only textures that represent complete horizons should be entered.

A “Representative indicator flag” is used to identify one representative texture (composed of texture modifier and class) in the “Horizon Texture Group” table in the NASIS database. A Boolean flag is set to “yes” by checking the box for the representative indicator flag. This indicates that the texture that comprises a record in the horizon texture group is representative. It also indicates that the selected texture validates the soil properties populated for the layer. The selected texture record must agree with the representative values for important soil properties, such as clay, sand, rock fragment, and organic matter content. The flag must be set even when only one texture record is populated for a particular horizon (such as in surface layers or bedrock layers). The default entry is “no” and is displayed by keeping the box for representative indicator flag unchecked. Only one texture record may be selected as representative for a given horizon or layer. This choice should match the representative values of the various soil particle-size separates posted elsewhere in the database.

F. Texture Class

(1) Definition

- (i) “Texture class” is an expression, based on the USDA system of particle sizes, for the relative portions of the various size groups of individual mineral soil grains less than 2 mm equivalent diameter in a mass of soil.
- (ii) Each texture class has defined limits for each particle separate class of mineral particles less than 2 mm in effective diameter. The basic texture classes, in the approximate order of increasing proportions of fine particles, are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further subdivided into coarse, fine, or very fine. The basic USDA texture classes are given graphically in section 618.87 as a percentage of sand, silt, and clay. The chart at the bottom of the figure shows the relationship between the particle size and texture classes among the AASHTO, USDA, and Unified soil classification systems. To calculate a single point texture class, use the interactive online soil texture calculator.

- (2) Entries.—Enter the texture class for each horizon using the list in section 618.94.

G. Terms Used in Lieu of Texture

- (1) Definition.—“Terms used in lieu of texture” are substitute terms applied to materials that do not fit into a texture class because of high organic matter content, high fragment content, high gypsum content, cementation, or another reason. Examples include artifacts, bedrock, gravel, muck, and shells. Part 618, subpart B, section 618.94, provides a list of these terms and their codes. Some of these terms may be modified with terms from the list of texture modifiers, such as mossy (code MS), when used to modify the term peat (e.g., “mossy peat”).

(2) Application

- (i) The terms used in lieu of texture “highly decomposed plant material,” “moderately decomposed plant material,” and “slightly decomposed plant material” (codes HPM, MPM, and SPM) should only be used to describe near-surface horizons composed of plant material in various stages of decomposition that are saturated with water for less than 30 cumulative days in normal years and are not artificially drained. These terms are used to describe folistic epipedons (i.e., in mineral soils only) or organic horizons of any thickness (i.e., in organic or mineral soils) provided they meet the saturation requirements. The terms “muck,” “mucky peat,” and “peat” (codes MUCK, MPT, and PEAT) are used to describe histic epipedons (i.e., in mineral soils only) and organic horizons of any thickness (i.e., in organic or mineral soils) that are saturated with water for 30 or more cumulative days in normal years or are artificially drained.
 - (ii) For soil materials with 40 percent or more gypsum (by weight) in the fine-earth fraction, gypsum dominates the physical and chemical properties of the soil and particle-size classes are not meaningful. Two terms in lieu of texture are used. “Coarse gypsum material” (code CGM) is used for these materials where 50 percent or more of the fine-earth fraction is composed of particles ranging from ≥ 0.1 to < 2.0 mm in diameter. “Fine gypsum material” (code FGM) is applied to materials where less than 50 percent of the fine-earth fraction is composed of particles ranging from ≥ 0.1 to < 2.0 mm in diameter.
 - (iii) The term “material” (code MAT) is generic and requires the use of a texture modifier. It is intended for cemented diagnostic horizons, such as duripans, petrocalcic horizons, and petrogypsic horizons, by using the texture modifier “cemented” with the term in lieu of texture “material.” The concatenated texture term for such horizons in pedon descriptions is “cemented material” (coded CEM-MAT). In the past, texture modifier terms, such as “coprogenous,” “gypsiferous,” and “marly,” were used to describe material, but such use has been discontinued and is no longer permitted.
- (3) Entries.—Enter the term used in lieu of texture for each horizon, if applicable, from the list in section 618.94.

H. Texture Modifier

- (1) Definition.—“Texture modifier” is a term used to denote the presence of a condition or object other than sand, silt, or clay.
- (2) Application.—Texture modifier terms may apply to both texture and terms used in lieu of texture. Some may apply to both; others only apply to one or the other. Combinations of some texture modifiers are allowed. A list of allowable texture modifier terms and their codes is given in section 618.94. Some rules of application are given below.
 - (i) If the content of fragments by volume equals 15 percent or more, texture modifiers are used. An example is gravelly loam or parachannery loam. The adjectives “very” and “extremely” are used when the content of fragments by volume equals 35 to less than 60 percent and 60 to less than 90 percent, respectively.
 - (ii) Texture modifiers, such as paragravelly and paracobbly, are used to identify the presence of pararock fragments. The size, shape, and amounts of pararock fragments required for these terms are the same as for rock fragments.
 - (iii) “Mucky” and “peaty” are used to modify near-surface horizons of mineral soils that are saturated with water for 30 or more cumulative days in normal years or are artificially drained. An example is mucky loam. Excluding live roots, the

horizon has 5 to less than 12 percent organic carbon content (by weight).

- (iv) “Highly organic” is used to modify near-surface horizons of mineral soils that are saturated with water for less than 30 cumulative days in normal years and are not artificially drained. Excluding live roots, the horizon has 5 to less than 12 percent organic carbon content (by weight).
- (v) Shell fragments can be recognized in subaqueous or subaerial soils. In this context, “shell” is a hard, protective outer layer created by invertebrate organisms in marine and freshwater environments and is composed primarily of calcium carbonate materials of Holocene age. Examples include oyster shells, hard and soft shell clams, scallops, snails (including terrestrial), mussel, and hard coral. Shell fragments greater than or equal to 2 mm in size are included in measurement. Rock fragment classes are to be used in addition to the shell fragment classes where appropriate, similar to the artifactual classes of anthropogenic soils.
- (vi) Compound texture modifiers may be used. For example, a term may be used to indicate the presence of fragments and another used to indicate some nonfragment condition. The term used to indicate rock fragments should be listed first. Examples are very gravelly mucky silt loam and paragravelly ashly loam; very flaggy-artifactual loam; or gravelly-shelly silt loam.
- (vii) In some cases, mineral soil may contain a combination of both artifacts and fragments in the soil, such as rock fragments and pararock fragments. In all cases, the artifacts, rock fragments, and pararock fragments are each described separately. The assignment of texture modifiers for such horizons is handled differently depending on the nature of the artifacts. Artifacts in soils which are discrete (i.e., ≥ 2 mm), cohesive, and persistent (e.g., concrete) function in a manner which is similar to rock fragments. Artifacts which are either noncohesive or nonpersistent (e.g., cardboard) behave differently than other discrete artifacts and rock fragments. When describing the texture of soil horizons with artifacts or a combination of artifacts and fragments, the following rules of application are followed:
 - Describe the individual kinds and amounts (percent by volume) of artifacts and any fragments if present. Record all pertinent attributes for artifacts (see section 618.5), paying particular attention to data on artifact cohesion and persistence.
 - If the combined volume of artifacts, which are both cohesive *and* persistent, and any rock fragments present is less than 15 percent, use the table below:

Figure 618-A31

Less than 15 percent	No artifact texture modifier is used.
15 to < 35 percent	The adjectival term “artifactual” is used as a modifier of the texture class, such as “artifactual loam.”
35 to < 60 percent	The adjectival term “very artifactual” is used as a modifier of the texture class, such as “very artifactual loam.”
60 to < 90 percent	The adjectival term “extremely artifactual” is used as a modifier of the texture class, such as “extremely artifactual loam.”
90 percent or more	No texture modifier terms are used. If there is too little fine earth to determine the texture class (less than about 10 percent by volume) the term used in lieu of texture, “artifacts,” is populated.

- If the combined volume of rock fragments and artifacts, which are both cohesive and persistent, is 15 percent or more, assign dual rock fragment-artifact texture modifiers. Dual rock fragment-artifact texture modifiers are based on the combined volume of both. The modifiers are concatenated terms joined with a hyphen. For example, use “gravelly-artifactual loam” as the texture modifier for a horizon with a fine- earth texture class of loam that contains 10 percent quartzite gravel, 3 percent brick (a cohesive and persistent artifact), 2 percent glass (a cohesive and persistent artifact), and 25 percent plasterboard (a noncohesive artifact). See section 618.94 for a list of the 18 dual rock fragment-artifact texture modifiers.
 - If artifacts, pararock fragments, and rock fragments are present, but the combined volume of rock fragments and artifacts, which are both cohesive and persistent, is less than 15 percent, compound texture modifiers are used. The compound texture modifiers connote only the artifacts and the pararock fragments. The modifier for artifacts is assigned (using the table shown above) preceding the texture modifier for pararock fragments. Some examples are “artifactual paracobbly coarse sandy loam” for a horizon that contains 20 percent rubber (e.g., shredded tires) and 20 percent granite paracobbles and “very artifactual parachannery clay” for a horizon with 40 percent carpet pieces and 20 percent siltstone parachanners. In NASIS, the compound texture modifier is built using an artifact and pararock fragment modifier selected from the choice list.
- (vii) If a horizon includes both rock fragments and pararock fragments, use the following rules for selecting texture modifiers:
- Describe the individual kinds and amounts of rock fragments and pararock fragments.
 - Do not use a fragment texture modifier when the combined volume of rock fragments and pararock fragments is less than 15 percent.
 - When the combined volume of rock fragments and pararock fragments is 15 percent or more and the volume of rock fragments is less than 15 percent, assign pararock fragment modifiers based on the combined volume of

fragments. For example, use “paragravelly” as a texture modifier for soils with 10 percent rock and 10 percent pararock gravel-sized fragments.

- When the volume of rock fragments is 15 percent or more, use the appropriate texture modifier for rock fragments (see section 618.90), regardless of the volume of pararock fragments. (Do not add the volume of rock and pararock fragments to determine the texture modifier.)

(viii) The definitions of the following four compositional texture modifiers guide their usage. Examples are “hydrous clay,” “medial silt loam,” “ashy loam,” and “gypsiferous fine sandy loam.”

- Hydrous.—Material that has andic soil properties and an undried 15 bar (1500 kPa) water content of 100 percent or more of the dry weight.
- Medial.—Material that has andic soil properties and has a 15 bar (1500 kPa) water content of less than 100 percent on undried samples and of 12 percent or more on air-dried samples.
- Ashy.—Material that has andic soil properties and is neither hydrous nor medial or material that does not have andic soil properties and the fine-earth fraction contains 30 percent or more particles ≥ 0.02 to < 2.0 mm in diameter, of which 5 percent or more is composed of volcanic glass and the [(aluminum plus 1/2 iron percent by ammonium oxalate) times 60] plus the volcanic glass percent is equal to or more than 30 percent.
- Gypsiferous.—Material that contains 15 to < 40 percent gypsum by weight.

(ix) Woody, grassy, mossy, and herbaceous texture modifiers are only used to modify muck, peat, or mucky peat terms (used for histic epipedons and organic horizons of any thickness that are saturated with water for 30 or more cumulative days in normal years, or are artificially drained, including those in Histels and Histosols, except for Folists). The definitions of the following four compositional texture modifiers guide their usage:

- Woody.—Any material that contains 15 percent or more wood fragments ≥ 2 cm in size or organic soil materials, other than SPM, MPM, or HPM, that contain 15 percent or more fibers that can be identified as wood origin and contain more wood fibers than any other kind of fiber.
- Grassy.—Organic soil material that contains more than 15 percent fibers that can be identified as grass, sedges, cattails, and other grasslike plants and contains more grassy fibers than any other kind of fiber.
- Mossy.—Organic soil material that contains more than 15 percent fibers that can be identified as moss and contains more moss fibers than any other kind of fiber.
- Herbaceous.—Organic soil material that contains more than 15 percent fibers that can be identified as herbaceous plants other than moss and grass or grasslike plants and more of these fibers than any other kind of fiber.

(x) Limnic materials have modifiers to texture to connote the origin of the material. The three kinds of limnic materials are coprogenous earth, diatomaceous earth, and marl. These materials were deposited in water by precipitation or through the action of aquatic organisms or derived from plants and organisms. Refer to the Keys to Soil Taxonomy for the complete definitions and taxonomic criteria of limnic materials. The following three compositional texture modifiers are used with limnic material to indicate presence and origin without respect to any set quantity of pellets, grains, or particles. Examples are “coprogenous silty clay loam,”

“diatomaceous very fine sandy loam,” and “marly silt loam.”

- Coprogenous.—Soil material that is a limnic layer containing many very small (0.1 to 0.001 mm) fecal pellets.
- Diatomaceous.—Soil material that is a limnic layer composed of diatoms.
- Marly.—Soil material that is a limnic layer that is light colored and reacts with HCl to evolve CO₂.

(xi) “Permanently frozen” is a texture modifier term applied to a soil layer in which the temperature is perennially at or below 0 degrees C, whether its consistence is very hard or loose.

(3) Entries.—Enter the applicable texture modifiers from the list in section 618.94.

Multiple texture modifiers are used in some horizons based on the application rules for texture modifier presented above. They must be assigned sequence numbers in the “Horizon Texture Modifier” table in the NASIS database for the proper calculated result. An organic compositional modifier is listed first and then the volcanic compositional texture modifier, so organic modifies the mineral component (e.g., PT-MEDL-SL and GR-HO-ASHY-SL).

I. Texture Modifier and Class

(1) Definition.—“Texture modifier and class” is a concatenation of texture modifier and texture class or texture modifier and a term used in lieu of texture. This data element indicates the full texture term of the horizon. If texture modifiers are used, they are attached to the texture class by a hyphen, for example, GR-SL. If a layer is stratified, enter SR as a texture modifier and the end members of the textural range and connect them by hyphens, for example, SR-C L and SR-GR S GR-C.

(2) Entries.—Enter the appropriate texture modifier and class for each horizon. These entries are calculated in the “Horizon Texture Group” table in the NASIS database. A “stratified texture flag” is used to identify stratified textures in the “Horizon Texture Group” table in the NASIS database. A Boolean flag is set to “yes” by checking the box for the stratified texture flag. This indicates that the textures that comprise a particular record are stratified. The default entry is “no” and is displayed by keeping the box for stratified texture flag unchecked.

618.73 Von Post Humification Scale

A. Definition.—The Von Post Humification Scale is a field method that indicates the scale of peat decomposition and characteristics. The scale ranges from least decomposed (H1) to most decomposed (H10) plant materials.

B. Significance.—The von Post scale is used in modeling to predict bulk density, hydraulic conductivity, and n value in organic soils. The scale can also be used to check the agreement between fibric (H1-H3), hemic (H4-H6), and sapric (H7-H10) materials. The von Post scale is

the most reliable field method available for estimating humification. Field estimates very closely match measurements obtained with costly laboratory measurements.

C. Estimates.—The humification scale is estimated by squeezing a handful of wet soil until as much soil as possible has extruded through the fingers. Color and viscosity of the extruded portion and material remaining in the hand are evaluated using the scale below.

- (1) H1.—Completely undecomposed peat; only clear water can be squeezed from peat.
- (2) H2.—Almost undecomposed; mud-free peat; water squeezed from peat is almost clear and colorless.
- (3) H3.—Very little decomposition; very slightly muddy peat; water squeezed from peat is muddy; no peat passes through fingers when squeezed; residue retains structure of peat.
- (4) H4.—Poorly decomposed; somewhat muddy peat; water squeezed from peat is muddy; residue is muddy but it shows structure of peat.
- (5) H5.—Somewhat decomposed; muddy; growth structure discernible but indistinct; when squeezed some peat passes through fingers but most muddy water passes through fingers; compressed residue is muddy.
- (6) H6.—Somewhat decomposed; muddy; growth structure indistinct; less than one-third of peat passes through fingers when squeezed; residue very muddy.
- (7) H7.—Well decomposed; very muddy; growth structure indistinct; about one-half of peat passes through fingers when squeezed; exuded liquid has a pudding-like consistence.
- (8) H8.—Well decomposed; growth structure very indistinct; about two-thirds of peat passes through fingers when squeezed; residue consists mainly of roots and resistant fibers.
- (9) H9.—Almost completely decomposed; peat is mud-like; almost no growth structure can be seen; almost all of peat passes through the fingers when squeezed.
- (10) H10.—Completely decomposed; no discernible growth structure; entire peat mass passes through fingers when squeeze.

D. Entries.—Enter von Post at field moist condition for each organic horizon. Pedons may be aggregated to identify the low, high, and representative values for each horizon where the von Post scale is applicable.

618.74 Water, One-Tenth Bar

A. Definition.—“Water, one-tenth bar” is the amount of soil water retained at a tension of 1/10 bar (10 kPa), expressed as a percentage of the whole soil on a volumetric basis.

B. Significance.—Water retained at one-tenth bar is significant in the determination of soil water-retention difference, which is used as the initial estimation of available water capacity for some soils.

C. Measurement.—Measurement in the laboratory is done on natural clods using a pressure desorption method. Measurement for nonswelling soils, loamy sand or coarser soils, and some sandy loams is also done using a pressure desorption method but sieved (< 2 mm) air-dry samples are used. Gravimetric water contents are reported in laboratory measurements as a

percentage of the fine-earth (<2 mm) fraction. Conversion to a volumetric basis is made using bulk density and rock fragment content.

D. Entries.—Enter the low, high, and representative values for the horizon. The range of valid entries is from 0 to 100 percent, and tenths (one decimal place) are allowed. A NASIS calculation is available and can be viewed in part 618, subpart B, section 618.105.

618.75 Water, One-Third Bar

A. Definition.—“Water, one-third bar” is the amount of soil water retained at a tension of 1/3 bar (33 kPa), expressed as a percentage of the whole soil on a volumetric basis.

B. Significance.—Water retained at one-third bar is significant in the determination of soil water-retention difference, which is used as the initial estimation of available water capacity for some soils.

C. Measurement.—Measurement in the laboratory is done on natural clods using a pressure desorption method. Measurement for nonswelling soils, loamy sand or coarser soils, and some sandy loams is also done using a pressure desorption method but sieved (< 2 mm) air-dry samples are used. Gravimetric water contents are reported in laboratory measurements as a percentage of the fine-earth (< 2 mm) fraction. Conversion to a volumetric basis is made using bulk density and rock fragment content.

D. Entries.—Enter the low, high, and representative values for the horizon. The range of valid entries is from 0 to 100 percent, and tenths (one decimal place) are allowed. A NASIS calculation is available and can be viewed in part 618, subpart B, section 618.105.

618.76 Water, 15 Bar

A. Definition.—“Water, 15 bar” is the amount of soil water retained at a tension of 15 bars (1500 kPa), expressed as a percentage of the whole soil on a volumetric basis.

B. Significance.—Water retained at 15 bar is significant in the determination of soil water-retention difference, which is used as the initial estimation of available water capacity for some soils. Water retained at 15 bar is an estimation of the wilting point.

C. Measurement.—Measurement in the laboratory is done on sieved (< 2 mm) air-dry samples using a pressure desorption method. Gravimetric water contents are reported in laboratory measurements as a percentage of the fine-earth (< 2 mm) fraction. Conversion to a volumetric basis is made using bulk density and rock fragment content.

D. Entries.—Enter the low, high, and representative values for the horizon. The range of valid entries is from 0 to 100 percent, and tenths (one decimal place) are allowed. A NASIS calculation is available and can be viewed in part 618, subpart B, section 618.105.

618.77 Water, Satiated

A. Definition.—“Water, satiated” is the estimated volumetric soil water content at or near zero bar tension, expressed as a percentage of the whole soil.

B. Significance.—“Water, satiated” represents the total possible water content of the soil, including the amount in excess of field capacity, and is used to estimate the amount of water

available for leaching and translocation. Saturated water content approximates the water content at saturated conditions. It is used in such resource assessment tools as Soil Hydrology, Water Budgets, Leaching, and Nutrient/Pesticide Loading models.

C. Estimates.—The values are derived by the following formula:

$$\text{Saturated water \%} = \text{total porosity \%} - \text{entrapped air \%}$$

Where total porosity $\% = 100(1 - \text{bulk density moist/particle density})$.

Assume approximately 3% entrapped air.

D. Entries.—Enter the high, low, and representative values for the horizon. The range of valid entries is from 0 to 100 percent, and only whole numbers (integers) are allowed. A NASIS calculation is available and can be viewed in part 618, subpart B, section 618.105.

618.78 Water Temperature

A. Definition.—“Water temperature” is the mean annual water temperature (MAWT) at or near the water/soil contact in a subaqueous soil setting.

B. Significance.—Temperature is important to many biological and physical processes that occur in marine and freshwater aquatic environments. The properties of the water column above subaqueous soils are important to interpretations such as aquaculture, shellfish restoration, and seagrass survival.

C. Estimates.—Water temperature can be estimated from measured water temperatures of the vicinity. Seasonal air temperature and water current fluctuations affect water temperatures. Estimates of water temperature should take these factors into account when water temperatures are extrapolated from one soil map unit component to another. Temperatures can be summations of the daily values collected and populated for point data in the NASIS data element “Water Temp – Lower” (sas_water_temp_lower). Such temperatures are measured in the lower 10 cm of the water column immediately above the surface of subaqueous soils.

D. Measurement.—Water temperature can be measured by many types of thermometers, including mercury, bimetallic, thermistors, and thermocouples. Many types of instruments can be configured for remote, unattended, and submerged operation.

E. Entries.—Enter the high, low, and representative values for the range of mean annual water temperature for the component as the average of the mean monthly water temperatures in the “Component” table in NASIS. The range of valid entries is from -10 to 50 degrees Celsius, and tenths (one decimal place) are allowed.

618.79 Wind Erodibility Group and Index

A. Definition.—A wind erodibility group (WEG) is a grouping of soils that have similar properties affecting their resistance to soil blowing in cultivated areas. The groups indicate the susceptibility to blowing. The wind erodibility index (I), used in the wind erosion equation, is assigned using the wind erodibility groups.

B. Significance.—There is a close correlation between soil blowing and the size and durability of surface clodiness, fragments, organic matter, and the calcareous reaction. The soil properties that are most important with respect to soil blowing are listed below. Soil moisture and the presence of frozen soil also influence soil blowing.

- (1) Soil texture class
- (2) Organic matter content
- (3) Carbonates in the fine-earth fraction as determined by effervescence class
- (4) Rock and pararock fragment content
- (5) Mineralogy

C. Estimates.—Soils are placed into wind erodibility groups on the basis of the properties of the soil surface layer. Part 618, subpart B, section 618.95, lists the wind erodibility index values assigned to the wind erodibility groups. The wind erodibility index values are assigned because the dry soil aggregates are very use-dependent on crop management factors.

D. Entries.—Enter the wind erodibility group and wind erodibility index values for surface layers only. The valid entries for wind erodibility group data are: 1, 2, 3, 4, 4L, 5, 6, 7, and 8. The lowest valid entry for wind erodibility index data is 0, and the highest is 310. The index values should correspond exactly to their wind erodibility group.

* As first defined by the 1951 *Soil Survey Manual* (p. 214), the upper diameter for gravel is 3 inches, the ASTM US standard test sieve size—a value that coincides with the upper limit used in engineering computations (*Soil Survey Manual*, 1991 edition, p. 142). In conversion, 3 inches equals 76.2 mm, which rounds to 76 mm. However, 75 mm (which is the standard of the International Standards Organization (ISO)) and 3 inches have both been reported as the upper limit for gravel because commercially available sieves exist for those size fractions, but not for the 76 mm fraction. Consequently, “< 75 mm” has sometimes been reported as the upper limit of gravel. The prime example occurs on the NRCS soil characterization data sheets (Method 3A2 in the *Soil Survey Laboratory Methods Manual*, Soil Survey Investigations Report No. 42, 2014 edition). At the bulk soil sample scale, 75 mm and 76 mm are functionally equivalent and the difference does not pose a problem. However, the reader needs to be aware of this discrepancy and recognize that because (1) samples have been measured using a 75-mm sieve and (2) more data has been entered in NASIS as 75 mm, the Standards Staff at the National Soil Survey Center decided that 75 mm, and not <76 mm, is to be used as the upper size limit for gravel.

Part 618 – Soil Properties and Qualities

Subpart B – Exhibits

618.80 Guides for Estimating Risk of Corrosion Potential for Uncoated Steel

Property	Limits		
	Low	Moderate	High
Internal free water occurrence class (or drainage class) and general texture group <u>1/</u> <u>2/</u>	•Very deep internal free water occurrence (or excessively drained to well drained) coarse to medium textured soils; <i>or</i> •Deep internal free water occurrence (or moderately well drained) coarse textured soils; <i>or</i> •Moderately deep internal free water occurrence (or somewhat poorly drained) coarse textured soils	•Very deep internal free water occurrence (or well drained) moderately fine textured soils; <i>or</i> •Deep internal free water occurrence (or moderately well drained) moderately coarse and medium textured soils; <i>or</i> •Moderately deep internal free water occurrence (or somewhat poorly drained) moderately coarse textured soils; <i>or</i> •Very shallow internal free water occurrence (or very poorly drained) soils with a stable high water table	•Very deep internal free water occurrence (or well drained) fine textured or stratified soils; <i>or</i> •Deep internal free water occurrence (or moderately well drained) moderately fine and fine textured or stratified soils; <i>or</i> •Moderately deep internal free water occurrence (or somewhat poorly drained) medium to fine textured or stratified soils; <i>or</i> •Shallow or very shallow internal free water occurrence (or poorly or very poorly drained) soils with a fluctuating water table
Total acidity (cmol(+)/kg ⁻¹) <u>3/</u> <u>4/</u>	<10	10-25	≥25
Conductivity of saturated extract (dS/m ⁻¹) <u>3/</u> <u>5/</u>	<1	1-4 4-10 for saturated soils <u>6/</u>	>4 >10 for saturated soils <u>6/</u>
Resistivity at saturation (ohm/cm) <u>1/</u> <u>7/</u>	≥5,000	2,000-5,000	<2,000

1/ Based on data in the publication "Underground Corrosion," table 99, p.167, Circular 579, U.S. Department of Commerce, National Bureau of Standards.

2/ The depth classes for internal free water occurrence are defined in table 3-5 of the Soil Survey Manual (1993). The classes relate to the wet water state in soils (i.e., free water present). The general texture groups are defined in chapter 3 of the Soil Survey Manual.

3/ Based on data in Moore and Hallmark (1987), "Soil Properties Influencing Corrosion of Steel in Texas Soils", Soil Sci. Soc. Am. J. 51:1250-1256.

4/ Total acidity is roughly equal to extractable acidity. Extractable acidity is determined by method 4B2a1a1, as outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004.

5/ Electrical conductivity is measured using method 4F2, as outlined in Soil Survey Investigations Report No. 42, *Soil Survey Laboratory Methods Manual*, Version 4.0, November 2004. The relationship between resistivity of a saturated soil paste and electrical conductivity of the saturation extract is influenced by variations in the saturation percentage, salinity, and conductivity of the soil minerals. These two measurements generally correspond closely enough to place a soil in one risk of corrosion potential class.

6/ Soils that remain saturated for extended periods are excluded from the high risk of corrosion potential class unless EC values are more than 10 dS m⁻¹ (Moore and Hallmark, 1987). In the NASIS steel corrosion calculation, saturation for extended periods is defined as having very shallow internal free water occurrence for 12 months.

7/ Resistivity at saturation is roughly equivalent to resistivity of fine and medium textured soils measured at saturation (Method 4F2b2 as outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004). Resistivity at saturation for coarse textured soils is generally lower than that obtained at field capacity and may cause the soil to be placed in a higher risk of corrosion potential class.

618.81 Guide for Estimating Risk of Corrosion Potential for Concrete

Property	Limits <u>1/</u>		
	Low	Moderate	High
Texture and reaction	Sandy and organic soils with pH>6.5 <i>or</i> Loamy and clayey soils with pH>6.0	Sandy and organic soils with pH 5.5 to 6.5 <i>or</i> Loamy and clayey soils with pH 5.0 to 6.0	Sandy and organic soils with pH<5.5 <i>or</i> Loamy and clayey soils with pH<5.0
Na and/or Mg sulfate (ppm)	Less than 1000	1000 to 7000	More than 7000
NaCl (ppm)	Less than 2000	2000 to 10000	More than 10000

1/ Based on data in National Handbook of Conservation Practices, Standard 606, Subsurface Drain, 1980.

618.82 Crop Names and Units of Measure

Refer to the NASIS-related metadata at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/tools/?cid=nrcs142p2_053548. Then follow the link to the “NASIS Version 7.x” index web page. On the NASIS Version index web page, see the file named “Domains.pdf” for the most current list of crop names and crop yield units.

618.83 Classification of Soils and Soil-Aggregate Mixtures for the AASHTO System

General Classification	Granular Materials (35% or less passing No. 200)							Silt-Clay Materials (More than 35% passing No. 200)			
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve analysis, % passing No. 10 No. 40 No. 200	50 max 30 max 15 max	- 50 max 25 max	- 51 min 10 max	- - 35 max	- - 35 max	- - 35 max	- - 35 max	- - 36 min	- - 36 min	- - 36 min	- - 36 min
Characteristics of fraction passing No. 40 Liquid limit Plasticity index	- 6 max		- NP	40 max 10 max	41 min 10 max	40 max 11 min	41 min 11 min	40 max 10 max	41 min 10 max	40 max 11 min	* 41 min 11 min
Usual types of significant constituent materials	Stone Fragments, Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General rating as subgrade	Excellent to Good					Fair to Poor					

* Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.

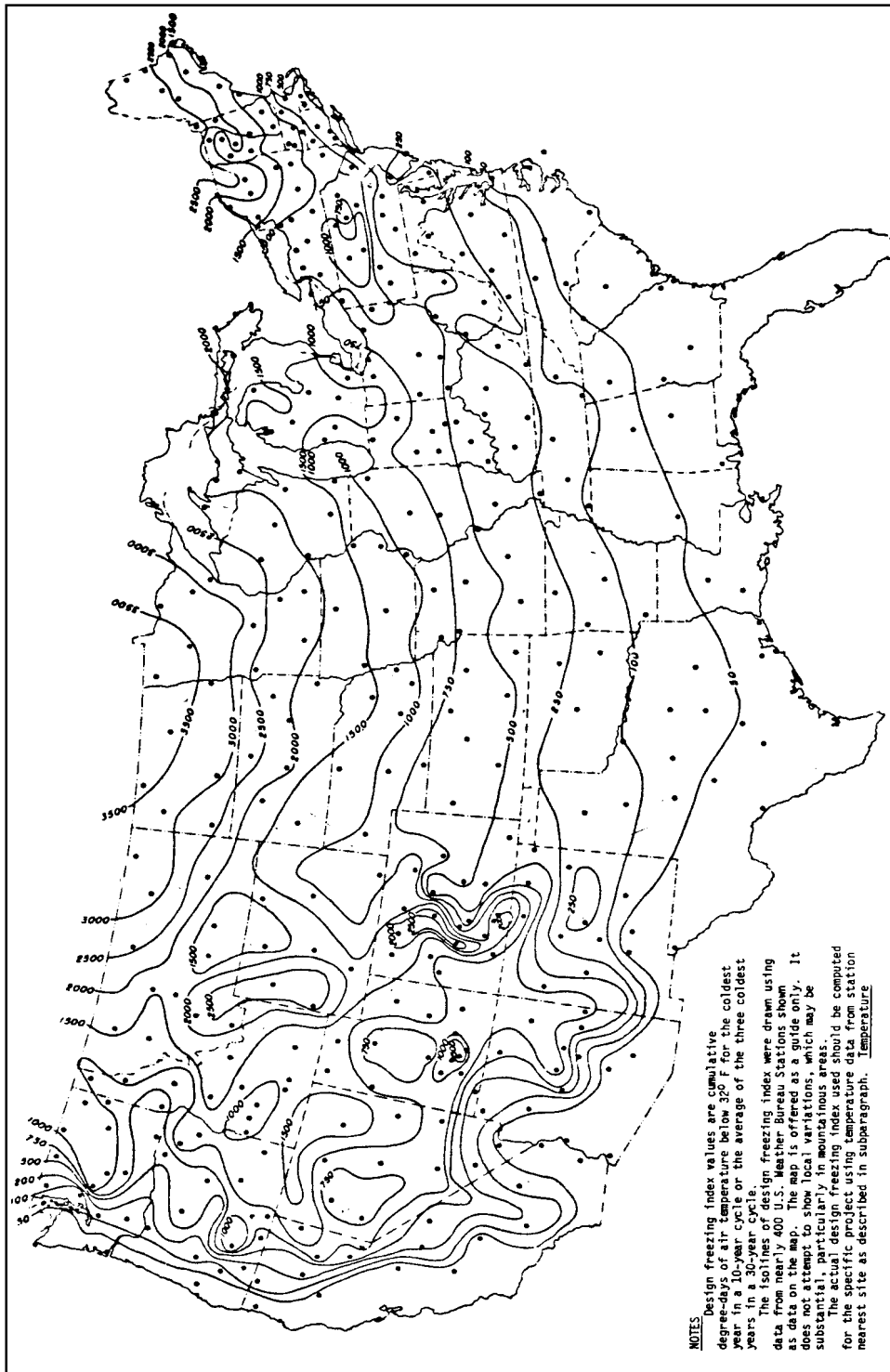
618.84 Potential Frost Action

Soil moisture regime	Frost action classes 1/, 2/		
	Low	Moderate	High 3/
Aquic, Peraquic	Cindery, Fragmental, Pumiceous	Sandy, Sandy-skeletal	Coarse-loamy, Fine-loamy, Coarse-silty, Fine-silty, Loamy, Loamy-skeletal, Clayey, Clayey-skeletal, Fine, Very-fine, Organic soil material, Ashy, Ashy-pumiceous, Ashy-skeletal, Medial, Medial-pumiceous, Medial-skeletal, Hydrous-pumiceous, Hydrous-skeletal, Hydrous
Udic, Perudic, Xeric, Ustic (when irrigated), Aridic and torric (when irrigated)	Fragmental, Cindery, Sandy, Sandy-skeletal, Pumiceous	Coarse-loamy, Fine-loamy, Loamy-skeletal, Clayey, Clayey-skeletal, Fine, Very-fine, Ashy-pumiceous, Ashy-skeletal, Hydrous-skeletal, Medial-skeletal, Medial-pumiceous	Coarse-silty, Fine-silty, Ashy, Medial, Hydrous-pumiceous, Hydrous
Ustic, Aridic and torric	Fragmental, Sandy, Sandy-skeletal, Clayey, Clayey-skeletal, Fine, Very-fine, Cindery, Ashy, Ashy-pumiceous, Ashy-skeletal, Medial, Medial-skeletal, Pumiceous	Coarse-loamy, Fine-loamy, Coarse-silty, Fine-silty, Loamy, Loamy-skeletal, Medial-pumiceous, Hydrous-pumiceous, Hydrous-skeletal, Hydrous	

Title 430 – National Soil Survey Handbook

- 1/ Taxonomic family particle-size classes apply to the whole soil to the depth of frost penetration, which is not necessarily the same as the taxonomic family particle-size control section.
- 2/ Isomesic and warmer soil temperature regimes should have no frost action problems (“none”).
- 3/ Organic soil materials with a mesic or colder soil temperature regime and a udic soil moisture regime (e.g., Folists) have a “high” frost action class.

618.85 Distribution of Design Freezing Index Values in the Continental United States



618.86 Estimating LL and PI from Percent and Type of Clay

The following two formulas provide estimates of liquid limit and plasticity index. These calculations are included in the NASIS database and provide default values to LL and PI.

$$LL = 11.60 + [1.49 \times 15 \text{ bar water \%}] + [1.35 \times \text{org. carbon \%}] + [0.6 \times \text{LEP}] + [0.26 \times \text{noncarbonate clay \%}]^*$$

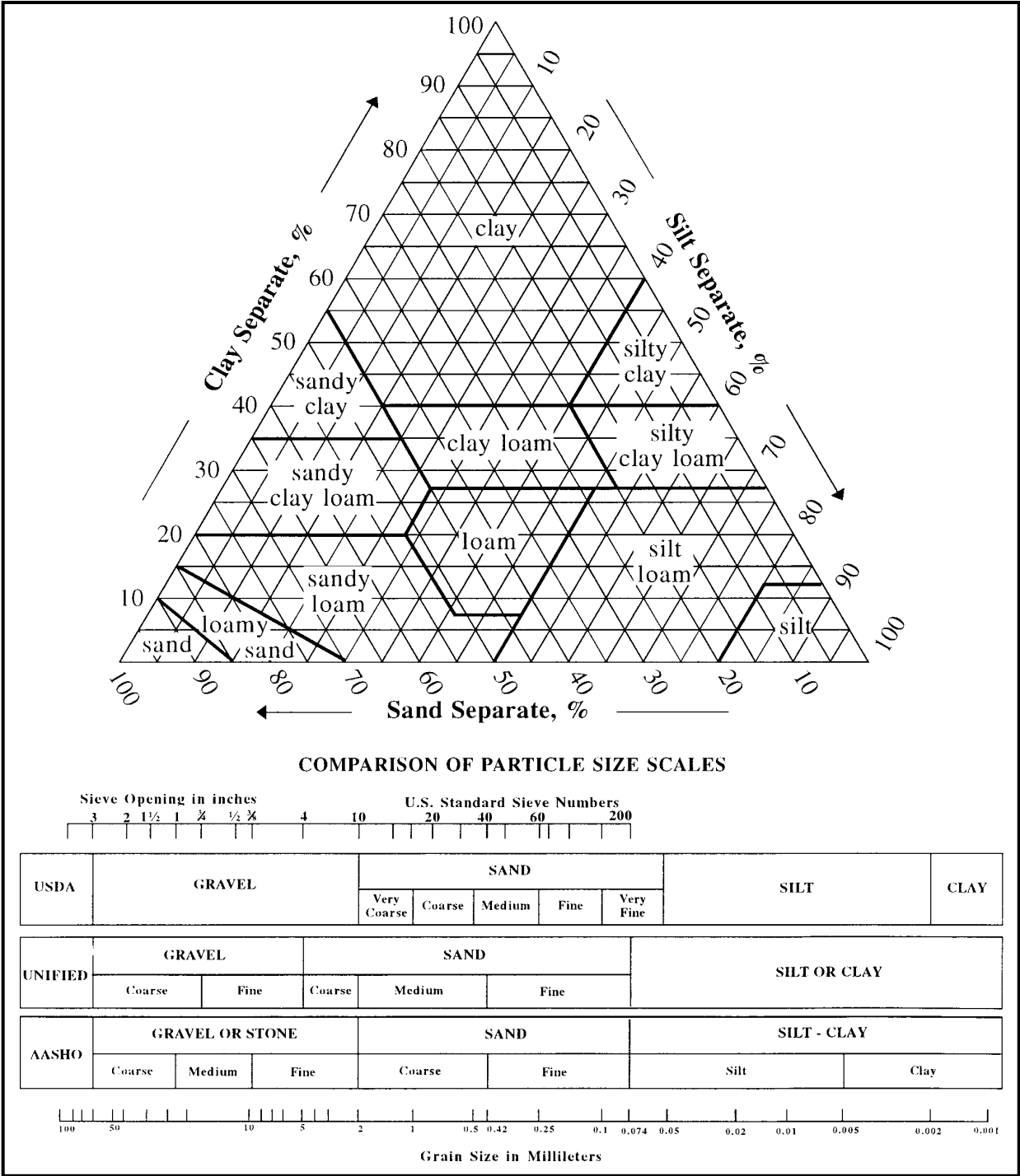
where LL is liquid limit and LEP is linear extensibility percent

$$PI = -1.86 + [0.69 \times 15 \text{ bar water \%}] - [1.19 \times \text{organic carbon \%}] + [0.13 \times \text{LEP}] + [0.47 \times \text{noncarbonate clay \%}]^*$$

where PI is plasticity index and LEP is linear extensibility percent

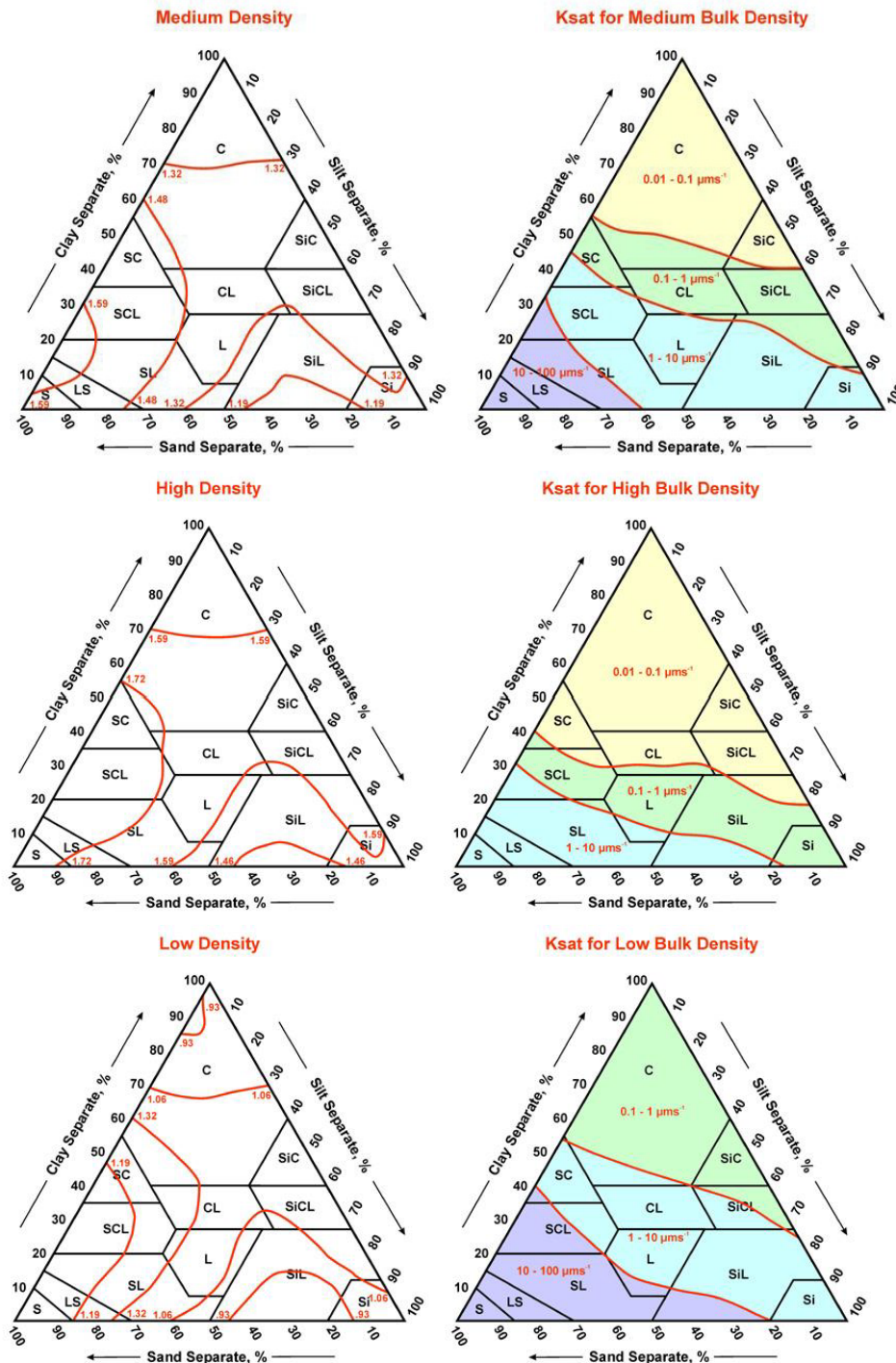
* When the calculated $PI < 0.5$, the PI is set to zero (nonplastic). When the calculated $LL < 15$ or $PI < 0.5$, the LL is set to zero.

618.87 Texture Triangle and Particle-Size Limits of AASHTO, USDA, and Unified Classification Systems



618.88 Guide for Estimating K_{sat} from Soil Properties

Estimate saturated hydraulic conductivity (K_{sat}) from soil texture by first selecting the bulk density class of medium, low, or high. Then use the corresponding texture triangle to select the range of saturated hydraulic conductivity in $\mu\text{m}^2\text{s}^{-1}$. Overrides follow the texture triangles.



If overriding conditions (listed below) exist, use this table to estimate K_{sat} instead of the texture triangles. A single property statement is sufficient for an override from the texture guides.

Overriding Condition	Saturated Hydraulic Conductivity ($\mu\text{m s}^{-1}$)
All fragmental, cindery, or pumiceous.	≥ 100
Many medium or coarser vertical pores that extend through the layer.	≥ 100
Medial-pumiceous, medial-skeletal, ashy-pumiceous, ashy-skeletal, or hydrous-pumiceous material that is very friable, friable, soft, or loose.	10 – 100
When material is moderately moist or wetter, structure is moderate or strong granular, strong blocky, or prismatic smaller than very coarse; no stress surfaces or slickensides.	10 – 100
Common medium or coarser vertical pores extend through the layer.	10 – 100
Strong very coarse blocky or prismatic structure and no stress surfaces or slickensides.	1 – 10
≥ 35 percent clay that is soft, slightly hard, very friable or friable; no stress surfaces or slickensides and the clay activity is in the range of the Subactive class (i.e., CEC7/noncarbonate clay = < 0.24) after subtracting the quantity $[2 \times (\% \text{ OC} \times 1.7)]$.	1 – 10
Few stress surfaces, few slickensides, or both.	0.1 – 1
Massive and very firm or extremely firm or weakly cemented.	0.1 – 1
Continuously moderately cemented.	0.1 – 1
Common or many stress surfaces or common or many slickensides.	0.01 – 0.1
Continuously indurated or very strongly cemented.	< 0.01

618.89 Guide to Estimating Water Movement Through Bedrock for Layers Designated as R and Cr

This table is to be used as a guide and may be adjusted to reflect local, regional, or State bedrock permeability data^{1,2}. Fracturing may increase hydraulic conductivity of consolidated rock by a factor of 10^4 to 10^6 , which is dependent on the degree and interconnection of fracturing. This table assumes that materials are level bedded. Tilted beds of some materials may have rapid rates of water movement for water that goes directly to an aquifer.

Material	Water Movement $\mu\text{m s}^{-1}$
Sandstone	
unfractured	<10
fractured	10-100
weathered	10-100
Limestone	
unfractured	<1
fractured	<10
weathered	<10
Limestone, Karst	>100
Shales and Mudstones	
consolidated	<1
weathered	<10
Igneous and Metamorphic Rocks	
unfractured	<1
fractured	1-100
weathered	<1

¹ Freeze, R., and J. Cherry. 1979. *Groundwater*.

² Legget, R., and P. Karrow. 1983. *Handbook of Geology in Civil Engineering*.

618.90 Rock Fragment Modifier of Texture

Instructions for Table 1, Guide for determining rock fragment modifier of texture: First choose the row with the appropriate total rock fragments. Then read the criteria in the columns under “Gravel, cobbles, stones, and boulders,” starting from the left-most column and proceeding to the right. Stop in the first column in which a criterion is met.

Table 1.—Guide for Determining Rock Fragment Modifier of Texture.

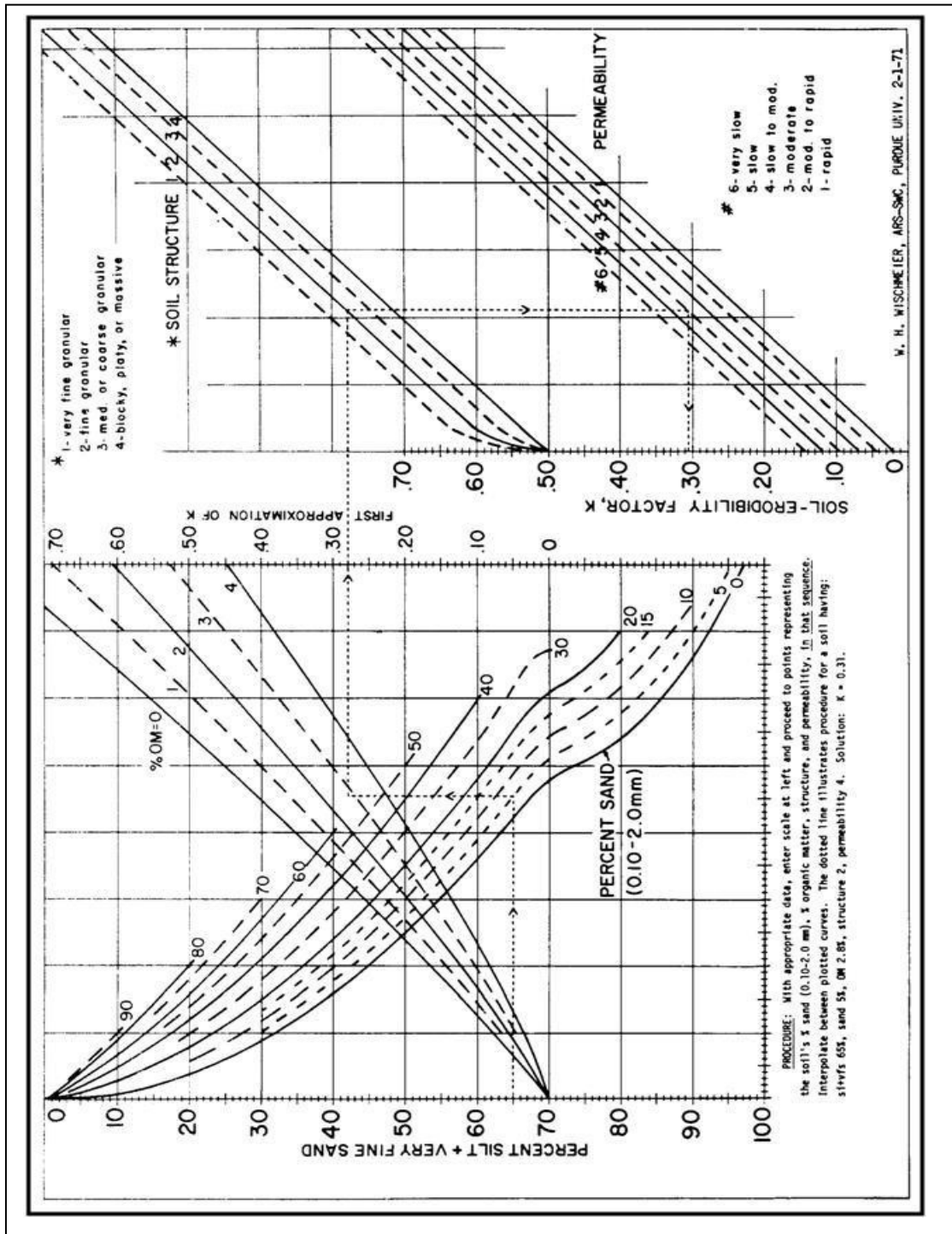
([Click here for an MS Excel spreadsheet that calculates the texture modifiers for flat and nonflat rock fragments.](#))

Total Rock Fragments (Vol. %)	Gravel (GR), cobbles (CB), stones (ST), and boulders (BY) (Substitute channers for gravel and flagstones for cobbles, where applicable) ¹			
	IF $GR \geq 1.5 CB + 2 ST + 2.5 BY$	IF $CB \geq 1.5 ST + 2 BY$	IF $ST \geq 1.5 BY$	IF $ST < 1.5 BY$
$\geq 15 < 35$	Gravelly	Cobbly	Stony	Bouldery
$\geq 35 < 60$	Very Gravelly	Very Cobbly	Very Stony	Very Bouldery
$\geq 60 < 90$	Extremely Gravelly	Extremely Cobbly	Extremely Stony	Extremely Bouldery
≥ 90	Gravel	Cobbles	Stones	Boulders
Example: Determine the rock fragment modifier for a soil that contains 15 percent gravel (GR), 10 percent cobbles (CB), and 3 percent stones (ST). - Since total rock fragments are 28 percent, choose the first row (≥ 15 and < 35). - Under “Gravel (GR), cobbles, . . .”, test the criterion in the left-most column. Is $15\%GR \geq 1.5 (10\% CB) + 2 (3\% ST)$? Answer: NO. - Proceed to the next column. Is $10\%CB \geq 1.5 (3\% ST)$? Answer: YES. STOP. The modifier is <u>Cobbly</u>. ¹ If both flat and nonflat rock fragments are present, the quantity in each size class is summed (e.g., gravel + channers, cobbles + flagstones). The sums are used to determine the appropriate quantity/size modifier. If the amounts of flat and nonflat rock fragments within any given size class are equal, the nonflat modifier takes precedence. For example, if there are 10 percent gravel and 10 percent channers, the modifier is gravelly.				

Soils With Pararock Fragments Only.—The same basic weighting rules apply with pararock fragments as with flat and nonflat rock fragments. However, the above spreadsheet only outputs modifier terms for rock fragments. To assign the correct pararock fragment modifier to the outputted rock modifier term, simply precede the modifier with “para.” For example, if the calculator outputs “very cobbly,” the correct modifier is “very paracobbly.”

Soils With Both Rock and Pararock Fragments.—Refer to instructions in section 618.67H(2)(vii) of this handbook.

618.91 Soil Erodibility Nomograph



618.92 Kw Value Associated With Various Fragment Contents

Fragment vol. %	Mulch factor ^{1/}	Kf value classes of less than 2 mm soil fraction										
		.10	.15	.20	.24	.28	.32	.37	.43	.49	.55	.64
5	.90	.09	.14	.18	.22	.25	.29	.33	.39	.44	.50	.58
10	.77	.08	.12	.15	.18	.22	.25	.28	.33	.38	.42	.49
15	.68	.07	.10	.14	.16	.19	.22	.25	.29	.33	.37	.43
20	.61	.06	.09	.12	.15	.17	.20	.23	.26	.30	.37	.39
25	.54	.05	.08	.11	.13	.15	.17	.20	.23	.26	.30	.35
30	.48	.05	.07	.10	.12	.13	.15	.18	.21	.24	.26	.31
35	.43	.04	.06	.09	.10	.12	.14	.16	.18	.21	.24	.28
40	.38	.04	.06	.08	.09	.11	.12	.14	.16	.19	.21	.24
45	.34	.03	.05	.07	.08	.10	.11	.13	.15	.17	.19	.22
50	.30	.03	.05	.06	.07	.08	.10	.11	.13	.15	.17	.19
55	.26	.03	.04	.05	.06	.07	.08	.09	.11	.13	.12	.14
60	.22	.02	.03	.04	.05	.06	.07	.08	.09	.11	.12	.14
65	.19	.02	.03	.04	.05	.05	.06	.07	.08	.09	.10	.12
70	.16	.02	.02	.03	.04	.04	.05	.06	.07	.08	.09	.10
75	.13	.01	.02	.03	.04	.04	.04	.04	.06	.06	.07	.08
80	.10	.01	.02	.02	.02	.03	.03	.04	.04	.05	.06	.06
85	.08	.01	.02	.02	.02	.02	.03	.03	.03	.04	.04	.05
90	.06	.01	.01	.01	.01	.02	.02	.02	.03	.03	.03	.04
95	.04	.01	.01	.01	.01	.01	.01	.02	.02	.02	.02	.03
100	.03	.01	.01	.01	.01	.01	.01	.01	.01	.02	.02	.02

^{1/} Mulch factor is the ratio of the soil loss from soils with the specified fragment volumes to that from soils with no fragments. The table was constructed from the zero canopy curve, figure 6, page 19 in Agriculture Handbook 537 (USDA Science and Education Administration, 1978).

618.93 General Guidelines for Assigning Soil Loss Tolerance “T”

Soil loss tolerance “T” is assigned according to properties of root and plant growth limiting subsurface soil layers. The designation of a limiting layer implies that the material above the layer has more favorable plant growth properties. As limiting or less favorable soil layers become closer to the soil surface, the relative ability of a soil to maintain its productivity through natural and managed processes decreases.

Caution should be used in comparing T factors across soils for soil quality or productivity. For examples, soils with a T factor of 5 may not be the most productive and soils with the same T factor rating may not be equally productive. For example, a soil that has a T factor of 5 and is sandy throughout is not as naturally fertile nor can it hold as much available water as a soil that has a T factor of 5 that is loamy throughout.

The criteria for assigning T factor are estimated from both of the following:

1. The severity of physical or chemical properties of subsurface layers
2. The economic feasibility of utilizing management practices to overcome limiting layers or conditions

The following general guide was used with specific soil properties and conditions to write criteria statements for programming T factors as a calculation in NASIS.

Depth to limiting	Soil loss tolerance in tons per acre		
	Group 1	Group 2	Group 3
0 - 25	1	1*	3
25 - 50	1	2	3
50 - 100	2	3	4
100 - 150	3	4	4
>150	5	5	5

* Some soils are assigned a soil loss tolerance of 2.

Group 1.—The limitations are significant or there are permanent layers of root limitation (nonrenewable).

Group 2.—The limitations for roots are moderate, or there is a less than permanent loss to productivity (renewable).

Group 3.—The limitations can be overcome through natural or managed processes, and the productivity level of the noneroded soil can be achieved (very renewable).

All restrictions in the NASIS “Component Restrictions Table” are considered root-limiting, either physically or chemically.

T factors are assigned based on the criteria presented below. If there is more than one limiting soil characteristic, then the soil is rated based on the most limiting soil characteristic based on the “T” criteria in the table.

“T” Criteria^{1/}

12/31/2009

Soil Characteristic	Definition	Depth Limit (cm)	T Factor ^{2/}
1. Organic	A. For Histosols, depth to the first mineral horizon with < 20% organic matter; soil is not in a lithic, limnic, hydric, or fluvaquentic subgroup and not in Sulfohemists or Sulfihemists great groups.	≤150	1
		>150	2
	OR		
	B. For soils that are Histosols in a lithic, limnic, hydric, or fluvaquentic subgroup or are in Sulfohemists or Sulfihemists great groups.		1
	OR		
	C. Except in Alaska; mineral soils that are histic intergrades (i.e., histic subgroup). If the histic epipedon has been destroyed, then ignore this rating and rate T based on other limiting features of the mineral soil.		1
2. Bedrock	A. Except in Alaska; depth to densic bedrock as identified in the NASIS “Component Restrictions Table.” (renewable)	<25	1
		25-50	2
		50-100	3
		100-150	4
		>150	5

Title 430 – National Soil Survey Handbook

	In Alaska (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5
	OR		
	B. Except in Alaska; depth to paralithic bedrock as identified in the NASIS “Component Restrictions Table.” (renewable)	<25	1
		25-50	2
		50-100	3
		100-150	4
		>150	5
	In Alaska (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5
	OR		
	C. Depth to lithic bedrock as identified in the NASIS “Component Restrictions Table.” (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5
3. Permafrost	Depth to permafrost as identified in the NASIS “Component Restrictions Table.” (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5
4. Cemented layers/pans	A. Depth to duripan or petroferric, petrocalcic, petrogypsic, placic, ortstein, or cemented layer (or contiguous layers) that is ≤ 7.6 cm (3 inches) thick; hardness (i.e., rupture resistance) is extremely weakly, very weakly, weakly, or moderately as identified in the NASIS “Component Restrictions Table.” (very renewable)	<50	3
		50-150	4
		>150	5

OR

B. Except in Alaska; depth to a duripan or petroferric,	<25	1
petrocalcic, petrogypsic, placic, ortstein, or cemented	25-50	2
layer (or contiguous layers) that is $\leq$ 7.6 cm (3 inches)	50-100	3
thick; hardness (i.e., rupture resistance) is strongly or	100-150	4
very strongly as identified in the NASIS “Component	>150	5
Restrictions Table.” (renewable)		

Alaska (nonrenewable)	<50	1
	50-100	2
	100-150	3
	>150	5

OR

C. Depth to a duripan or petroferric, petrocalcic,	<50	1
petrogypsic, placic, ortstein, or cemented layer that is $\leq$	50-100	2
7.6 cm (3 inches) thick; hardness (i.e., rupture	100-150	3
resistance) is indurated as identified in the NASIS	>150	5
“Component Restrictions Table.” (nonrenewable)		

OR

D. Except in Alaska; depth to a duripan or petrocalcic,	<25	1
petrogypsic, petroferric, placic, ortstein, or cemented	25-50	2
layer (or contiguous layers) that is $>$ 7.6 cm (3 inches)	50-100	3
thick (or if thickness is not specified); hardness (i.e.,	100-150	4
rupture resistance) is extremely, very weakly, weakly, or	>150	5
moderately as identified in the NASIS “Component		
Restrictions Table.” (renewable)		

In Alaska (nonrenewable)	<50	1
	50-100	2
	100-150	3
	>150	5

OR

Title 430 – National Soil Survey Handbook

	E. Depth to a duripan or petrocalcic, petrogypsic, petroferic, placic, ortstein, or cemented layer (or contiguous layers) that is > 7.6 cm (3 inches) thick (or if thickness is not specified); strongly or greater hardness (i.e., rupture resistance) as identified in the NASIS “Component Restrictions Table.” (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5
5. Fragmental	Depth to fragmental layer (i.e., consists of “in lieu of” textures of artifacts, boulders, cobbles, channers, flagstones, gravel, or stones). (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5
6. Rock fragments	A. Except in Alaska; if the weighted average of rock fragments in the 0-25 cm depth is < 35% (by volume), then rate T based on depth to the first subsurface layer with ≥ 60% rock fragments that has its lower boundary extending to 150 cm or more. (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5
	In Alaska only; if the weighted average of rock fragments in the 0-12 cm depth is < 35% (by volume), then rate T based on depth to the first subsurface layer with ≥ 60% rock fragments that has its lower boundary extending to 150 cm or more. (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5
	OR		
	B. Except in Alaska; if the weighted average of rock fragments in the 0-25 cm depth is < 35% (by volume), then rate T based on depth to the first subsurface layer with ≥ 60% rock fragments that has its lower boundary within 150 cm. (very renewable)	<50	3
		50-150	4
		>150	5
	In Alaska only; if the weighted average of rock fragments in the 0-12 cm depth is < 35% (by volume), then rate T based on depth to the first subsurface layer with ≥ 60% rock fragments that has its lower boundary within 150 cm. (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5

OR			
	C. Except in Alaska; if the weighted average of rock fragments in the 0-25 cm depth is $\leq 15\%$ (by volume), then rate T based on depth to the first subsurface layer with $\geq 35\%$ rock fragments that has its lower boundary extending to 150 cm or more. (very renewable)	<50	3
		50-150	4
		>150	5
	In Alaska only; if the weighted average of rock fragments in the 0-12 cm depth is $\leq 15\%$ (by volume), then rate T based on depth to the first subsurface layer with $\geq 35\%$ rock fragments that has its lower boundary extending to 150 cm or more. (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5
7. Plinthite	Depth to plinthite as identified in the NASIS “Component Restrictions Table.” (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5
8. Fragipan and fragic soil properties	A. Depth to fragipan, as identified in the NASIS “Component Restrictions Table,” that has $\geq 35\%$ rock fragments. (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5
OR			
	B. Depth to fragipan, as identified in the NASIS “Component Restrictions Table,” that has $< 35\%$ rock fragments. (very renewable)	<50	3
		50-150	4
		>150	5
OR			
	C. Soils that are in a fragic subgroup or have an “x” suffix symbol (fragipan character) in any horizon designation; rate T based on depth to the layer that has the greatest bulk density change (from a lower to higher bulk density) and has a $K_{\text{sat}} \leq 1.41 \mu\text{m/s}$ (0.5 cm/h). (very renewable)	<50	3
		50-150	4
		>150	5

9. Natric	A. Depth to natric horizon, as identified in the NASIS “Component Restrictions Table.” (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5
	OR		
	B. For soils that have horizons that do not meet natric horizon criteria but have a subsoil with $\geq 35\%$ clay, $K_{sat} \leq 1.41 \mu\text{m/s}$ (0.5 cm/h), and $SAR \geq 13$ and have adjacent upper layers with a $K_{sat} > 1.41 \mu\text{m/s}$ (0.5 cm/h) that extend to the surface (and the soils are not glossic). (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5
10. Dense layers	Except in Alaska; depth to densic material, as identified in the NASIS “Component Restrictions Table.” (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5
	In Alaska (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5
11. Abrupt increase in clay	A. Depth to layer with an abrupt textural change as identified in the NASIS “Component Restrictions Table.” (very renewable)	<50	3
		50-150	4
		>150	5
	OR		
	B. Depth to substratum that has $\geq 35\%$ clay, has a $K_{sat} < 1.41 \mu\text{m/s}$ (0.5 cm/h), and an adjacent upper layer with a $K_{sat} > 4.23 \mu\text{m/s}$ (1.5 cm/h); or a subsoil that has a $K_{sat} < 0.42 \mu\text{m/s}$ (0.15 cm/h) and an adjacent upper surface layer with a $K_{sat} > 1.41 \mu\text{m/s}$ (0.5 cm/h); the clay increase between the adjacent layers must be $\geq 20\%$, and the surface or upper layers are greater than or equal to 25 cm thick. (very renewable)	<50	3
		50-150	4
		>150	5

12. Strongly contrasting textural stratification	Depth to layers that have strongly contrasting textural stratification, as identified in the NASIS “Component Restrictions Table.” (very renewable)	<50	3
		50-150	4
		>150	5
13. Sandy substratum	A. Except in Alaska; depth to sandy substratum (COS, S, FS, LS, LCOS, or LFS) with a $K_{sat} > 42.3 \mu\text{m/s}$ (15.2 cm/h) that extends to 150 cm or more, and the adjacent upper layers have a $K_{sat} < 42.3 \mu\text{m/s}$ (15.2 cm/h) and have $< (0.667 * \% \text{ clay} + 50)$ percent fine or coarser sand separates in the fine-earth fraction that extends to the surface ^{3/} ; the surface or upper layers are greater than or equal to 25 cm in thickness. (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5
	In Alaska only; depth to sandy substratum (COS, S, FS, LS, LCOS, or LFS) with a $K_{sat} > 42.3 \mu\text{m/s}$ (15.2 cm/h) that extends to 150 cm or more, and the adjacent upper layers have a $K_{sat} < 42.3 \mu\text{m/s}$ (15.2 cm/h) and have $< (0.667 * \% \text{ clay} + 50)$ percent fine or coarser sand separates in the fine-earth fraction that extends to the surface ^{3/} ; the surface or upper layers are greater than or equal to 12 cm in thickness. (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5
	OR		
	B. Except in Alaska; depth to substratum with strongly contrasting sandy textural stratification or stratified with sandy textures of COS, S, LS, FS, LCOS, or LFS and $K_{sat} > 42.3 \mu\text{m/s}$ (15.2 cm/h) that extends to 150 cm or below, and the adjacent upper layers have a $K_{sat} < 42.3 \mu\text{m/s}$ (15.2 cm/h) and have $< (0.667 * \% \text{ clay} + 50)$ percent fine or coarser sand separates in the fine-earth fraction that extends to the surface ^{3/} ; the surface or upper layers are greater than or equal to 25 cm in thickness. (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5

	In Alaska only; depth to substratum with strongly contrasting sandy textural stratification or stratified with sandy textures of COS, S, LS, FS, LCOS, or LFS and $K_{\text{sat}} > 42.3 \mu\text{m/s}$ (15.2 cm/h) that extends to 150 cm or below, and the adjacent upper layers have a $K_{\text{sat}} < 42.3 \mu\text{m/s}$ (15.2 cm/h) and have $< (0.667 * \% \text{ clay} + 50)$ percent fine or coarser sand separates in the fine-earth fraction that extends to the surface ^{3/} ; the surface or upper layers are greater than or equal to 12 cm in thickness. (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5
14. High gypsum	A. Soils that have a surface layer with $\leq 15\%$ gypsum (by weight) and have subsurface layers with $\geq 25\%$ gypsum; rate T based on depth to the first subsurface layer with $\geq 25\%$ gypsum. (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5
	OR		
	B. Soils that have a surface layer with > 15 and $\leq 60\%$ gypsum (by weight) and have subsurface layers that exceed the surface layer in gypsum content by 20% or more; rate T based on depth to the first subsurface layer that exceeds the surface by 20% or more gypsum. (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5
15. High salts	Depth to salic horizon, as identified in the NASIS “Component Restrictions Table.” (very renewable)	<50	3
		50-150	4
		>150	5
16. High sulfur	Depth to sulfuric horizon, as identified in the NASIS “Component Restrictions Table.” (very renewable)	<50	3
		50-150	4
		>150	5
17. High carbonates	A. Soils that have a surface layer with $\leq 15\%$ calcium carbonate (CaCO_3) equivalent and have subsurface layers with $\geq 40\%$ CaCO_3 equivalent; rate T based on depth to the first subsurface layer with $\geq 40\%$ CaCO_3 equivalent. (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5

OR			
	B. Soils that have a surface layer with > 15 and $\leq 60\%$ calcium carbonate (CaCO_3) equivalent and have subsurface layers that exceeds the surface layer in CaCO_3 equivalent by 25% or more; rate T based on depth to the first subsurface layer that exceeds the surface layer by 25% or more CaCO_3 equivalent. (renewable)	<50	2
		50-100	3
		100-150	4
		>150	5
18. Human-manufactured materials	Depth to human-manufactured materials ('M' layers), as identified in the NASIS "Component Restrictions Table." (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5
19. High aluminum	A. Depth to $\geq 60\%$ Al saturation of the ECEC and soil pH (1:1 water) is ≤ 5.5 . (very renewable)	<50	3
		50-150	4
		>150	5
OR			
	B. In Pacific Islands only; for Oxisols or soils in Oxic subgroups or for Ultisols with an isohyperthermic soil temperature regime; depth to $\geq 45\%$ Al saturation of the ECEC and soil pH (1:1 water) is ≤ 5.5 . (nonrenewable)	<50	1
		50-100	2
		100-150	3
		>150	5

1/ Subaqueous soils (i.e., soils classified in Wassents or Wassists suborders) are excluded from assignment of T factors.

2/ Severely eroded soils, as designated by a the local phase or erosion class of 3 or 4, are adjusted one class of T factor lower.

3/ Determines the line between the 30% clay and 70% sand point and the 0% clay and 50% sand point on the texture triangle (see part 618, subpart B, section 618.87). If the total of the vcos, cos, ms, and fs sand separates and total clay (of the adjacent layers above the sandy substratum) plot above this line on the texture triangle, then the uppers layers are considered different from the sandy substratum textures. Thus, the sandy substratum is recognized and the T factor is lowered.

618.94 Texture Class, Texture Modifier, and Terms Used in Lieu of Texture

Texture Class		Texture Modifier 1/		Terms Used in Lieu of Texture	
Class	Code	Modifier	Code	Term	Code
Clay	C	Artifactual	ART	Artifacts	ART
Clay loam	CL	Very artifactual	ARTV	Bedrock	BR
Coarse sand	COS	Extremely artifactual	ARTX	Boulders	BY
Coarse sandy loam	COSL	Ashy	ASHY	Cobbles	CB
Fine sand	FS	Bouldery	BY	Coarse gypsum material	CGM
Fine sandy loam	FSL	Bouldery-artifactual	BYART	Channers	CN
Loam	L	Very bouldery	BYV	Fine gypsum material	FGM
Loamy coarse sand	LCOS	Very bouldery-	BYVART	Flagstones	FL
Loamy fine sand	LFS	artifactual		Gravel	GR
Loamy sand	LS	Extremely bouldery	BYX	Highly decomposed plant	HPM
Loamy very fine sand	LVFS	Extremely bouldery-	BYXART	material	
Sand	S	artifactual		Material	MAT
Sandy clay	SC	Cobbly	CB	Moderately decomposed plant	MPM
Sandy clay loam	SCL	Cobbly-artifactual	CBART	material	
Silt	SI	Very cobbly	CBV	Mucky peat	MPT
Silty clay	SIC	Very cobbly-	CBVART	Muck	MUCK
Silty clay loam	SICL	artifactual		Paraboulders	PBY
Silt loam	SIL	Extremely cobbly	CBX	Paracobbles	PCB
Sandy loam	SL	Extremely cobbly-	CBXART	Parachanners	PCN
Very fine sand	VFS	artifactual		Peat	PEAT
Very fine sandy loam	VFSL	Cemented	CEM	Paraflagstones	PFL
		Channery	CN	Paragravel	PG
		Channery-artifactual	CNART	Parastones	PST
		Very channery	CNV	Shells	SHL
		Very channery-	CNVART	Slightly decomposed plant	SPM
		artifactual		material	
		Extremely channery	CNX	Stones	ST
		Extremely channery-	CNXART	Water	W
		artifactual			
		Coprogenous	COP		
		Diatomaceous	DIA		
		Flaggy	FL		
		Flaggy-artifactual	FLART		
		Very flaggy	FLV		
		Very flaggy-	FLVART		
		artifactual			
		Extremely flaggy	FLX		
		Extremely flaggy-	FLXART		
		artifactual			
		Gravelly	GR		
		Gravelly-artifactual	GRART		
		Coarse gravelly	GRC		
		Fine gravelly	GRF		
		Medium gravelly	GRM		
		Very gravelly	GRV		
		Very gravelly-	GRVART		
		artifactual			
		Extremely gravelly	GRX		

Title 430 – National Soil Survey Handbook

		Extremely gravelly-artifactual	GRXART		
		Grassy	GS		
		Gypsiferous	GYP		
		Herbaceous	HB		
		Highly organic	HO		
		Hydrous	HYDR		
		Medial	MEDL		
		Mucky	MK		
		Marly	MR		
		Mossy	MS		
		Parabouldery	PBY		
		Very parabouldery	PBYV		
		Extremely parabouldery	PBYX		
		Paracobbly	PCB		
		Very paracobbly	PCBV		
		Extremely paracobbly	PCBX		
		Parachannery	PCN		
		Very parachannery	PCNV		
		Extremely parachannery	PCNX		
		Permanently frozen	PF		
		Paraflaggy	PFL		
		Very paraflaggy	PFLV		
		Extremely paraflaggy	PFLX		
		Paragravelly	PGR		
		Very paragravelly	PGRV		
		Extremely paragravelly	PGRX		
		Parastony	PST		
		Very parastony	PSTV		
		Extremely parastony	PSTX		
		Peaty	PT		
		Shelly	SHF		
		Very shelly	SHFV		
		Extremely shelly	SHFX		
		Shelly-artifactual	SHFART		
		Very shelly-artifactual	SHFVART		
		Extremely shelly-artifactual	SHFEART		
		Stony	ST		
		Stony-artifactual	START		
		Very stony	STV		
		Very stony-artifactual	STVART		
		Extremely stony	STX		
		Extremely stony-artifactual	STXART		
		Woody	WD		

1/ “Texture modifiers” may apply to both “texture class” and “terms used in lieu of texture.” Some apply to both, others only apply to one or the other. See part 618, subpart A, section 618.71, for more information.

618.95 Wind Erodibility Groups (WEG) and Index

WEG 1,3,4,5,7	Properties of Soil Surface Layer	Dry Soil Aggregates More Than 0.84 mm (wt.%)	Wind Erodibility Index (I) (tons/ac/yr)
1	Very fine sand, fine sand, sand, or coarse sand ²	1	310
		2	250
		3	220
		5	180
		7	160
2	Loamy very fine sand, loamy fine sand, loamy sand, and loamy coarse sand; very fine sandy loam and silt loam with 5 or less percent clay; and sapric soil materials (as defined in Soil Taxonomy), except Folists.	10	134
3	Very fine sandy loam (but does not meet WEG criterion 2), fine sandy loam, sandy loam, and coarse sandy loam; noncalcareous silt loam that has greater than or equal to 20 to less than 50 percent very fine sand and greater than or equal to 5 to less than 12 percent clay.	25	86
4	Clay, silty clay, noncalcareous clay loam that has more than 35 percent clay and noncalcareous silty clay loam that has more than 35 percent clay; all of these do not have sesquic, parasesquic, ferritic, ferruginous, or kaolinitic mineralogy (high iron oxide content).	25	86
4L	Calcareous ⁶ loam, calcareous silt loam, calcareous silt, calcareous sandy clay, calcareous sandy clay loam, calcareous clay loam, and calcareous silty clay loam.	25	86
5	Noncalcareous loam that has less than 20 percent clay, noncalcareous silt loam with greater than or equal to 5 to less than 20 percent clay (but does not meet WEG criterion 3), noncalcareous sandy clay loam, noncalcareous sandy clay, and hemic soil materials (as defined in Soil Taxonomy).	40	56
6	Noncalcareous loam and silt loam that have greater than or equal to 20 percent clay; noncalcareous clay loam and noncalcareous silty clay loam that have less than or equal to 35 percent clay; silt loam that has parasesquic, ferritic, or kaolinitic mineralogy (high iron oxide content).	45	48
7	Noncalcareous silt; noncalcareous silty clay, noncalcareous silty clay loam, and noncalcareous clay that have sesquic, parasesquic, ferritic, ferruginous, or kaolinitic mineralogy (high content of iron oxide) and are Oxisols or Ultisols; and fibric soil materials (as defined in Soil Taxonomy).	50	38
8	Soils not susceptible to wind erosion due to rock and pararock fragments at the surface and/or wetness; and Folists.	--	0

Title 430 – National Soil Survey Handbook

The following footnotes are applied in the order listed:

1 For all WEGs except 1 and 2 (sands and loamy sand textures), if percent rock and pararock fragments (>2mm) by volume is 15-35, reduce "I" value by one group with more favorable rating. If percent rock and pararock fragments by volume is 35-60, reduce "I" value by two favorable groups except for sands and loamy sand textures which are reduced by one group with more favorable rating. If percent rock and pararock fragments is greater than 60, use "I" value of 0 for all textures except sands and loamy sand textures which are reduced by three groups with more favorable ratings. An example of more favorable "I" rating is next lower number: "I" factor of 160 to "I" factor of 134 or "I" factor of 86 to "I" factor of 56. The index values should correspond exactly to their wind erodibility group (e.g., "I" factor of 56 = WEG 5).

2 The "I" values for WEG 1 vary from 160 for coarse sands to 310 for very fine sands. Use an "I" of 220 as an average figure.

3 All material that meets criterion 3 in the required characteristics for andic soil properties as defined in the Keys to Soil Taxonomy, 11th edition. Such material is placed in WEG 2 regardless of the texture class of the fine-earth fraction.

4 All material that meets criterion 2, but not criterion 3, in the required characteristics for andic soil properties as defined in the Keys to Soil Taxonomy, 11th edition. Such material is placed in WEG 6, regardless of the texture class of the fine-earth fraction. The only exception to this is for Cryic Spodosols which have a medial substitute class and a MAAT < 4 degrees C.; these soils are placed in WEG 2.

5 For surface layers or horizons that do not meet the required characteristics for andic soil properties but do meet Vitrandic, Vitritrandic, Vitrixerandic, and Ustivitrandidic subgroup criteria (thickness criterion excluded) move one wind erodibility group (WEG) with a less favorable rating.

6 Calcareous is a strongly or violently effervescent reaction (class) of the fine-earth fraction to cold dilute (1N) HCL; a paper "Computing the Wind Erodible Fraction of Soils" by D. W. Fryear et.al (1994) in the Journal of Soil and Water Conservation 49 (2) 183-188 raises a yet unresolved question regarding the effect of carbonates on wind erosion.

7 For mineral soils with thin "O" horizons, the WEG is based on the first mineral horizon.

618.96 Key Landforms and Their Susceptibility to Slippage

Topography	Landform or Geological Materials	Slippage Potential ^A
I. Level Terrain		
A. Not elevated	Flood plain, till plain, lakebed	3
B. Elevated		
1. Uniform tones	Terrace, lakebed,	2
2. Surface irregularities, sharp cliffs	basaltic plateau	1
3. Interbedded, porous over impervious layers	lakebed, coastal plain	1
II. Hilly Terrain		
A. Surface drainage not well integrated		
1. Disconnected drainage	Limestone	3
2. Deranged drainage, overlapping hills, associated with lakes and swamps (glaciated areas only)	Moraine	2
B. Surface drainage well integrated		
1. Parallel ridges		
a. Parallel drainage, dark tones	Basaltic hills	1
b. Trellis drainage, ridge-and-valley topography, banded hills	Downslope tilted sedimentary rock	1
c. Pinnate drainage, vertical-sided gullies	Loess	2
2. Branching ridges, hilltops at common elevation		
a. Pinnate drainage, vertical-sided gullies	Loess	2
b. Dendritic drainage		
(1) Banding on slopes	Flat-lying sed. rocks	2
(2) No banding on slopes		
(a) Moderately to highly dissected ridges, uniform slopes	Clay shale	1
(b) Low ridges associated with coastal features	Dissected coastal plains	1
(c) Winding ridges connection, conical hills, sparse vegetation	Serpentinite	1
3. Random ridges or hills		
a. Dendritic drainage		
(1) Low, rounded hills, meandering streams	Clay shale	1
(2) Winding ridges, connecting conical hills, sparse vegetation	Serpentinite	1
(3) Massive, uniform, rounded to A-shaped hills	Granite	2
(4) Bumpy topography (glaciated areas only)	Moraines	2
III. Level to Hilly Terrain		
A. Steep slopes	Talus, colluvium	1
B. Moderate to flat slopes	Fan, delta	3
C. Hummocky slopes with scarp at head	Old slide	1

A. Ratings for slippage potential:

1 = susceptible to slippage (unstable); 2 = susceptible to slippage under certain conditions (moderately unstable); 3 = not susceptible to slippage except in vulnerable locations (slightly unstable to stable)

(430-618-H, 1st Ed., Amend. 35, August 2019)

618.97 Example Worksheets for Soil Moisture State by Month and Depth**SOIL MOISTURE STATE BY MONTH AND DEPTH**

Aridic Thermic

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)	10	10	8	4	6	2	8	10	6	4	8	8
0	<u>M</u>	<u>M</u>	<u>M</u>	<u>M</u>								<u>M</u>
SOIL DEPTH	D	D	D	D	D	D	D	D	D	D	D	D
200 cm												

Xeric Mesic

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)	180	140	110	60	40	30	10	20	40	80	170	200
0						<u>D</u>	<u>D</u>	<u>D</u>	<u>M</u>			
SOIL DEPTH	M	M	M	M	M	M	M	M	M	M	M	
200 cm	<u>W</u>	<u>W</u>	<u>W</u>									<u>W</u>

Ustic Mesic

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)	10	15	50	60	80	100	70	70	70	40	25	15
0	<u>M</u>	<u>M</u>	<u>M</u>				<u>D</u>	<u>D</u>		<u>M</u>	<u>M</u>	<u>M</u>
SOIL DEPTH	<u>D</u>	<u>D</u>	<u>D</u>	M	M	M	M	M	<u>D</u>	<u>D</u>	<u>D</u>	<u>D</u>
200 cm	M	M	M						M	M	M	M

Title 430 – National Soil Survey Handbook

Udic Mesic

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)	50	60	80	80	100	100	110	90	70	50	80	70
0								<u>D</u>	<u>D</u>			
SOIL DEPTH	M	M	M	M	M	M	M	M	M	M	M	M
200 cm	<u>W</u>	<u>W</u>	<u>W</u>	<u>W</u>	<u>W</u>						<u>W</u>	<u>W</u>

SOIL MOISTURE STATE BY MONTH AND DEPTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)												
0												
SOIL DEPTH												
200 cm												

SOIL MOISTURE STATE BY MONTH AND DEPTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)												
0												
SOIL DEPTH												
200 cm												

SOIL MOISTURE STATE BY MONTH AND DEPTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)												
0												
SOIL DEPTH												
200 cm												

618.98 NASIS Calculation for Estimating AASHTO Group Index

Definition.—Computes the AASHTO Group Index for a horizon

Inputs.—This calculation requires the following data to be populated:

number 200 sieve
liquid limit
plasticity index

Calculation.

DEFINE skip_ll ANY (aashto_class == "a-2-6" or aashto_class == "a-2-7").
DEFINE aashind .01*(sieveno200_r-15)*(pi_r-10).

ASSIGN aashind IF skip_ll OR (sieveno200_r<35 and pi_r>=10) THEN aashind ELSE (sieveno200_r - 35)*(.2 + .005*(ll_r - 40)) + aashind.

ASSIGN aashind IF pi_r==0 OR (aashind<0 AND NOT ISNULL(aashind)) THEN 0 ELSE aashind.

618.99 NASIS Calculation for Estimating Cation-Exchange Capacity

Definition.—If the rv pH (in water) is greater than or equal to 5.5, then CEC is calculated; if the rv pH is less than 5.5, then ECEC is calculated for a horizon.

Caution: Estimates of CEC or ECEC for soil layers with andic soil properties may be unreliable. Read the documentation to this calculation to see if it will work for your soils.

Inputs.—This calculation requires the following data to be populated:

organic matter (high, low, and rv)
 pH in water (high, low, and rv)
 pH in CaCl (for organic layers) (high, low, and rv)
 total clay (high, low, and rv)
 carbonate clay (high, low, and rv)
 total silt (high, low, and rv)
 CaCO₃ (high, low, and rv) used only for soils containing gypsum
 gypsum (high, low, and rv) used only for soils containing gypsum
 taxonomic family mineralogy
 taxonomic order
 taxonomic CEC-activity class

- 1) The calculation is based on Soil Taxonomy (Soil Survey Staff, 1999). The CEC or ECEC is calculated based on the family mineralogy/CEC-activity class first. If an equation does not exist for a mineralogy/CEC-activity class, then the CEC/ECEC is based on the soil order.
- 2) If the family mineralogy class, CEC-activity class (if appropriate), and soil order are not populated, a null is returned.
- 3) If there is more than one family mineralogy class populated in the “Component-Taxonomic- Family-Mineralogy Table,” the first one is used.
- 4) If the pH in water is not populated, then pH in CaCl is used. If the pH (CaCl) is greater than or equal to 5.1, then CEC is calculated; otherwise ECEC is calculated for a horizon.
- 5) If any required data element (OM, pH, clay, silt) for an equation is not populated (null entry), a null is returned, except for carbonate clay.
- 6) If carbonate clay is null, zero carbonate clay is assumed.
- 7) Noncarbonate clay is calculated by subtracting percent carbonate clay from total clay (noncarbonated clay = total_clay - carbonate_clay).
- 8) Percent organic matter is converted to percent organic C by dividing by 1.72 (OC = OM/1.72).
- 9) If only low and high values are populated for a data element, an rv is calculated by taking the average of the low and high values.
- 10) In the calculation of CEC for isotic and amorphous mineralogies and Andisols and for isotic mineralogy for ECEC, gravimetric 15-bar water is used. An internal calculation calculates the 15-bar water using the following formula:

$$15\text{-bar water} = [\text{total_clay} (1 - \text{organic_matter} / 100) 0.4 + \text{organic_matter}]$$
- 11) In the calculation of ECEC, if the mineralogy class is not parasesquic, smectitic, or isotic and is not mixed or siliceous with a CEC activity class and the soil order is Andisols, Gelisols, Aridisols, or Vertisols, then no ECEC is calculated (null is returned).

Calculation.

Estimate # ----- gypsum soils -----

DEFINE cecr IF ISNULL(ph1) THEN 1/0

(430-618-H, 1st Ed., Amend. 35, August 2019)

```
ELSE IF ph1=="yes" and gyp2mm > 4 and gyp2mm <= 40 THEN EXP(0.851*ln_clayr - 0.02*caco3_r -
0.009*gyp2mm + 0.174) * (1-(gyp2mm/100))
ELSE IF ph1=="yes" and gyp2mm > 40 THEN 10.035 - 0.093*gyp2mm
```

```
# ----- phwat >= 5.5 or phcac12 >=5.1 and phwat<=7.0 and OC > 8 -----
```

```
ELSE IF ph1=="yes"and ocr>14.5 and ph2=="no"and
(lieutex1 == "muck" OR lieutex1 == "hpm")
THEN ((2.12 * (ocr)) + (9.992 * (phcac12r)) - 10.684)
ELSE IF ph1=="yes"and ocr>14.5 and ph2=="no"and
(lieutex1 == "mpt" OR lieutex1 == "mpm")
THEN ((2.03 * (ocr)) + (3.396 * (phcac12r)) - 2.939)
ELSE IF ph1=="yes"and ocr>14.5 and ph2=="no"and
(lieutex1 == "peat" or lieutex1 == "spm")
THEN ((1.314 * (ocr)) + 27.047)
ELSE IF ph1=="yes"and ocr>8 and ph2=="no"and ocr <= 14.5
THEN ((1.823 * (ocr)) + (0.398 * (nclayr)) + 15.54)
```

```
# ----- phwat >=5.5 or phcac12r >= 5.1 and OC >8 and phwat >7.0 -----
```

```
ELSE IF ph1=="yes"and ocr>8 and ph2=="yes"and ocr <= 14.5
THEN EXP(1.316 * (ln_ocr) + 1.063 * (ln_nclayr) - 3.211)
ELSE IF ph1=="yes"and ocr>8 and ph2=="yes"and ocr >14.5
THEN (4.314 * (ocr) - 26.492)
```

```
# ----- phwat >= 5.5 or phcac12 >= 5.1 and OC <= 8, use Mineralogy -----
```

```
ELSE IF (ph1=="yes"and ocr <= 8 and taxminalogy1 == "ferruginous")
THEN (2.48 * (ocr) + 0.128 * (siltr) + 3.208)
ELSE IF (ph1=="yes"and ocr <= 8 and taxminalogy1 == "amorphic")
THEN EXP((0.182*(ln_ocr)) + (0.817*(ln_w15barr)) + (0.736*(ln_phwatr)) - 0.608)
ELSE IF (ph1=="yes"and ocr <= 8 and taxminalogy1 == "glassy")
THEN EXP((0.102*(ln_ocr)) + (1.219*(ln_w15barr)) - 0.005)
ELSE IF (ph1=="yes"and ocr <= 8 and (taxminalogy1 == "carbonatic" or taxminalogy1 == "calcareous"))
THEN EXP((0.253*(ln_ocr)) + (0.828*(ln_nclayr)) + 0.321)
ELSE IF (ph1=="yes"and ocr <= 8 and taxminalogy1 == "magnesian")
THEN (2.38*(ocr) + 0.555*(nclayr) - 0.219*(siltr) + 10.428)
ELSE IF (ph1=="yes"and ocr <= 8 and taxminalogy1 == "parasesquic")
THEN EXP((0.13*(ln_ocr)) + (0.65*(ln_nclayr)) + (0.340*(ln_phwatr)) - 0.406)
ELSE IF (ph1=="yes"and ocr <= 8 and taxminalogy1 == "kaolinitic")
THEN EXP((0.206*(ln_ocr)) + (0.618*(ln_nclayr)) + (0.303*(ln_siltr)) + (0.491*(ln_phwatr)) - 1.786)
ELSE IF (ph1=="yes"and ocr <= 8 and (taxminalogy1 == "smectitic" OR taxminalogy1 ==
"montmorillonitic"))
THEN EXP((0.033*(ln_ocr)) + (0.861*(ln_nclayr)) + 0.246)
ELSE IF (ph1=="yes"and ocr <= 8 and taxminalogy1 == "illitic")
THEN EXP((0.102*(ln_ocr)) + (0.596*(ln_nclayr)) - (1.108*(ln_phwatr)) + 2.892)
ELSE IF (ph1=="yes"and ocr <= 8 and taxminalogy1 == "vermiculitic")
THEN (0.365*(nclayr) - 9.724*(phwatr) + 90.293)
ELSE IF (ph1=="yes"and ocr <= 8 and taxminalogy1 == "isotitic")
THEN EXP((0.163*(ln_ocr)) + (0.683*(ln_w15barr)) + (0.812*(ln_phwatr)) - 0.299)
ELSE
```

```
# ----- use CEC Activity Class -----
```

```
IF (ph1=="yes"and ocr <=8 and taxceactcl1 == "superactive")
THEN EXP((0.039*(ln_ocr)) + (0.901*(ln_nclayr)) + 0.131)
```

```

ELSE IF (ph1 == "yes" and ocr <= 8 and taxceactcl1 == "active")
THEN EXP((0.015*(ln_ocr)) + (0.987*(ln_nclayr)) - 0.576)
ELSE IF (ph1 == "yes" and ocr <= 8 and taxceactcl1 == "semiactive")
THEN EXP((0.02*(ln_ocr)) + (0.974*(ln_nclayr)) - 0.927)
ELSE IF (ph1 == "yes" and ocr <= 8 and taxceactcl1 == "subactive")
THEN EXP((0.009*(ln_ocr)) + (1.02*(ln_nclayr)) - 1.675)
ELSE

# -----use Taxonomic Order -----
IF (ph1 == "yes" and ocr <= 0.3 and taxorder1 == "alfisols")
THEN EXP((0.911*(ln_nclayr)) - 0.308)
ELSE IF (ph1 == "yes" and ocr > 0.3 and ocr <= 8 and taxorder1 == "alfisols")
THEN EXP((0.158*(ln_ocr)) + (0.805*(ln_nclayr)) + 0.216)
ELSE IF (ph1 == "yes" and ocr <= 8 and taxorder1 == "andisols")
THEN EXP((0.088*(ln_ocr)) + (0.885*(ln_w15barr)) + (0.867*(ln_phwatr)) - 0.985)
ELSE IF (ph1 == "yes" and ocr <= 8 and taxorder1 == "aridisols")
THEN EXP((0.042*(ln_ocr)) + (0.828*(ln_nclayr)) + 0.236)
ELSE IF (ph1 == "yes" and ocr <= 8 and taxorder1 == "entisols")
THEN EXP((0.078*(ln_ocr)) + (0.873*(ln_nclayr)) + 0.084)
ELSE IF (ph1 == "yes" and ocr <= 8 and taxorder1 == "inceptisols")
THEN EXP((0.134*(ln_ocr)) + (0.794*(ln_nclayr)) + 0.239)
ELSE IF (ph1 == "yes" and ocr <= 0.3 and taxorder1 == "mollisols")
THEN EXP((0.932*(ln_nclayr)) - 0.174)
ELSE IF (ph1 == "yes" and ocr > 0.3 and ocr <= 8 and taxorder1 == "mollisols")
THEN EXP((0.113*(ln_ocr)) + (0.786*(ln_nclayr)) + 0.475)
ELSE IF (ph1 == "yes" and ocr <= 8 and taxorder1 == "oxisols")
THEN (2.738*(ocr) + 0.103*(nclayr) + 0.123*(siltr) - 2.531)
ELSE IF (ph1 == "yes" and ocr <= 8 and taxorder1 == "spodosols")
THEN EXP((0.045*(ln_ocr)) + (0.798*(ln_nclayr)) + 0.029)
ELSE IF (ph1 == "yes" and ocr <= 8 and taxorder1 == "ultisols")
THEN EXP((0.184*(ln_ocr)) + (0.57*(ln_nclayr)) + (0.365*(ln_siltr)) - 0.906)
ELSE IF (ph1 == "yes" and ocr <= 8 and taxorder1 == "vertisols")
THEN EXP((0.059*(ln_ocr)) + (0.86*(ln_nclayr)) + 0.312)
ELSE IF (ph1 == "yes" and ocr <= 8 and taxorder1 == "histosols")
THEN EXP((0.319*(ln_ocr)) + (0.497*(ln_nclayr)) + 1.075) ELSE 1/0.

```

618.100 NASIS Calculation for Estimating Effective Cation-Exchange Capacity

Inputs.—See the documentation in part 618, subpart B, section 618.99, on the NASIS calculation for estimating cation-exchange capacity.

Calculation.

```
#-----Calculates ECEC when pH(water) < 5.5-----
DEFINE ececr
IF ISNULL(ph1) THEN 1/0
ELSE IF ph1 == "no" AND ocr > 8 AND taxminalogy1 == "andisols"
THEN EXP(0.938*ln_ocr - 0.029*phcacl2r - 0.054)
ELSE IF ph1 == "no" AND ocr > 8
THEN EXP(0.699*ln_ocr + 0.556*phcacl2r - 1.497)
ELSE IF ph1 == "no" AND ocr <= 8 AND desgnmaster1 == "E"
THEN EXP((0.371*ln_ocr) + (0.728*ln_nclayr) + (0.392*ln_siltr) + (0.728*ln_phwatr) - 2.145)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxminalogy1 == "parasesquic"
THEN EXP(0.109*ln_ocr + 0.904*ln_clayr - 0.927*ln_phwatr - 0.083)
ELSE IF ph1 == "no" AND ocr <= 8 AND (taxminalogy1 == "smectitic" OR taxminalogy1 ==
"montmorillonitic")
THEN EXP(0.965*ln_clayr + 0.939*ln_phwatr - 1.974)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxminalogy1 == "isotic"
THEN EXP(0.124*ln_ocr + 0.535*ln_w15barr + 0.405*ln_siltr - 0.455)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxceactcl1 == "superactive"
THEN EXP(0.035*ln_ocr + 0.913*ln_clayr - 0.341)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxceactcl1 == "active"
THEN EXP(1.15*ln_clayr - 0.115*ln_ocr - 1.725)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxceactcl1 == "semiaactive"
THEN EXP(1.049*ln_clayr - 0.058*ln_ocr - 1.864)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxceactcl1 == "subactive"
THEN EXP(0.757*ln_clayr - 1.01*ln_phwatr + 0.214*ln_siltr - 0.465)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxorder1 == "alfisols"
THEN EXP(0.019*ln_ocr + 0.834*ln_clayr + 0.325*ln_phwatr + 0.288*ln_siltr - 1.937)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxorder1 == "entisols"
THEN EXP(0.387*ln_ocr + 0.818*ln_clayr - 0.343)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxorder1 == "inceptisols"
THEN EXP(0.283*ln_ocr + 0.541*ln_clayr + 1.913*ln_phwatr - 2.869)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxorder1 == "mollisols"
THEN EXP(0.122*ln_ocr + 0.721*ln_clayr + 0.6*ln_phwatr - 0.635)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxorder1 == "oxisols"
THEN EXP(0.21*ln_ocr + 0.685*ln_clayr - 2.381*ln_phwatr + 0.355*ln_siltr + 1.169)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxorder1 == "spodosols"
THEN EXP(0.309*ln_ocr + 0.526*ln_clayr + 0.25*ln_siltr - 0.535)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxorder1 == "ultisols"
THEN EXP(0.555*ln_clayr + 0.481*ln_siltr - 1.204*ln_phwatr + 0.016)
ELSE IF ph1 == "no" AND ocr <= 8 AND taxorder1 == "histosols"
THEN 0.443*clayr + 2.377*ocr - 2.906
ELSE 1/0.
```

618.101 NASIS Calculation for Estimating Extractable Acidity

Definition.—Computes the extractable acidity for a horizon.

Inputs.—This calculation requires the following data to be populated:

- organic matter (high, low, and rv)
- pH in water (high, low, and rv)
- pH in CaCl₂ (high, low, and rv) only used for organic layers
- total clay (high, low, and rv) only used for medial textures
- CEC or ECEC (high, low, and rv)
- texture (used for identifying hydrous, medial, ashy, and organic soil layers)
- taxonomic order

Limitations.

- 1) The calculation is based on regression equations developed from measured data in the characterization database. There are regression equations for O horizons of Histosols, O horizons of other soil orders, hydrous textures, medial textures, ashy textures, and mineral layers for each soil order.
- 2) There are a set of regression equations that use CEC and another set that use ECEC as a predictor variable. IF the pH is < 5.5, then the set of equations that use ECEC is used. IF ECEC is not populated then a null is returned (regardless if CEC is populated or not).
- 3) If any required data element (OM, pH, CEC, or ECEC) for an equation is not populated (null entry), a null is returned.
- 4) Organic C is used in the equations. Percent organic matter is converted to percent organic C by dividing by 1.72 (OC = OM/1.72).

Calculation.

DEFINE ocr om_r/1.72.

DEFINE ocl om_l/1.72.

DEFINE och om_h/1.72.

#-----Calculate RV extractable acidity-----

```
DEFINE acidr IF NOT ISNULL(cec7_r) AND (ph1to1h2o_r >= 5.5 OR ph01mcacl2_r >= 5.5) THEN
IF (hzname matches "*O*" OR texture matches "*MPT*" OR texture matches "*MUCK*" OR texture
matches "*PEAT*" OR texture matches "*HPM*" OR texture matches "*MPM*" OR texture matches
"*SPM*") AND ph1to1h2o_r > 6.1 THEN 0.19*cec7_r - 11.411*ph1to1h2o_r + 78.341 ELSE IF taxord
== "histosols" AND NOT ISNULL(taxord) AND (hzname matches "*O*" OR texture matches "*MPT*"
OR texture matches "*MUCK*" OR texture matches "*PEAT*") THEN 0.289*cec7_r + 0.358*ocr -
26.390*ph01mcacl2_r + 149.662 ELSE IF (hzname matches "*O*" AND NOT ISNULL(hzname)) OR
((texture matches "*HPM*" OR texture matches "*MPM*" OR texture matches "*SPM*" OR texture
matches "*MPT*" OR texture matches "*MUCK*" OR texture matches "*PEAT*") AND NOT
ISNULL(texture)) THEN 0.470*cec7_r + 0.298*ocr - 19.702*ph01mcacl2_r + 100.585 ELSE IF texture
matches "*HYDR*" AND NOT ISNULL(texture) THEN -0.312*cec7_r + 3.726*ocr -
20.442*ph1to1h2o_r + 159.093 ELSE IF texture matches "*MEDL*" AND NOT ISNULL(texture)
THEN 0.564*cec7_r - 0.326*claytotal_r - 8.825*ph1to1h2o_r + 75.799 ELSE IF texture matches
"*ASHY*" AND NOT ISNULL(texture) THEN 0.134*cec7_r + 2.669*ocr - 1.972*ph1to1h2o_r +
14.051 ELSE IF taxord == "histosols" THEN 0.673*cec7_r - 7.659*ph1to1h2o_r + 44.466 ELSE IF
taxord == "gelisols" THEN 0.36*cec7_r - 4.301*ph1to1h2o_r + 31.87 ELSE IF taxord == "entisols"
THEN 0.148*cec7_r + 1.679*ocr - 1.791*ph1to1h2o_r + 12.254 ELSE IF taxord == "mollisols" THEN
```



```

0.112*cec7_r + 0.595*ocr - 2.745*ph1to1h2o_r + 19.964 ELSE IF taxord == "alfisols" THEN
0.205*cec7_r + 1.113*ocr - 2.928*ph1to1h2o_r + 19.545 ELSE IF taxord == "aridisols" THEN
0.047*cec7_r + 0.535*ocr - 0.973*ph1to1h2o_r + 7.735 ELSE IF taxord == "ultisols" THEN
0.850*cec7_r + 0.361*ocr - 2.125*ph1to1h2o_r + 11.741 ELSE IF taxord == "inceptisols" THEN
0.496*cec7_r + 0.698*ocr - 5.010*ph1to1h2o_r + 31.299 ELSE IF taxord == "vertisols" THEN
0.061*cec7_r + 0.775*ocr - 3.557*ph1to1h2o_r + 26.936 ELSE IF taxord == "spodosols" THEN
1.226*cec7_r - 0.524*ocr - 3.429*ph1to1h2o_r + 20.975 ELSE IF taxord == "oxisols" THEN
0.499*cec7_r + 1.679*ocr - 2.055*ph1to1h2o_r + 16.422 ELSE IF taxord == "andisols" THEN
0.763*cec7_r - 4.328*ph1to1h2o_r + 28.591 ELSE 1/0 ELSE IF NOT ISNULL(ecec_r) THEN IF taxord
== "histosols" AND NOT ISNULL(taxord) AND (hzname matches "*O*" OR texture matches "*MPT*"
OR texture matches "*MUCK*" OR texture matches "*PEAT*") THEN 0.471*ocr -
20.556*ph01mcacl2_r + 142.732 ELSE IF (hzname matches "*O*" AND NOT ISNULL(hzname)) OR
((texture matches "*HPM*" OR texture matches "*MPM*" OR texture matches "*SPM*" OR texture
matches "*MPT*" OR texture matches "*MUCK*" OR texture matches "*PEAT*") AND NOT
ISNULL(texture)) THEN 1.03*ocr - 19.587*ph01mcacl2_r + 110.208 ELSE IF taxord == "histosols"
THEN 2.717*ocr + 9.247 ELSE IF taxord == "gelisols" THEN 0.965*ocr - 4.503*ph1to1h2o_r + 35.377
ELSE IF taxord == "entisols" THEN 0.147*claytotal_r + 2.7*ocr - 1.484*ph1to1h2o_r + 9.572 ELSE IF
taxord == "mollisols" THEN 0.148*claytotal_r + 1.692*ocr - 2.411*ph1to1h2o_r + 15.606 ELSE IF
taxord == "alfisols" THEN 0.188*claytotal_r + 2.353*ocr - 4.612*ph1to1h2o_r + 25.601 ELSE IF taxord
== "aridisols" THEN 0.033*claytotal_r + 2.392*ocr + 2.391*ph1to1h2o_r - 9.935 ELSE IF taxord ==
"ultisols" THEN 0.899*ecec_r + 0.111*claytotal_r + 2.438*ocr - 1.254*ph1to1h2o_r + 6.046 ELSE IF
taxord == "inceptisols" THEN 0.429*ecec_r + 0.078*claytotal_r + 3.052*ocr - 2.053*ph1to1h2o_r +
15.165 ELSE IF taxord == "vertisols" THEN 0.157*claytotal_r + 2.437*ocr - 2.949*ph1to1h2o_r +
15.531 ELSE IF taxord == "spodosols" THEN 1.581*ecec_r + 3.054*ocr + 6.68 ELSE IF taxord ==
"oxisols" THEN 0.342*ecec_r + 0.078*claytotal_r + 3.176*ocr + 3.932 ELSE IF taxord == "andisols"
THEN 0.879*ocr - 12.847*ph1to1h2o_r + 96.871 ELSE 1/0 ELSE 1/0.

```

```

ASSIGN acidr IF acidr < 0 AND NOT ISNULL(acidr) THEN 0 ELSE acidr.

```

```

#----Calculate low extractable acidity-----

```

```

DEFINE acidl

```

```

IF NOT ISNULL(cec7_l) AND (ph1to1h2o_r >= 5.5 OR ph01mcacl2_r >= 5.5) THEN IF (hzname
matches "*O*" OR texture matches "*MPT*" OR texture matches "*MUCK*" OR texture matches
"*PEAT*" OR texture matches "*HPM*" OR texture matches "*MPM*" OR texture matches "*SPM*")
AND ph1to1h2o_r > 6.1 THEN 0.19*cec7_l - 11.411*ph1to1h2o_h + 78.341 ELSE IF taxord ==
"histosols" AND NOT ISNULL(taxord) AND (hzname matches "*O*" OR texture matches "*MPT*" OR
texture matches "*MUCK*" OR texture matches "*PEAT*") THEN 0.289*cec7_l + 0.358*ocl -
26.390*ph01mcacl2_h + 149.662 ELSE IF (hzname matches "*O*" AND NOT ISNULL(hzname)) OR
((texture matches "*HPM*" OR texture matches "*MPM*" OR texture matches "*SPM*" OR texture
matches "*MPT*" OR texture matches "*MUCK*" OR texture matches "*PEAT*") AND NOT
ISNULL(texture)) THEN 0.470*cec7_l + 0.298*ocl - 19.702*ph01mcacl2_h + 100.585 ELSE IF texture
matches "*HYDR*" AND NOT ISNULL(texture) THEN -0.312*cec7_h + 3.726*ocl -
20.442*ph1to1h2o_h + 159.093 ELSE IF texture matches "*MEDL*" AND NOT ISNULL(texture)
THEN 0.564*cec7_l - 0.326*claytotal_h - 8.825*ph1to1h2o_h + 75.799 ELSE IF texture matches
"*ASHY*" AND NOT ISNULL(texture) THEN 0.134*cec7_l + 2.669*ocl - 1.972*ph1to1h2o_h +
14.051 ELSE IF taxord == "histosols" THEN 0.673*cec7_l - 7.659*ph1to1h2o_h + 44.466 ELSE IF
taxord == "gelisols" THEN 0.36*cec7_l - 4.301*ph1to1h2o_h + 31.87 ELSE IF taxord == "entisols"
THEN 0.148*cec7_l + 1.679*ocl - 1.791*ph1to1h2o_h + 12.254 ELSE IF taxord == "mollisols" THEN

```

```

0.112*cec7_l + 0.595*ocl - 2.745*ph1tolh2o_h + 19.964 ELSE IF taxord == "alfisols" THEN
0.205*cec7_l + 1.113*ocl - 2.928*ph1tolh2o_h + 19.545 ELSE IF taxord == "aridisols" THEN
0.047*cec7_l + 0.535*ocl - 0.973*ph1tolh2o_h + 7.735 ELSE IF taxord == "ultisols" THEN
0.850*cec7_l + 0.361*ocl - 2.125*ph1tolh2o_h + 11.741 ELSE IF taxord == "inceptisols" THEN
0.496*cec7_l + 0.698*ocl - 5.010*ph1tolh2o_h + 31.299 ELSE IF taxord == "vertisols" THEN
0.061*cec7_l + 0.775*ocl - 3.557*ph1tolh2o_h + 26.936 ELSE IF taxord == "spodosols" THEN
1.226*cec7_l - 0.524*och - 3.429*ph1tolh2o_h + 20.975 ELSE IF taxord == "oxisols" THEN
0.499*cec7_l + 1.679*ocl - 2.055*ph1tolh2o_h + 16.422 ELSE IF taxord == "andisols" THEN
0.763*cec7_l - 4.328*ph1tolh2o_h + 28.591 ELSE 1/0 ELSE IF NOT ISNULL(ecec_l) THEN IF taxord
== "histosols" AND NOT ISNULL(taxord) AND (hzname matches "*O*" OR texture matches "*MPT*"
OR texture matches "*MUCK*" OR texture matches "*PEAT*") THEN 0.471*ocl -
20.556*ph01mcacl2_h + 142.732 ELSE IF (hzname matches "*O*" AND NOT ISNULL(hzname)) OR
((texture matches "*HPM*" OR texture matches "*MPM*" OR texture matches "*SPM*" OR texture
matches "*MPT*" OR texture matches "*MUCK*" OR texture matches "*PEAT*") AND NOT
ISNULL(texture)) THEN 1.03*ocl - 19.587*ph01mcacl2_h + 110.208 ELSE IF taxord == "histosols"
THEN 2.717*ocl + 9.247 ELSE IF taxord == "gelisols" THEN 0.965*ocl - 4.503*ph1tolh2o_h + 35.377
ELSE IF taxord == "entisols" THEN 0.147*claytotal_l + 2.7*ocl - 1.484*ph1tolh2o_h + 9.572 ELSE IF
taxord == "mollisols" THEN 0.148*claytotal_l + 1.692*ocl - 2.411*ph1tolh2o_h + 15.606 ELSE IF
taxord == "alfisols" THEN 0.188*claytotal_l + 2.353*ocl - 4.612*ph1tolh2o_h + 25.601 ELSE IF taxord
== "aridisols" THEN 0.033*claytotal_l + 2.392*ocl + 2.391*ph1tolh2o_l - 9.935 ELSE IF taxord ==
"ultisols" THEN 0.899*ecec_l + 0.111*claytotal_l + 2.438*ocl - 1.254*ph1tolh2o_h + 6.046 ELSE IF
taxord == "inceptisols" THEN 0.429*ecec_l + 0.078*claytotal_l + 3.052*ocl - 2.053*ph1tolh2o_h +
15.165 ELSE IF taxord == "vertisols" THEN 0.157*claytotal_l + 2.437*ocl - 2.949*ph1tolh2o_h +
15.531 ELSE IF taxord == "spodosols" THEN 1.581*ecec_l + 3.054*ocl + 6.68 ELSE IF taxord ==
"oxisols" THEN 0.342*ecec_l + 0.078*claytotal_l + 3.176*ocl + 3.932 ELSE IF taxord == "andisols"
THEN 0.879*ocl - 12.847*ph1tolh2o_h + 96.871 ELSE 1/0 ELSE 1/0.

```

```

ASSIGN acidl IF acidl < 0 AND NOT ISNULL(acidl) THEN 0 ELSE acidl.

```

```

#----Calculate high extractable acidity-----

```

```

DEFINE acidh IF NOT ISNULL(cec7_h) AND (ph1tolh2o_r >= 5.5 OR ph01mcacl2_r >= 5.5)
THEN IF (hzname matches "*O*" OR texture matches "*MPT*" OR texture matches "*MUCK*" OR
texture matches "*PEAT*" OR texture matches "*HPM*" OR texture matches "*MPM*" OR texture
matches "*SPM*") AND ph1tolh2o_r > 6.1 THEN 0.19*cec7_h - 11.411*ph1tolh2o_l + 78.341 ELSE
IF taxord == "histosols" AND NOT ISNULL(taxord) AND (hzname matches "*O*" OR texture matches
"*MPT*" OR texture matches "*MUCK*" OR texture matches "*PEAT*") THEN 0.289*cec7_h +
0.358*och - 26.390*ph01mcacl2_l + 149.662 ELSE IF (hzname matches "*O*" AND NOT
ISNULL(hzname)) OR ((texture matches "*HPM*" OR texture matches "*MPM*" OR texture matches
"*SPM*" OR texture matches "*MPT*" OR texture matches "*MUCK*" OR texture matches "*PEAT*")
AND NOT ISNULL(texture)) THEN 0.470*cec7_h + 0.298*och - 19.702*ph01mcacl2_l + 100.585
ELSE IF texture matches "*HYDR*" AND NOT ISNULL(texture) THEN -0.312*cec7_l + 3.726*och -
20.442*ph1tolh2o_l + 159.093 ELSE IF texture matches "*MEDL*" AND NOT ISNULL(texture)
THEN 0.564*cec7_h - 0.326*claytotal_l - 8.825*ph1tolh2o_l + 75.799 ELSE IF texture matches
"*ASHY*" AND NOT ISNULL(texture) THEN 0.134*cec7_h + 2.669*och - 1.972*ph1tolh2o_l +
14.051 ELSE IF taxord == "histosols" THEN 0.673*cec7_h - 7.659*ph1tolh2o_l + 44.466 ELSE IF
taxord == "gelisols" THEN 0.36*cec7_h - 4.301*ph1tolh2o_l + 31.87 ELSE IF taxord == "entisols"
THEN 0.148*cec7_h + 1.679*och - 1.791*ph1tolh2o_l + 12.254 ELSE IF taxord == "mollisols" THEN
0.112*cec7_h + 0.595*och - 2.745*ph1tolh2o_l + 19.964 ELSE IF taxord == "alfisols" THEN
0.205*cec7_h + 1.113*och - 2.928*ph1tolh2o_l + 19.545 ELSE IF taxord == "aridisols" THEN
0.047*cec7_h + 0.535*och - 0.973*ph1tolh2o_l + 7.735 ELSE IF taxord == "ultisols" THEN

```

```

0.850*cec7_h + 0.361*och - 2.125*ph1to1h2o_l + 11.741 ELSE IF taxord == "inceptisols" THEN
0.496*cec7_h + 0.698*och - 5.010*ph1to1h2o_l + 31.299 ELSE IF taxord == "vertisols" THEN
0.061*cec7_h + 0.775*och - 3.557*ph1to1h2o_l + 26.936 ELSE IF taxord == "spodosols" THEN
1.226*cec7_h - 0.524*ocl - 3.429*ph1to1h2o_l + 20.975 ELSE IF taxord == "oxisols" THEN
0.499*cec7_h + 1.679*och - 2.055*ph1to1h2o_l + 16.422 ELSE IF taxord == "andisols" THEN
0.763*cec7_h - 4.328*ph1to1h2o_l + 28.591 ELSE 1/0 ELSE IF NOT ISNULL(ecec_h) THEN IF
taxord == "histosols" AND NOT ISNULL(taxord) AND (hzname matches "*O*" OR texture matches
"*MPT*" OR texture matches "*MUCK*" OR texture matches "*PEAT*") THEN 0.471*och -
20.556*ph01mcac12_l + 142.732 ELSE IF (hzname matches "*O*" AND NOT ISNULL(hzname)) OR
((texture matches "*HPM*" OR texture matches "*MPM*" OR texture matches "*SPM*" OR texture
matches "*MPT*" OR texture matches "*MUCK*" OR texture matches "*PEAT*") AND NOT
ISNULL(texture)) THEN 1.03*och - 19.587*ph01mcac12_l + 110.208 ELSE IF taxord == "histosols"
THEN 2.717*och + 9.247 ELSE IF taxord == "gelisols" THEN 0.965*och - 4.503*ph1to1h2o_l + 35.377
ELSE IF taxord == "entisols" THEN 0.147*claytotal_h + 2.7*och - 1.484*ph1to1h2o_l + 9.572 ELSE IF
taxord == "mollisols" THEN 0.148*claytotal_h + 1.692*och - 2.411*ph1to1h2o_l + 15.606 ELSE IF
taxord == "alfisols" THEN 0.188*claytotal_h + 2.353*och - 4.612*ph1to1h2o_l + 25.601 ELSE IF taxord
== "aridisols" THEN 0.033*claytotal_h + 2.392*och + 2.391*ph1to1h2o_h - 9.935 ELSE IF taxord ==
"ultisols" THEN 0.899*ecec_h + 0.111*claytotal_h + 2.438*och - 1.254*ph1to1h2o_l + 6.046 ELSE IF
taxord == "inceptisols" THEN 0.429*ecec_h + 0.078*claytotal_h + 3.052*och - 2.053*ph1to1h2o_l +
15.165 ELSE IF taxord == "vertisols" THEN 0.157*claytotal_h + 2.437*och - 2.949*ph1to1h2o_l +
15.531 ELSE IF taxord == "spodosols" THEN 1.581*ecec_h + 3.054*och + 6.68 ELSE IF taxord ==
"oxisols" THEN 0.342*ecec_h + 0.078*claytotal_h + 3.176*och + 3.932 ELSE IF taxord == "andisols"
THEN 0.879*och - 12.847*ph1to1h2o_l + 96.871 ELSE 1/0 ELSE 1/0.

```

```

ASSIGN acidh IF acidh < 0 AND NOT ISNULL(acidh) THEN 0 ELSE acidh.

```

Calcareous soils have little or no acidity. A pH value of 8.2 approximates the pH of calcareous soils.

A check to make sure that zero extractable acidity is included in the acidity range when pH is >= 8.3

```

ASSIGN acidr IF ph1to1h2o_l >= 8.3 THEN 0 ELSE acidr.

```

```

ASSIGN acidl IF acidr == 0 THEN 0 ELSE acidl.

```

```

ASSIGN acidl IF ph1to1h2o_r >= 8.3 THEN 0 ELSE acidl.

```

618.102 NASIS Calculation for Estimating Liquid Limit and Plasticity Index

Definition.—This calculation computes the Atterberg Limits (liquid limit and plasticity index). The low, rv, and high are calculated.

The calculation works on all records (horizons) in your selected set that you have permission to edit, except as described in (7) below. For some horizons, such as bedrock or cemented layers, it may not be appropriate to calculate Atterberg limits. You may wish to tailor your selected set accordingly.

There is a companion report available to preview results of this calculation. The calculation script is imbedded in the report script. The report is designed to display your current stored LL and PI values alongside the calculated values. Viewing the results in this fashion might be useful in determining whether or not you wish to run the calculation on your selected set. The name of the Pangaea report is “UTIL - Comparison of LL and PI, stored vs calculated.”

Caution: These calculations for liquid limit and plasticity index may produce poor estimates for Andisols and Spodosols.

Inputs.—This calculation requires that the following data must be populated:

- organic matter percent (l,rv,h)
- linear extensibility percent
- (l,rv,h) clay total separate (l,rv,h)
- clay sized carbonate (l,rv,h)

Guidelines For Implementing Equations for LL and PI In NASIS

- 1) Values for LL and PI (low, high, and rv) are computed.
- 2) The calculations are based on the noncarbonate clay fraction.
- 3) If clay sized carbonate is null, then noncarbonate clay = total clay.
- 4) The water 15bar (volumetric) values from the database are not used. Instead water 15-bar value is estimated on a gravimetric basis using total clay and organic matter values.
- 5) If low and/or high values for LEP, clay sized carbonate, or OM are null, set to zero and proceed with estimate (reduced accuracy is < 1.5%).
- 6) If rv values for these input variables are null, compute as the average of low and high values $(L + H/2)$ and proceed with the calculation.
- 7) If OM > 25% or total clay is null, then LL and PI are not calculated.
- 8) The PI is estimated first, then LL.
- 9) If PI equals 0, LL rv and low values are set to 0 and the LL high value is set to 14.
- 10) If LL is < 15, then LL rv and low values are set to 0 and LL high value is set to 14.
- 11) Computed values for LL and PI are converted to nearest whole number.

Calculation.

Use zero if inputs are null (l).

```

DEFINE oml      IF ISNULL(om_l) THEN 0 ELSE om_l.
DEFINE lepl     IF ISNULL(lep_l) THEN 0 ELSE lep_l.
DEFINE claytotal  IF ISNULL(claytotal_l) THEN 0 ELSE claytotal_l.
DEFINE claysizedcarb1 IF ISNULL(claysizedcarb_l) THEN 0 ELSE claysizedcarb_l.
DEFINE ncclayl   claytotal - claysizedcarb1.

```

```

# Calculate the 15 bar water content (low) on a gravimetric basis.
# Assume ratio of 1500KPa to Clay percent is 0.4
DEFINE F INITIAL 0.4.
DEFINE wfifteenbarl (claytotal * (1 - oml/100) * F + oml).

# Calculate the low assuming all inputs are in range.
DEFINE pi_l -1.86 + 0.69*wfifteenbarl - 0.69*oml + 0.13*lepl + 0.47*ncclayl.
DEFINE ll_l 11.6 + 1.49*wfifteenbarl + 0.78*oml + 0.6*lepl + 0.26*ncclayl.

# Use zero if inputs are null (h).
DEFINE omh IF ISNULL(om_h) THEN 0 ELSE om_h.
DEFINE leph IF ISNULL(leph_h) THEN 0 ELSE leph_h.
DEFINE claytotalh IF ISNULL(claytotal_h) THEN 0 ELSE claytotal_h.
DEFINE claysizedcarbh IF ISNULL(claysizedcarb_h) THEN 0 ELSE claysizedcarb_h.
DEFINE ncclayh claytotalh - claysizedcarbh.

# Calculate the 15 bar water content (high) on a gravimetric basis.
# Assume ratio of 1500KPa to Clay percent is 0.4
# DEFINE F INITIAL 0.4 was done above.
DEFINE wfifteenbarh (claytotalh * (1 - omh/100) * F + omh).

# Calculate the high assuming all inputs are in range.
DEFINE pi_h -1.86 + 0.69*wfifteenbarh - 0.69*omh + 0.13*leph + 0.47*ncclayh.
DEFINE ll_h 11.6 + 1.49*wfifteenbarh + 0.78*omh + 0.6*leph + 0.26*ncclayh.

# Use (low + high)/2 if inputs are null (rv).
DEFINE om IF ISNULL(om_r) THEN (oml + omh)/2 ELSE om_r.
DEFINE lep IF ISNULL(lep_r) THEN (lepl + leph)/2 ELSE lep_r.
DEFINE claytotal IF ISNULL(claytotal_r) THEN (claytotall + claytotalh)/2 ELSE claytotal_r.
DEFINE claysizedcarb IF ISNULL(claysizedcarb_r) THEN (claysizedcarbl + claysizedcarbh)/2 ELSE
claysizedcarb_r.
DEFINE ncclay claytotal - claysizedcarb.

# Calculate the 15 bar water content (rv) on a gravimetric basis.
# Assume ratio of 1500KPa to Clay percent is 0.4
# DEFINE F INITIAL 0.4 was done above.
DEFINE wfifteenbar (claytotal * (1 - om/100) * F + om).

# Calculate the rv assuming all inputs are in range.
DEFINE pi_r -1.86 + 0.69*wfifteenbar - 0.69*om + 0.13*lep + 0.47*ncclay.
DEFINE ll_r 11.6 + 1.49*wfifteenbar + 0.78*om + 0.6*lep + 0.26*ncclay.

# Check for inputs out of range and set results to null.

ASSIGN pi_r IF ISNULL(claytotal_r) OR om > 25 OR ncclay < 0 THEN 1/0 ELSE pi_r.
ASSIGN ll_r IF ISNULL(claytotal_r) OR om > 25 OR ncclay < 0 THEN 1/0 ELSE ll_r.

```

```

ASSIGN pi_l  IF ISNULL(claytotal_l) OR oml > 25 OR ncclayl < 0 THEN 1/0 ELSE pi_l.
ASSIGN ll_l  IF ISNULL(claytotal_l) OR oml > 25 OR ncclayl < 0 THEN 1/0 ELSE ll_l.
ASSIGN pi_h  IF ISNULL(claytotal_h) OR omh > 25 OR ncclayh < 0 THEN 1/0 ELSE pi_h.
ASSIGN ll_h  IF ISNULL(claytotal_h) OR omh > 25 OR ncclayh < 0 THEN 1/0 ELSE ll_h.

```

If calculated PI is negative, set both PI and LL to zero.

```

ASSIGN pi_r  IF NOT ISNULL(pi_r) AND pi_r < 0 THEN 0 ELSE pi_r.
ASSIGN ll_r  IF ISNULL(pi_r) THEN 1/0 ELSE IF pi_r < 0.5 OR (NOT ISNULL(ll_r) AND ll_r < 15)
THEN 0 ELSE ll_r.
ASSIGN pi_l  IF NOT ISNULL(pi_l) AND pi_l < 0 THEN 0 ELSE pi_l.
ASSIGN ll_l  IF ISNULL(pi_l) THEN 1/0 ELSE IF pi_l < 0.5 OR (NOT ISNULL(ll_l) AND ll_l < 15)
THEN 0 ELSE ll_l.
ASSIGN pi_h  IF NOT ISNULL(pi_h) AND pi_h < 0 THEN 0 ELSE pi_h.
ASSIGN ll_h  IF ISNULL(pi_h) THEN 1/0 ELSE IF pi_h < 0.5 OR (NOT ISNULL(ll_h) AND ll_h <
15) THEN 14 ELSE ll_h.

```

#Set results to interger values.

```

ASSIGN pi_r  ROUND(pi_r).
ASSIGN ll_r  ROUND(ll_r).
ASSIGN pi_l  ROUND(pi_l).
ASSIGN ll_l  ROUND(ll_l).
ASSIGN pi_h  ROUND(pi_h).
ASSIGN ll_h  ROUND(ll_h).

```

618.103 NASIS Calculation for Estimating Particle Size

Definition.—This calculation computes representative values for the sand fractions, total sand, and total silt. The following rules apply:

- 1) The results will be blank if needed data are not entered. Total clay and texture are always required, and particle size class is required for textures CL, L, SCL, SICL, and SIL.
- 2) When a horizon has multiple textures, the one marked rv is used or the first texture is used if there is no rv. No results are calculated for stratified textures at this time.
- 3) If total sand (rv) has been entered, the sand fractions will be adjusted so their sum equals the specified total. If you want to calculate a new sand total, you must erase the old one before running the calculation.

Inputs.—This calculation requires that the following data must be populated:

texture
 clay total separate (l,rv,h)
 taxonomic particle-size
 class

Calculation.

```
ASSIGN texcl IF ISNULL(texcl) OR stratextsflag==1
      THEN "null" ELSE CODENAME(texcl).
```

```
DEFINE sandclass
```

```
  IF (texcl=="sl" or texcl=="cosl" or texcl=="fsl" or texcl=="vfsl") THEN
    IF ISNULL(sandtotal_r) THEN 1 ELSE
    IF sandtotal_r > 60 THEN 1 ELSE
    IF sandtotal_r >= 53 THEN 2 ELSE 3
  ELSE IF (texcl=="cl" or texcl=="l" or texcl=="scl" or texcl=="sicl" or
    texcl=="sil") THEN family_sandclass
  ELSE 0.
```

```
DEFINE paramid_by_tex LOOKUP(1, texcl==texture and
  (sandcode==0 or sandcode==sandclass),
  paramid).
```

```
DEFINE claypct_by_tex LOOKUP(1, texcl==texture and
  (sandcode==0 or sandcode==sandclass),
  claypct).
```

```
DEFINE claydiff_by_tex ABS(claypct_by_tex - claytotal_r).
```

```
DEFINE closest_clay ARRAYMIN(claydiff_by_tex).
```

```
DEFINE select_row ARRAYMIN(LOOKUP(closest_clay, claydiff_by_tex,
  paramid_by_tex)).
```

Get the equation number and coefficients from the selected parameter row.

```
DEFINE eqn lookup(select_row, paramid, equation).
```

```
DEFINE p1 lookup(select_row, paramid, param1).
```

```
DEFINE p2 lookup(select_row, paramid, param2).
```

```
DEFINE p3 lookup(select_row, paramid, param3).
```

```
DEFINE p4 lookup(select_row, paramid, param4).
```

```
DEFINE p5 lookup(select_row, paramid, param5).
```

```
# Compute all the distributions. We compute all 5 equations first then
# pick the right result, because this language doesn't have conditional
# execution.
# Start by computing some things that are used more than once.

DEFINE diamclay LOOKUP("clay", psclass, psdiam). # Upper clay diameter.
DEFINE cr2 POW(2, 1/3). # Cube root of 2.
DEFINE crdiam POW(psdiam, 1/3). # Cube root of psclass diameter.
DEFINE crdiamclay POW(diamclay, 1/3). # Cube root of clay diam.
DEFINE sqr2 SQRT(2). # Square root of 2.
DEFINE sqrdiam SQRT(psdiam). # Square root of psclass diameter.

DEFINE eq1tmp POW(1 + p4*POW(cr2-crdiam, p3), p2).
DEFINE eq2tmp EXP(p3 * POW(cr2-crdiam, p2)).
DEFINE eq3tmp EXP(1/POW(p4*cr2,p3) - 1/POW(p4*crdiam,p3)).
DEFINE eq4tmp p3*(POW(crdiam,2) - POW(cr2,2)) + p4*(psdiam-2) +
    p5*(POW(crdiam,4) - POW(cr2,4)).
DEFINE eq5tmp p3*(1/psdiam - 1/2) + p4*(sqrdiam - sqr2).

# Next adjust the parameters to make the clay come out the same as the input.

DEFINE tmp LOOKUP("clay", psclass, eq1tmp).
DEFINE eq1p1 (tmp * claytotal_r - 100) / (tmp - 1).

ASSIGN tmp LOOKUP("clay", psclass, eq2tmp).
DEFINE eq2p1 (tmp * claytotal_r - 100) / (tmp - 1).

ASSIGN tmp LOOKUP("clay", psclass, eq3tmp).
DEFINE eq3p2 (claytotal_r - 100 * tmp) / (1 - tmp).

ASSIGN tmp LOOKUP("clay", psclass, eq4tmp).
DEFINE eq4p2 (claytotal_r - 100 - tmp) / (crdiamclay - cr2).

ASSIGN tmp LOOKUP("clay", psclass, eq5tmp).
DEFINE eq5p2 (claytotal_r - 100 - tmp) / (diamclay - 2).

# Compute the five equations for all particle size classes.

DEFINE eq1 eq1p1 + (100-eq1p1) / eq1tmp.
DEFINE eq2 eq2p1 + (100-eq2p1) / eq2tmp.
DEFINE eq3 eq3p2 + (100-eq3p2) * eq3tmp.
DEFINE eq4 100 + eq4p2*(crdiam - cr2) + eq4tmp.
DEFINE eq5 100 + eq5p2*(psdiam - 2) + eq5tmp.

# Select the right equation. The variable psd will have 7 vaules, one
# for each particle size class. The value for each class is picked out
# of the array with a LOOKUP.

DEFINE psd IF eqn==1 THEN eq1 ELSE IF
    eqn==2 THEN eq2 ELSE
    IF eqn==3 THEN eq3 ELSE
    IF eqn==4 THEN eq4 ELSE
    IF eqn==5 THEN eq5 ELSE
    eq5/0. # sets psd to 7 nulls when texcl is null
```


Pick out the cumulative percents then compute the individual fractions.

```

DEFINE clay LOOKUP("clay", psclass, psd).
DEFINE silt LOOKUP("silt", psclass, psd).
DEFINE vfs LOOKUP("vfs", psclass, psd).
DEFINE fs LOOKUP("fs", psclass, psd).
DEFINE ms LOOKUP("ms", psclass, psd).
DEFINE cs LOOKUP("cos", psclass, psd).
DEFINE vcs LOOKUP("vcos", psclass, psd).

```

```

ASSIGN vcs vcs - cs.
ASSIGN cs cs - ms.
ASSIGN ms ms - fs.
ASSIGN fs fs - vfs.
ASSIGN vfs vfs - silt.
ASSIGN silt silt - clay.

```

```

DEFINE sand vfs + fs + ms + cs + vcs.

```

Find an adjustment factor for the sand fractions.
 # If total sand was given, adjust each sand fraction by the ratio needed to
 # make the sum equal to the given total.
 # If total sand was not given, verify that the sand and silt are within the
 # texture class limits and if not adjust them by the appropriate ratio.

```

DEFINE sand_diff IF ISNULL (sandtotal_r) THEN
  IF (texcl=="cos" or texcl=="s" or texcl=="fs" or texcl=="vfs")
    and ((clay + silt) > (15 - .5*clay))
  THEN (clay + silt) - (15 - .5*clay) ELSE
  IF (texcl=="lcos" or texcl=="ls" or texcl=="lfs" or texcl=="lvfs")
    and (clay + silt) > (30 - clay)
  THEN (clay + silt) - (30 - clay) ELSE
  IF texcl=="sil" and silt < 50
  THEN silt - 50 ELSE
  IF texcl=="sicl" and sand > 20
  THEN 20 - sand ELSE
  IF texcl=="sc" and sand < 45
  THEN 45 - sand ELSE
  IF texcl=="sic" and silt < 40
  THEN silt - 40 ELSE 0
ELSE
  sandtotal_r - sand.

```

```

DEFINE adj (sand + sand_diff) / sand.

```

Adjust the sands and silt by the adjustment factor.
 # Round to one decimal place before computing total sand to avoid roundoff error.

```

ASSIGN vfs ROUND(vfs * adj, 1).
ASSIGN fs ROUND(fs * adj, 1).
ASSIGN ms ROUND(ms * adj, 1).
ASSIGN cs ROUND(cs * adj, 1).

```

```

ASSIGN vcs ROUND(vcs * adj, 1).
ASSIGN sand vfs + fs + ms + cs + vcs.

# The rounding may result in a sum that does not equal the target sandtotal,
# so another adjustment has to be made.
# This time, apply it to the first non-zero fraction.

ASSIGN adj IF NOT ISNULL(sandtotal_r) THEN sandtotal_r - sand ELSE 0.

ASSIGN vcs IF vfs==0 AND fs==0 AND ms==0 AND cs==0 THEN vcs + adj ELSE vcs.
ASSIGN cs IF vfs==0 AND fs==0 AND ms==0 AND cs>0 THEN cs + adj ELSE cs.
ASSIGN ms IF vfs==0 AND fs==0 AND ms>0 THEN ms + adj ELSE ms.
ASSIGN fs IF vfs==0 AND fs>0 THEN fs + adj ELSE fs.
ASSIGN vfs IF vfs > 0 THEN vfs + adj ELSE vfs.
ASSIGN sand vfs + fs + ms + cs + vcs.

ASSIGN silt 100 - sand - clay.

# When vcos is < 0.
ASSIGN cs IF vcs < 0 AND vfs+fs+ms+cs > sand THEN cs - ((vfs+fs+ms+cs) - sand) ELSE cs.
ASSIGN vcs IF vcs < 0 THEN 0 ELSE vcs.

# Store the results as RV values for the horizon.

SET sandtotal_r from sand,
   sandvc_r from vcs,
   sandco_r from cs,
   sandmed_r from ms,
   sandfine_r from fs,
   sandvf_r from vfs,
   silttotal_r from silt.

```

618.104 NASIS Calculation for Estimating Rock Fragments and Percent Passing Sieves

Definition.—This calculation computes the percent soil material (< 3 inch basis) passing the #4 (4.7 mm), #10 (2.0 mm), #40 (0.42 mm), and #200 sieves (0.074 mm) and the percent rock fragments 3 to 10 inches and > 10 inches (whole soil basis).

1. Percent passing sieves are on a < 3-inch basis and rock fragments are a whole-soil basis.
2. The calculation of percent passing sieves and rock fragments excludes pararock fragments, wood, and noncemented fragments. Pararock fragments are defined by fragment hardness of extremely weakly, very weakly, weakly, or moderately cemented.
3. If fragment hardness is not populated, “indurated” is assumed.
4. If fragment kind is not populated, a fragment density of 2.65 g cm⁻³ is assumed.
5. Fragment density is assigned based on the fragment kind (table 2). If an average density for each fragment kind is not available, a default density of 2.65 g cm⁻³ is used.
6. If only low and high values are populated for fragment volume, fragment size, total sand, total silt, total clay, or sand separates, then rv’s are generated from the high and low values (takes the average).
7. The low and high values must be populated for fragment size, otherwise the calculation will produce incorrect or no results.
8. Low and high values for percent passing #40 and #200 sieves are based on the average low and high values for the particle-size separates.
9. If low and high values are not populated for total sand, total silt, or total clay or for the sand separates, then low and high values for the #40 and #200 sieves are generated from the low and high values of total clay. If high and low values for total clay are also null, then nulls are returned.
10. Low and high values for percent passing #4 and #10 sieves and the rock fragments are based on the low and high fragment volumes (in “Horizon Table,” if populated). If low and high fragment volumes (in “Horizon Table”) are not populated, then total low and high fragment volumes in the “Horizon Fragment Table” are used. If low and high fragment volumes in the “Horizon Fragment Table” are null, then nulls are returned.
11. **Caution:** If percent passing sieves are populated and only clay is populated (l, rv, h) in the particle-size separates, the calculation will wipe out the calculated values and put in null values. If there is not enough data to run the calculation, nulls are returned.
12. For stratified textures, if data is populated, the calculation proceeds as normal. If the particle-size separates are not populated, then the #40 and #200 sieves are not calculated (nulls are returned).
13. If the organic matter content > 35%, then percent passing sieves is not calculated and only rock fragments (3 to 10 in and >10 in) are calculated.
14. **Caution:** If 1/3-bar bulk density rv is not populated, null values for all sieves and rock fragments are returned.
15. The calculation rounds all sieve values to the nearest whole number.

Limitations

- 1) The pararock fragments are not included in the calculation because they can be crushed to < 2 mm. It is assumed that the pararock fragments, when crushed, will reflect the existing particle-size distribution. If there are pararock fragments that when crushed produce a different particle-size distribution, the calculation will over- or under-estimate the percent passing the #40 and #200 sieves.

- 2) When actually measuring percent passing sieves, the organic matter is not removed. The calculation of percent passing sieves calculates using organic matter free particle-size fractions. The calculation does not take into account the distribution of organic matter particles.
- 3) The fragment densities applied here are average values from the literature and may not represent the true density of fragments in your area. Fragment densities can be highly variable from location to location for a fragment kind.
- 4) If the total fragment volumes in the "Component Horizon Table" are not populated, then the low and high calculated values are based on the "Horizon Fragment Table" volumes and texture ranges in the NASIS database; these values may not reflect the actual percent passing sieves and rock fragment ranges. It is assumed that the total of the lows and the total of the highs in the "Horizon Fragment Table" equal the total high and low fragment volumes.
- 5) If the low and high calculated values are based on the total fragment volumes in the "Component Horizon Table" because actual fragment kind distributions (e.g., rock vs. pararock) that make up the fragment volume totals are not known, percent passing sieves and rock fragment may not reflect actual ranges. It computes representative values for the sand fractions, total sand and total silt. The following rules apply:
 - a. The results will be blank if needed data are not entered. Total clay and texture are always required, and particle size class is required for textures CL, L, SCL, SICL, and SIL.
 - b. When a horizon has multiple textures the one marked rv is used; the first texture is used if there is no rv. No results are calculated for stratified textures at this time.
 - c. If total sand (rv) has been entered, the sand fractions will be adjusted so their sum equals the specified total. If you want to calculate a new sand total you must erase the old one before running the calculation.

Inputs.—This calculation requires the following data to be populated:

fragment volume total (high, low) in "Horizon Table"
 fragment volume (high, low, and rv) in "Horizon Fragment Table"
 fragment kind in "Horizon Fragment Table"
 fragment size (high, low, and rv) in "Horizon Fragment Table"
 fragment hardness in "Horizon Fragment Table"
 total sand (high, low, and rv)
 total clay (high, low, and rv)
 total silt (high, low, and rv)
 very fine sand (high, low, and rv)
 fine sand (high, low, and rv)
 medium sand (high, low, and rv)
 coarse sand (high, low, and rv)
 very coarse sand (high, low, and rv)
 one-third bar bulk density (rv)
 organic matter (rv)

Calculation

```
DEFINE curvenum_l 0.56559. #run curve fitting routine
DEFINE curvenum_h 0.56559. #run curve fitting routine
DEFINE curvenum_r 0.56559. #run curve fitting routine
```

```
DEFINE densityrock
IF fragkind2 == "a`a lava" THEN 2.00
ELSE IF fragkind2 == "amphibolite" THEN 2.99
```

Title 430 – National Soil Survey Handbook

```

ELSE IF fragkind2 == "andesite" THEN 2.65
ELSE IF fragkind2 == "anorthosite" THEN 2.73
ELSE IF fragkind2 == "basalt" THEN 2.69
ELSE IF fragkind2 == "calcrete (caliche)" THEN 1.44
ELSE IF fragkind2 == "chalk" THEN 2.35
ELSE IF fragkind2 == "charcoal" THEN 0.45

ELSE IF fragkind2 == "chert" THEN 2.76
ELSE IF fragkind2 == "cinders" THEN 1.45
ELSE IF fragkind2 == "coal" THEN 1.6
ELSE IF fragkind2 == "dacite" THEN 1.67
ELSE IF fragkind2 == "diabase" THEN 2.92
ELSE IF fragkind2 == "diorite" THEN 2.83
ELSE IF fragkind2 == "dolomite (dolostone)" THEN 2.79
ELSE IF fragkind2 == "gabbro" THEN 2.99
ELSE IF fragkind2 == "gibbsite concretions" THEN 2.35
ELSE IF fragkind2 == "gneiss" THEN 2.79
ELSE IF fragkind2 == "granite" THEN 2.66
ELSE IF fragkind2 == "granodiorite" THEN 2.72
ELSE IF fragkind2 == "granulite" THEN 2.91
ELSE IF fragkind2 == "graywacke" THEN 2.69
ELSE IF fragkind2 == "gypsum, rock" THEN 2.55
ELSE IF fragkind2 == "ironstone concretions" THEN 2.93
ELSE IF fragkind2 == "limestone, unspecified" THEN 2.61
ELSE IF fragkind2 == "marble" THEN 2.74
ELSE IF fragkind2 == "monzonite" THEN 2.8
ELSE IF fragkind2 == "obsidian" THEN 2.37
ELSE IF fragkind2 == "orthoquartzite" THEN 2.41
ELSE IF fragkind2 == "peridotite" THEN 3.22
ELSE IF fragkind2 == "petroferric fragments" THEN 2.93
ELSE IF fragkind2 == "phyllite" THEN 2.74
ELSE IF fragkind2 == "pumice" THEN 0.98
ELSE IF fragkind2 == "pyroxenite" THEN 3.28
ELSE IF fragkind2 == "quartz-diorite" THEN 2.79
ELSE IF fragkind2 == "quartzite" THEN 2.7
ELSE IF fragkind2 == "rhyolite" THEN 2.51
ELSE IF fragkind2 == "sandstone, calcareous" THEN 2.03
ELSE IF fragkind2 == "sandstone, unspecified" THEN 2.29
ELSE IF fragkind2 == "schist, mica" THEN 2.76
ELSE IF fragkind2 == "schist, unspecified" THEN 2.84
ELSE IF fragkind2 == "serpentine" THEN 2.63
ELSE IF fragkind2 == "shale, calcareous" THEN 2.67
ELSE IF fragkind2 == "shale, clayey" THEN 2.78
ELSE IF fragkind2 == "shale, unspecified" THEN 2.6
ELSE IF fragkind2 == "slate" THEN 2.81
ELSE IF fragkind2 == "soapstone" THEN 2.7
ELSE IF fragkind2 == "syenite" THEN 2.74
ELSE IF fragkind2 == "tonalite" THEN 2.67
ELSE IF fragkind2 == "trachyte" THEN 2.57
ELSE IF fragkind2 == "tuff, unspecified" THEN 1.84
ELSE IF fragkind2 == "wood" THEN 0.6
ELSE 2.65.

```

#-----

Start of percent passing sieves and rock fragments calculation for RV.

#-----

Compute total volume percent of rock fragments, minus pararocks,
on a whole soil basis.

DEFINE fragvols IF (fraghard2=="strongly" or fraghard2=="very strongly" or
fraghard2=="indurated" or ISNULL(fraghard2)) AND fragkind2 != "wood"

THEN fragvlr ELSE 0.

DEFINE fragvolr ARRAYSUM(fragvols).

Compute percent volume of rock fragments that are < 75mm for each row
in the rock fragment table.

DEFINE rockfrag_row_r IF (75 >= fragsize_l and 75 <= fragsize_r)
THEN ((75-fragsize_l)/(fragsize_r-fragsize_l)/2*fragvlr)
ELSE IF (75 > fragsize_r and 75 <= fragsize_h)
THEN (((75-fragsize_r)/(fragsize_h-fragsize_r)/2)+0.5)*fragvlr
ELSE IF 75 > fragsize_h THEN fragvlr ELSE 0.

Compute total volume percent of rock fragments that are < 75mm on a
whole soil basis, minus pararocks.

DEFINE totalRFvol_s IF (fraghard2=="strongly" or fraghard2=="very strongly" or
fraghard2=="indurated" or ISNULL(fraghard2)) AND fragkind2 != "wood"
THEN rockfrag_row_r ELSE 0.

DEFINE totalRFvol_r ARRAYSUM(totalRFvol_s).

Compute volume percent of rock fragments that are < 75mm on a < 75mm basis.

DEFINE vol75mm_r totalRFvol_r/(1-(fragvolr-totalRFvol_r)/100).

Compute volume percent of rock fragments that are < 75mm
to a weight percent for each row in the rock fragment table.

DEFINE wtRF_row_r IF totalRFvol_r == 0 THEN 0 ELSE
(rockfrag_row_r/totalRFvol_r*vol75mm_r)*densityrock/(((vol75mm_r/100)*densityrock)+((1-
vol75mm_r/100)*dbthirdbar_r)).

Compute volume percent of rock fragments that are < 5mm to a weight percent for each row in the rock
fragment table.

DEFINE wtRF5mm_row_r IF 5>=fragsize_h THEN wtRF_row_r
ELSE IF (5>=fragsize_l and 5<=fragsize_r)
THEN (5-fragsize_l)/(fragsize_r-fragsize_l)/2*wtRF_row_r
ELSE IF (5>fragsize_r and 5<=fragsize_h)
THEN (((5-fragsize_r)/(fragsize_h-fragsize_r)/2)+0.5)*wtRF_row_r
ELSE 0.

Compute weight percent of rock fragments of the whole soil for each row.

DEFINE wtRFwhole_row_r fragvlr*densityrock/(((fragvlr/100)*densityrock)+((1-
fragvlr/100)*dbthirdbar_r)).

Compute weight percent of rock fragments > 75mm of the whole soil for each row.

```
DEFINE wtRFwhole75mm_row_s IF (75>=fragsize_l and 75<=fragsize_r)
THEN ((1-((75-fragsize_l)/(fragsize_r-fragsize_l)/2))*wtRFwhole_row_r)
ELSE IF (75>fragsize_r and 75<=fragsize_h)
THEN ((1-(((75-fragsize_r)/(fragsize_h-fragsize_r)/2)+0.5))*wtRFwhole_row_r)
ELSE IF 75>fragsize_h THEN 0 ELSE wtRFwhole_row_r.
```

Compute the percent weight of rock fragments > 75mm of whole soil, minus pararocks.

```
DEFINE wtRFwhole75mm_row_2 IF ISNULL(fragvlr) and ISNULL(fragvol_l) and
ISNULL(fragvol_h)
THEN 0 ELSE IF (fraghard2=="strongly" or fraghard2=="very strongly" or fraghard2=="indurated" or
ISNULL(fraghard2)) AND fragkind2 != "wood"
THEN wtRFwhole75mm_row_s ELSE 0.
```

```
DEFINE wtRFwhole75mm_r ARRAYSUM(wtRFwhole75mm_row_2).
```

Compute weight percent of rock fragments >250mm of whole soil for each row.

```
DEFINE wtRFwhole250mm_row_s IF (250>=fragsize_l and 250<=fragsize_r)
THEN ((1-((250-fragsize_l)/(fragsize_r-fragsize_l)/2))*wtRFwhole_row_r)
ELSE IF (250>fragsize_r and 250<=fragsize_h)
THEN ((1-(((250-fragsize_r)/(fragsize_h-fragsize_r)/2)+0.5))*wtRFwhole_row_r)
ELSE IF fragsize_l>=250 THEN wtRFwhole_row_r ELSE 0.
```

Compute the total weight percent of rock fragments >250mm of whole soil, minus pararocks.

```
DEFINE wtRFwhole250mm_row_2 IF ISNULL(fragvlr) and ISNULL(fragvol_l) and
ISNULL(fragvol_h)
THEN 0 ELSE IF (fraghard2=="strongly" or fraghard2=="very strongly" or fraghard2=="indurated" or
ISNULL(fraghard2)) AND fragkind2 != "wood"
THEN wtRFwhole250mm_row_s ELSE 0.
```

```
DEFINE rockfrag_250r ARRAYSUM(wtRFwhole250mm_row_2).
```

Compute total weight percent of rock fragments 75 to 250mm, minus pararocks.

```
DEFINE rockfrag_75r wtRFwhole75mm_r - rockfrag_250r.
```

Compute percent passing #10 sieve, minus pararocks.

```
DEFINE sieve_10s IF (fraghard2=="strongly" or fraghard2=="very strongly" or
fraghard2=="indurated" or ISNULL(fraghard2)) AND fragkind2 != "wood" THEN wtRF_row_r ELSE 0.
```

```
DEFINE sieve_10r IF ISNULL(ARRAYSUM(sieve_10s))
THEN 100 ELSE 100-ARRAYSUM(sieve_10s).
```

Compute percent passing #4 sieve, minus pararocks.

```
DEFINE sieve_4s    IF (fraghard2=="strongly" or fraghard2=="very strongly" or fraghard2=="indurated"
or ISNULL(fraghard2)) AND fragkind2 != "wood" THEN wtRF5mm_row_r ELSE 0.
```

```
DEFINE sieve_4r    IF ISNULL(ARRAYSUM(fragv1r)) THEN 100 ELSE
ARRAYSUM(sieve_4s)+sieve_10r.
```

Compute percent passing #40 sieve, minus pararocks.

```
DEFINE sieve_40r   IF ISNULL(ARRAYSUM(fragv1r)) THEN 100 - (vcos_r + cos_r + ms_r*0.2515)
ELSE sieve_10r/100*((0.7485*ms_r)+fs_r+vfs_r+siltr+clayr).
```

Compute percent passing #200 sieve, minus pararocks.

```
DEFINE sieve_200r  IF ISNULL(ARRAYSUM(fragv1r))
THEN IF vfs_r < 15 THEN (vfs_r*0.56559 + siltr + clayr)
ELSE (vfs_r*curvenum_r + siltr + clayr)
ELSE IF vfs_r < 15 THEN (vfs_r*0.56559 + siltr + clayr)*sieve_10r/100
ELSE (vfs_r*curvenum_r + siltr + clayr)*sieve_10r/100.
```

```
ASSIGN sieve_10r   IF om_r > 35 OR ISNULL(clayr) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE
sieve_10r.
```

```
ASSIGN sieve_4r    IF om_r > 35 OR ISNULL(clayr) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE
sieve_4r.
```

```
ASSIGN sieve_40r   IF om_r > 35 OR (stratextsflag == 1 AND (ISNULL(clayr) OR ISNULL(siltr) OR
ISNULL(vcos_r) OR ISNULL(cos_r) OR ISNULL(ms_r))) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE
sieve_40r.
```

```
ASSIGN sieve_200r  IF om_r > 35 OR (stratextsflag == 1 AND (ISNULL(clayr) OR ISNULL(siltr)
OR ISNULL(vfs_r))) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE sieve_200r.
```

```
ASSIGN rockfrag_250r IF om_r > 35 AND ISNULL(fragvolr) THEN 0 ELSE IF (ISNULL(clayr)
AND stratextsflag != 1) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE rockfrag_250r.
```

```
ASSIGN rockfrag_75r IF om_r > 35 AND ISNULL(fragvolr) THEN 0 ELSE IF (ISNULL(clayr)
AND stratextsflag != 1) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE rockfrag_75r.
```

```
#-----
# Start of percent passing sieves and rock fragments calculation of low values.
#-----
```

Compute total volume percent of rock fragments, minus pararocks,
on a whole soil basis.

```
DEFINE fragvolls IF (fraghard2=="strongly" or fraghard2=="very strongly" or fraghard2=="indurated"
or ISNULL(fraghard2)) AND fragkind2 != "wood" THEN fragvol_1 ELSE 0.
DEFINE fragvoll  ARRAYSUM(fragvolls).
```

Uses the low fragment volume total from the Horizon Table.
DEFINE sumlowfrags ARRAYSUM(fragvol_1).


```

ASSIGN fragvoll IF (fragvoll / sumlowfrags) < 1 AND fragvoll != 0 AND NOT
ISNULL(sumlowfrags) AND sumlowfrags > 0 THEN (fragvoll / sumlowfrags) * fragvoltot_1 ELSE IF
ISNULL(fragvoltot_1) THEN fragvoll ELSE fragvoltot_1.

```

```

# Compute volume percent of rock fragments that are < 75mm for each row
# in the rock fragment table.

```

```

DEFINE rockfrag_row_1 IF (75 >= fragsize_1 and 75 <= fragsize_r)
THEN ((75-fragsize_1)/(fragsize_r-fragsize_1)/2*fragvol_1)
ELSE IF (75 > fragsize_r and 75 <= fragsize_h)
THEN (((75-fragsize_r)/(fragsize_h-fragsize_r)/2)+0.5)*fragvol_1
ELSE IF 75 > fragsize_h THEN fragvol_1 ELSE 0.

```

```

# Compute total volume percent of rock fragments that are < 75mm on a
# whole soil basis, minus pararocks.

```

```

DEFINE totalRFvol_ls IF (fraghard2=="strongly" or fraghard2=="very strongly" or
fraghard2=="indurated" or ISNULL(fraghard2)) AND fragkind2 != "wood" THEN rockfrag_row_1
ELSE 0.

```

```

DEFINE totalRFvol_1 ARRAYSUM(totalRFvol_ls).

```

```

# Compute volume percent of rock fragments that are < 75mm on a < 75mm basis.

```

```

DEFINE vol75mm_1 totalRFvol_1/(1-(fragvoll-totalRFvol_1)/100).

```

```

# Compute volume percent of rock fragments that are < 75mm
# to a weight percent for each row in the rock fragment table.

```

```

DEFINE wtRF_row_1 IF totalRFvol_1 == 0 THEN 0 ELSE (rockfrag_row_1/totalRFvol_1*vol75mm_1)
* densityrock/(((vol75mm_1/100)*densityrock)+((1-vol75mm_1/100)*dbthirdbar_r)).

```

```

# Compute volume percent of rock fragments that are < 5mm
# to a weight percent for each row in the rock fragment table.

```

```

DEFINE wtRF5mm_row_1 IF 5>=fragsize_h THEN wtRF_row_1
ELSE IF (5>=fragsize_1 and 5<=fragsize_r)
THEN (5-fragsize_1)/(fragsize_r-fragsize_1)/2*wtRF_row_1
ELSE IF (5>fragsize_r and 5<=fragsize_h)
THEN (((5-fragsize_r)/(fragsize_h-fragsize_r)/2)+0.5)*wtRF_row_1
ELSE 0.

```

```

# Compute weight percent of rock fragments of whole soil for each row.

```

```

DEFINE wtRFwhole_row_1 fragvol_1*densityrock/(((fragvol_1/100)*densityrock)+((1-fragvol_1/100)
* dbthirdbar_r)).

```

```

# Compute weight percent of rock fragments > 75mm of whole soil, minus pararocks.

```

```

DEFINE wtRFwhole75mm_row_ls IF (75>=fragsize_1 and 75<=fragsize_r)
THEN ((1-((75-fragsize_1)/(fragsize_r-fragsize_1)/2))*wtRFwhole_row_1)

```

```

ELSE IF (75>fragsize_r and 75<=fragsize_h)
THEN ((1-(((75-fragsize_r)/(fragsize_h-fragsize_r)/2)+0.5))*wtRFwhole_row_l)
ELSE IF 75>fragsize_h THEN 0 ELSE wtRFwhole_row_l.

DEFINE wtRFwhole75mm_row_l IF ISNULL(fragvlr) and ISNULL(fragvol_l) and ISNULL(fragvol_h)
THEN 0 ELSE IF (fraghard2=="strongly" OR fraghard2=="very strongly" or fraghard2=="indurated" or
ISNULL(fraghard2)) AND fragkind2 != "wood" THEN wtRFwhole75mm_row_ls ELSE 0.

DEFINE wtRFwhole75mm_l    ARRAYSUM(wtRFwhole75mm_row_l).

# Compute weight percent of rock fragments > 250mm of whole soil, minus pararocks.

DEFINE wtRFwhole250mm_row_j IF (250>=fragsize_l and 250<=fragsize_r) THEN ((1-((250-
fragsize_l)/(fragsize_r-fragsize_l)/2))*wtRFwhole_row_l) ELSE IF (250>fragsize_r and
250<=fragsize_h) THEN ((1-(((250-fragsize_r)/(fragsize_h-fragsize_r)/2)+0.5))*wtRFwhole_row_l)
ELSE IF fragsize_l>=250 THEN wtRFwhole_row_l ELSE 0.

DEFINE wtRFwhole250mm_row_l IF ISNULL(fragvlr) and ISNULL(fragvol_l) and
ISNULL(fragvol_h)
THEN 0 ELSE IF (fraghard2=="strongly" or fraghard2=="very strongly" or fraghard2=="indurated" or
ISNULL(fraghard2)) AND fragkind2 != "wood" THEN wtRFwhole250mm_row_j ELSE 0.

DEFINE rockfrag_250l    ARRAYSUM(wtRFwhole250mm_row_l).

# Compute weight percent of rock fragments that are 75 to 250mm, minus pararocks.

DEFINE rockfrag_75l      wtRFwhole75mm_l - rockfrag_250l.

#-----
# Start of percent passing sieves and rock fragments calculation for high values.
#-----
# Compute total volume percent of rock fragments, minus pararocks,
# on a whole soil basis.

DEFINE fragvolhs IF (fraghard2=="strongly" or fraghard2=="very strongly" or fraghard2=="indurated"
or ISNULL(fraghard2)) AND fragkind2 != "wood" THEN fragvol_h ELSE 0.

DEFINE fragvolh    ARRAYSUM(fragvolhs).
ASSIGN fragvolh    IF fragvolh > 90 THEN 90 ELSE fragvolh. #Assumes there is at least 10% soil (<
2mm) at the high fragment condition.

# Uses the high fragment volume total from the Horizon Table.
DEFINE sumhighfrags    ARRAYSUM(fragvol_h).
ASSIGN fragvolh    IF (fragvolh / sumhighfrags) < 1 AND fragvolh < fragvoltot_h AND fragvolh != 0
AND NOT ISNULL(sumhighfrags) AND sumhighfrags > 0 THEN (fragvolh / sumhighfrags) *
fragvoltot_h ELSE IF ISNULL(fragvoltot_h) THEN fragvolh ELSE fragvoltot_h.

# Compute volume percent of rock fragments that are < 75mm for each row
# in the fragment table.

DEFINE rockfrag_row_h    IF (75 >= fragsize_l and 75 <= fragsize_r) THEN ((75-
fragsize_l)/(fragsize_r-fragsize_l)/2*fragvol_h) ELSE IF (75 > fragsize_r and 75 <= fragsize_h) THEN

```

```
((75-fragsize_r)/(fragsize_h-fragsize_r/2)+0.5)*fragvol_h ELSE IF 75 > fragsize_h THEN fragvol_h
ELSE 0.
```

```
# Compute total volume % of rock fragments that are < 75mm on a
# whole soil basis, minus pararocks.
```

```
DEFINE totalRFvol_hs IF (fraghard2=="strongly" or fraghard2=="very strongly" or fraghard2 ==
"indurated" or ISNULL(fraghard2)) AND fragkind2 != "wood" THEN rockfrag_row_h ELSE 0.
```

```
DEFINE totalRFvol_h ARRAYSUM(totalRFvol_hs).
```

```
# Compute volume percent of rock fragments that are < 75mm on a < 75mm basis.
```

```
DEFINE vol75mm_h totalRFvol_h/(1-(fragvolh-totalRFvol_h)/100).
```

```
# Compute volume percent of rock fragments that are < 75mm
# to a weight percent for each row in the fragment table.
```

```
DEFINE wtRF_row_h IF totalRFvol_h == 0 THEN 0 ELSE (rockfrag_row_h/totalRFvol_h
*vol75mm_h)*densityrock/ (((vol75mm_h/100)*densityrock)+((1-vol75mm_h/100)*dbthirdbar_r)).
```

```
# Compute volume percent of rock fragments that are < 5mm to a weight percent for each row in the
fragment table.
```

```
DEFINE wtRF5mm_row_h IF 5>=fragsize_h THEN wtRF_row_h ELSE IF (5>=fragsize_l and
5<=fragsize_r) THEN (5-fragsize_l)/(fragsize_r-fragsize_l/2)*wtRF_row_h ELSE IF (5>fragsize_r and
5<=fragsize_h) THEN (((5-fragsize_r)/(fragsize_h-fragsize_r/2)+0.5)*wtRF_row_h ELSE 0.
```

```
# Compute weight percent of rock fragments of whole soil for each row.
```

```
DEFINE wtRFwhole_row_h fragvol_h*densityrock/(((fragvol_h/100)*densityrock)+ ((1-
fragvol_h/100)*dbthirdbar_r)).
```

```
# Compute weight percent of rock fragments > 75mm of whole soil, minus pararocks.
```

```
DEFINE wtRFwhole75mm_row_k IF (75>=fragsize_l and 75<=fragsize_r) THEN ((1-((75-
fragsize_l)/(fragsize_r-fragsize_l/2))*wtRFwhole_row_h) ELSE IF (75>fragsize_r and 75<=fragsize_h)
THEN ((1-(((75-fragsize_r)/(fragsize_h-fragsize_r/2)+0.5))*wtRFwhole_row_h)
ELSE IF 75>fragsize_h THEN 0 ELSE wtRFwhole_row_h.
```

```
DEFINE wtRFwhole75mm_row_h IF ISNULL(fragvlr) and ISNULL(fragvol_l) and
ISNULL(fragvol_h)
THEN 0 ELSE IF (fraghard2=="strongly" or fraghard2=="very strongly" or fraghard2=="indurated" or
ISNULL(fraghard2)) AND fragkind2 != "wood" THEN wtRFwhole75mm_row_k ELSE 0.
```

```
DEFINE wtRFwhole75mm_h ARRAYSUM(wtRFwhole75mm_row_h).
```

```
# Compute weight percent of rock fragments > 250mm of the whole soil, minus pararocks.
```

```
DEFINE wtRFwhole250mm_row_k IF (250>=fragsize_l and 250<=fragsize_r) THEN ((1-((250-
fragsize_l)/(fragsize_r-fragsize_l/2))*wtRFwhole_row_h) ELSE IF (250>fragsize_r and
```

```
250<=fragsize_h) THEN ((1-(((250-fragsize_r)/(fragsize_h-fragsize_r)/2)+0.5))*wtRFwhole_row_h)
ELSE IF fragsize_l>=250 THEN wtRFwhole_row_h ELSE 0.
```

```
DEFINE wtRFwhole250mm_row_h IF ISNULL(fragvlr) and ISNULL(fragvol_l) and
ISNULL(fragvol_h)
THEN 0 ELSE IF (fraghard2=="strongly" or fraghard2=="very strongly" or fraghard2=="indurated" or
ISNULL(fraghard2)) AND fragkind2 != "wood" THEN wtRFwhole250mm_row_k ELSE 0.
```

```
DEFINE rockfrag_250h ARRAYSUM(wtRFwhole250mm_row_h).
```

Compute weight percent of rock fragments that are 75 to 250mm, minus pararocks.

```
DEFINE rockfrag_75h wtRFwhole75mm_h-rockfrag_250h.
```

Compute percent passing #10 sieve, minus pararocks.

```
DEFINE sieve_10hs IF (fraghard2=="strongly" or fraghard2=="very strongly" or
fraghard2=="indurated" or ISNULL(fraghard2)) AND fragkind2 != "wood" THEN wtRF_row_l ELSE 0.
```

```
DEFINE sieve_10h IF ISNULL(ARRAYSUM(fragvlr)) THEN 100 ELSE 100-
RRAYSUM(sieve_10hs).
```

Compute percent passing #4 sieve (minus pararocks).

```
DEFINE sieve_4hs IF (fraghard2=="strongly" or fraghard2=="very strongly" or
fraghard2=="indurated" or ISNULL(fraghard2)) AND fragkind2 != "wood" THEN wtRF5mm_row_l
ELSE 0.
```

```
DEFINE sieve_4h IF ISNULL(ARRAYSUM(fragvlr)) THEN 100 ELSE
ARRAYSUM(sieve_4hs)+sieve_10h.
```

Compute percent passing #40 sieve (minus pararocks).

```
DEFINE sieve_40h IF ISNULL(ARRAYSUM(fragvlr)) AND (ISNULL(ms_h) OR ISNULL(fs_h) OR
ISNULL(vfs_h) OR ISNULL(silth)) THEN (((0.7485*ms_r)+fs_r+vfs_r+siltr+clayr)+(clayh-clayr))
ELSE IF NOT ISNULL(ARRAYSUM(fragvlr)) and NOT ISNULL(ARRAYSUM(fragvol_l)) and NOT
ISNULL(ARRAYSUM(fragvol_h)) AND (ISNULL(ms_h) OR ISNULL(fs_h) OR ISNULL(vfs_h) OR
ISNULL(silth)) THEN sieve_10h/100*(((0.7485*ms_r)+fs_r+vfs_r+siltr+clayr)+(clayh-clayr)) ELSE
ISNULL(ARRAYSUM(fragvlr)) THEN (((0.7485*ms_r)+fs_r+vfs_r+siltr+clayr)+(((ms_h-ms_r)+(fs_h-
fs_r)+(vfs_h-vfs_r)+(silth-siltr)+(clayh-clayr))/5)) ELSE sieve_10h/100 *(((0.7485*ms_r)
+fs_r+vfs_r+siltr+clayr) + (((ms_h-ms_r)+(fs_h-fs_r)+(vfs_h-vfs_r)+(silth-siltr)+(clayh-clayr))/5)).
```

Compute percent passing #200 sieve (minus pararocks).

```
DEFINE sieve_200h IF ISNULL(ARRAYSUM(fragvlr)) AND (ISNULL(vfs_h) OR ISNULL(silth))
THEN (((vfs_r*0.56559)+siltr+clayr)+(clayh-clayr)) ELSE IF NOT ISNULL(ARRAYSUM(fragvlr))
and NOT ISNULL(ARRAYSUM(fragvol_l)) and NOT ISNULL(ARRAYSUM(fragvol_h)) AND
(ISNULL(vfs_h) OR ISNULL(silth)) THEN sieve_10h/100*(((vfs_r*0.56559)+siltr+clayr)+(clayh-
clayr))
ELSE ISNULL(ARRAYSUM(fragvlr)) THEN IF (vfs_r) < 15 THEN (((vfs_r*0.56559)+
siltr+clayr)+(((vfs_h-vfs_r)+(silth-siltr)+(clayh-clayr))/3)) ELSE
```

```
((vfs_r*curvenum_h)+siltr+clayr)+(((vfs_h-vfs_r)+(silth-siltr)+(clayh-clayr))/3)) ELSE IF vfs_r < 15
THEN sieve_10h/100*(((vfs_r*0.56559)+siltr+clayr)+(((vfs_h-vfs_r)+(silth-siltr)+(clayh-clayr))/3))
ELSE sieve_10h/100*(((vfs_r*curvenum_h)+siltr+clayr)+(((vfs_h-vfs_r)+(silth-siltr)+(clayh-clayr))/3)).
```

```
ASSIGN sieve_10h IF om_r > 35 OR ISNULL(clayr) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE
sieve_10h.
```

```
ASSIGN sieve_4h IF om_r > 35 OR ISNULL(clayr) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE
sieve_4h.
```

```
ASSIGN sieve_40h IF om_r > 35 OR (stratextsflag == 1 AND (ISNULL(clayr) OR ISNULL(siltr) OR
ISNULL(vcos_r) OR ISNULL(cos_r) OR ISNULL(ms_r))) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE
sieve_40h.
```

```
ASSIGN sieve_200h IF om_r > 35 OR (stratextsflag == 1 AND (ISNULL(clayr) OR ISNULL(siltr)
OR ISNULL(vfs_r))) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE sieve_200h.
```

```
ASSIGN rockfrag_250h IF om_r > 35 AND ISNULL(ARRAYSUM(fragvolh)) THEN 0 ELSE IF
(ISNULL(clayr) AND stratextsflag != 1) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE rockfrag_250h.
```

```
ASSIGN rockfrag_75h IF om_r > 35 AND ISNULL(ARRAYSUM(fragvolh)) THEN 0 ELSE IF
(ISNULL(clayr) AND stratextsflag != 1) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE rockfrag_75h.
```

```
#-----
# Rest of calculation for low values.
#-----
```

```
# Compute percent passing #10 sieve (minus pararocks).
```

```
DEFINE sieve_10ls IF (fraghard2=="strongly" or fraghard2=="very strongly" or fraghard2=="indurated"
or ISNULL(fraghard2)) AND fragkind2 != "wood" THEN wtRF_row_h ELSE 0.
```

```
DEFINE sieve_10l IF ISNULL(ARRAYSUM(fragvlr)) THEN 100 ELSE 100-
ARRAYSUM(sieve_10ls).
```

```
# Compute percent passing #4 sieve (minus pararocks).
```

```
DEFINE sieve_4ls IF (fraghard2=="strongly" or fraghard2=="very strongly" or
fraghard2=="indurated" or ISNULL(fraghard2)) AND fragkind2 != "wood" THEN wtRF5mm_row_h
ELSE 0.
```

```
DEFINE sieve_4l IF ISNULL(ARRAYSUM(fragvlr)) THEN 100 ELSE ARRAYSUM(sieve_4ls) +
sieve_10l.
```

```
# Compute percent passing #40 sieve (minus pararocks).
```

```
DEFINE sieve_40l IF ISNULL(ARRAYSUM(fragvlr)) AND (ISNULL(ms_l) OR ISNULL(fs_l) OR
ISNULL(vfs_l) OR ISNULL(siltl)) THEN (((0.7485*ms_r)+fs_r+vfs_r+siltr+clayr)-(clayr-clayl)) ELSE
IF NOT ISNULL(ARRAYSUM(fragvlr)) and NOT ISNULL(ARRAYSUM(fragvol_l)) and NOT
ISNULL(ARRAYSUM(fragvol_h)) AND (ISNULL(ms_l) OR ISNULL(fs_l) OR ISNULL(vfs_l) OR
ISNULL(siltl)) THEN sieve_10l/100*(((0.7485*ms_r)+fs_r+vfs_r+siltr+clayr)-(clayr-clayl)) ELSE
ISNULL(ARRAYSUM(fragvlr)) THEN (((0.7485*ms_r)+fs_r+vfs_r+siltr+clayr)-(((ms_r-ms_l)+(fs_r-
fs_l)+(vfs_r-vfs_l)+(siltr-siltl)+(clayr-clayl))/5)) ELSE sieve_10l/100
```

Title 430 – National Soil Survey Handbook

$$*(((0.7485*ms_r)+fs_r+vfs_r+siltr+clayr) - (((ms_r-ms_l)+(fs_r-fs_l)+(vfs_r-vfs_l)+(siltr-siltl)+(clayr-clayl))/5)).$$

Compute percent passing #200 sieve (minus pararocks).

```
DEFINE sieve_200l    IF ISNULL(ARRAYSUM(fragvlr)) AND (ISNULL(vfs_l) OR ISNULL(siltl))
THEN (((vfs_r*0.56559)+siltr+clayr)-(clayr-clayl)) ELSE IF NOT ISNULL(ARRAYSUM(fragvlr)) and
NOT ISNULL(ARRAYSUM(fragvol_l)) and NOT ISNULL(ARRAYSUM(fragvol_h)) AND
(ISNULL(vfs_l) OR ISNULL(siltl)) THEN sieve_10l/100*(((vfs_r*0.56559)+siltr+clayr)-(clayr-clayl))
ELSE ISNULL(ARRAYSUM(fragvlr)) THEN IF (vfs_r) < 15 THEN (((vfs_r*0.56559)+siltr+clayr)-
(((vfs_r-vfs_l)+(siltr-siltl)+(clayr-clayl))/3)) ELSE (((vfs_r*curvenum_l)+siltr+clayr)-(((vfs_r-vfs_l)+
(siltr-siltl)+(clayr-clayl))/3)) ELSE IF vfs_r < 15 THEN sieve_10l/100*(((vfs_r*0.56559)+siltr+clayr)-
(((vfs_r-vfs_l)+(siltr-siltl)+(clayr-clayl))/3)) ELSE sieve_10l/100*(((vfs_r*curvenum_l)+siltr+clayr)-
(((vfs_r-vfs_l)+(siltr-siltl)+(clayr-clayl))/3)).
```

```
ASSIGN sieve_10l    IF om_r > 35 OR ISNULL(clayr) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE
sieve_10l.
```

```
ASSIGN sieve_4l     IF om_r > 35 OR ISNULL(clayr) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE
sieve_4l.
```

```
ASSIGN sieve_40l    IF om_r > 35 OR (stratextsflag == 1 AND (ISNULL(clayr) OR ISNULL(silr) OR
ISNULL(vcos_r) OR ISNULL(cos_r) OR ISNULL(ms_r))) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE
sieve_40l.
```

```
ASSIGN sieve_200l   IF om_r > 35 OR (stratextsflag == 1 AND (ISNULL(clayr) OR ISNULL(silr)
OR ISNULL(vfs_r))) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE sieve_200l.
```

```
ASSIGN rockfrag_250l IF om_r > 35 AND ISNULL(ARRAYSUM(fragvoll)) THEN 0 ELSE IF
(ISNULL(clayr) AND stratextsflag != 1) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE rockfrag_250l.
```

```
ASSIGN rockfrag_75l IF om_r > 35 AND ISNULL(ARRAYSUM(fragvoll)) THEN 0 ELSE IF
(ISNULL(clayr) AND stratextsflag != 1) OR ISNULL(dbthirdbar_r) THEN 1/0 ELSE rockfrag_75l.
```

#-----

Checks for high values that are lower than the low values and vise versa for rock fragments.
This occurs when the fragvol_l and fragvol_h are not different from fragvol_r.

```
ASSIGN rockfrag_250l IF rockfrag_250l > rockfrag_250h THEN rockfrag_250h ELSE IF
rockfrag_250l > rockfrag_250r THEN rockfrag_250r ELSE rockfrag_250l.
```

```
ASSIGN rockfrag_250h IF rockfrag_250h < rockfrag_250l THEN rockfrag_250l ELSE IF
rockfrag_250h < rockfrag_250r THEN rockfrag_250r ELSE rockfrag_250h.
```

```
ASSIGN rockfrag_75l IF rockfrag_75l > rockfrag_75h THEN rockfrag_75h ELSE IF rockfrag_75l >
rockfrag_75r THEN rockfrag_75r ELSE rockfrag_75l.
```

```
ASSIGN rockfrag_75h IF rockfrag_75h < rockfrag_75l THEN rockfrag_75l ELSE IF rockfrag_75h <
rockfrag_75r THEN rockfrag_75r ELSE rockfrag_75h.
```

#-----

Checks that low values are not < 0 and high values are not > 100,
and rounds to whole numbers.

```
ASSIGN sieve_10l    IF NOT ISNULL(sieve_10l) AND sieve_10l < 0 THEN 0 ELSE
```

Title 430 – National Soil Survey Handbook

```
ROUND(sieve_10l,0).
ASSIGN sieve_4l    IF NOT ISNULL(sieve_4l) AND sieve_4l < 0 THEN 0 ELSE
ROUND(sieve_4l,0).
ASSIGN sieve_40l   IF NOT ISNULL(sieve_40l) AND sieve_40l < 0 THEN 0 ELSE
ROUND(sieve_40l,0).
ASSIGN sieve_200l  IF NOT ISNULL(sieve_200l) AND sieve_200l < 0 THEN 0 ELSE
ROUND(sieve_200l,0).
ASSIGN rockfrag_250l IF NOT ISNULL(rockfrag_250l) AND rockfrag_250l < 0 THEN 0 ELSE
rockfrag_250l.
ASSIGN rockfrag_75l  IF NOT ISNULL(rockfrag_75l) AND rockfrag_75l < 0 THEN 0 ELSE
rockfrag_75l.
```

```
ASSIGN sieve_10r  ROUND(sieve_10r,0).
ASSIGN sieve_4r   ROUND(sieve_4r,0).
ASSIGN sieve_40r  ROUND(sieve_40r,0).
ASSIGN sieve_200r ROUND(sieve_200r,0).
```

```
ASSIGN sieve_10h  IF NOT ISNULL(sieve_10h) AND sieve_10h > 100 THEN 100 ELSE
ROUND(sieve_10h,0).
ASSIGN sieve_4h   IF NOT ISNULL(sieve_4h) AND sieve_4h > 100 THEN 100 ELSE
ROUND(sieve_4h,0).
ASSIGN sieve_40h  IF NOT ISNULL(sieve_40h) AND sieve_40h > 100 THEN 100 ELSE
ROUND(sieve_40h,0).
ASSIGN sieve_200h IF NOT ISNULL(sieve_200h) AND sieve_200h > 100 THEN 100 ELSE
ROUND(sieve_200h,0).
ASSIGN rockfrag_250h IF NOT ISNULL(rockfrag_250h) AND rockfrag_250h > 100 THEN 100 ELSE
rockfrag_250h.
ASSIGN rockfrag_75h  IF NOT ISNULL(rockfrag_75h) AND rockfrag_75h > 100 THEN 100 ELSE
rockfrag_75h.
```

```
#-----
# Rounding errors (rounds to 1 instead of zero, when < 0.5)
```

```
ASSIGN rockfrag_250h  IF NOT ISNULL(rockfrag_250h) AND rockfrag_250h > 0.05 and
rockfrag_250h < 1 THEN 1 ELSE rockfrag_250h.
ASSIGN rockfrag_75h   IF NOT ISNULL(rockfrag_75h) AND rockfrag_75h > 0.05 and rockfrag_75h
< 1 THEN 1 ELSE rockfrag_75h.
```

```
#-----
assign sieve_10l  sieve_10l > sieve_4l ? sieve_4l : sieve_10l.
assign sieve_40l  sieve_40l > sieve_10l ? sieve_10l : sieve_40l.
assign sieve_200l sieve_200l > sieve_40l ? sieve_40l : sieve_200l.

assign sieve_10h  sieve_10h > sieve_4h ? sieve_4h : sieve_10h.
assign sieve_40h  sieve_40h > sieve_10h ? sieve_10h : sieve_40h.
assign sieve_200h sieve_200h > sieve_40h ? sieve_40h : sieve_200h.

assign sieve_10r  sieve_10r > sieve_4r ? sieve_4r : sieve_10r.
assign sieve_40r  sieve_40r > sieve_10r ? sieve_10r : sieve_40r.

assign sieve_200r sieve_200r > sieve_40r ? sieve_40r : sieve_200r.
```

618.105 NASIS Calculation for Estimating Water Content Data

Definition.—This calculation computes the low, representative, and high values for water_one-tenth_bar (0.1 bar H₂O), water_one-third_bar (0.33 bar H₂O), water_15_bar (15 bar H₂O), water_satiated (Satiated H₂O), and bulk_density_oven_dry (Db oven dry).

Inputs.—This calculation requires the following data to be populated:

organic_matter_percent (OM) l,rv,h
 rock_frag_greater_than_10_in (Rock >10) l,rv,h
 rock_frag_3_to_10_in (Rock 3-10) l,rv,h
 sieve_number_10 (#10) l,rv,h
 bulk_density_one_third_bar (Db 0.33 bar H₂O) l,rv,h
 or bulk_density_one_tenth_bar (Db 0.1 bar H₂O) l,rv,h
 clay_total_separate (Total Clay) l,rv,h
 linear_extensibility_percent (LEP) l,rv,h
 texture_class (Texture) or
 texture_modifier_and_class (Tex Mod & Class)*

Limitations.—This calculation computes water contents for organic and mineral layers.

- If no entry is found for rock elements, it is assumed to be zero.
- Missing data in other elements may result in no output.
- Calculation uses texture_class if populated, if not use texture_modifier_and_class; however, calculation does not work if texture_modifier_and_class contain SR or modifiers.
- Calculation uses the texture group marked as rv for each horizon and the first texture sequence number within that texture group. If no texture group is marked rv or no sequence number is used, one texture will be selected at random.

Calculation.

```
DEFINE lieutex1 CODENAME(lieutex).
```

```
DEFINE oc_r IF ISNULL(om_r) THEN 1/0 ELSE om_r/1.72.
```

```
DEFINE oc_l IF ISNULL(om_l) THEN 1/0 ELSE om_l/1.72.
```

```
DEFINE oc_h IF ISNULL(om_h) THEN 1/0 ELSE om_h/1.72.
```

```
DEFINE db_r IF ISNULL(dbthirdbar_r) THEN dbtenthbar_r ELSE dbthirdbar_r.
```

```
DEFINE db_l IF ISNULL(dbthirdbar_l) THEN dbtenthbar_l ELSE dbthirdbar_l.
```

```
DEFINE db_h IF ISNULL(dbthirdbar_h) THEN dbtenthbar_h ELSE dbthirdbar_h.
```

```
ASSIGN claytotal_l IF claytotal_l == 0 THEN 0.1 ELSE claytotal_l.
```

```
ASSIGN fragvol_r IF ISNULL(fragvol_r) THEN 0 ELSE fragvol_r.
```

```
ASSIGN fragvol_l IF ISNULL(fragvol_l) THEN 0 ELSE fragvol_l.
```

```
ASSIGN fragvol_h IF ISNULL(fragvol_h) THEN 0 ELSE fragvol_h.
```

```
# Assume particle density of rock fragments is 2.65 g/cc
```

```
DEFINE D_p_gt_2 INITIAL 2.65.
```

```
# Try to use single texture if available.
```

(430-618-H, 1st Ed., Amend. 35, August 2019)


```
DEFINE tex IF ISNULL(texcl) THEN texgrp ELSE UPCASE(CODENAME(texcl)).
```

```
# 1500kPa to clay ratio varies with bulk density and texture,
```

```
# otherwise assume ratio of 1500KPa to Clay is 0.4
```

```
DEFINE F IF claytotal_r >= 40 AND db_r <= 1.60 THEN 0.65 - 0.189*db_r ELSE IF claytotal_r >= 40  
AND db_r > 1.6 THEN 0.3 ELSE IF tex = "SCL" OR tex = "CL" OR tex = "SL" THEN 0.42 ELSE  
IF tex = "FSL" OR tex = "COSL" OR tex = "LFS" OR tex = "LS" THEN 0.45 ELSE IF tex =  
"VFSL" OR tex = "LCOS" OR tex = "FS" THEN 0.46 ELSE IF tex = "S" THEN 0.44 ELSE IF tex  
= "SC" THEN 0.36 ELSE 0.4.
```

```
DEFINE F_l IF claytotal_l >= 40 AND db_r <= 1.60 THEN 0.65 - 0.189*db_r ELSE IF claytotal_l >= 40  
AND db_r > 1.6 THEN 0.3 ELSE IF tex = "SCL" OR tex = "CL" OR tex = "SL" THEN 0.42  
ELSE IF tex = "FSL" OR tex = "COSL" OR tex = "LFS" OR tex = "LS" THEN 0.45 ELSE IF tex  
= "VFSL" OR tex = "LCOS" OR tex = "FS" THEN 0.46 ELSE IF tex = "S" THEN 0.44 ELSE IF  
tex = "SC" THEN 0.36 ELSE 0.4.
```

```
DEFINE F_h IF claytotal_h >= 40 AND db_r <= 1.60 THEN 0.65 - 0.189*db_r ELSE IF claytotal_h >= 40  
AND db_r > 1.6 THEN 0.3 ELSE IF tex = "SCL" OR tex = "CL" OR tex = "SL" THEN 0.42  
ELSE IF tex = "FSL" OR tex = "COSL" OR tex = "LFS" OR tex = "LS" THEN 0.45 ELSE IF tex  
= "VFSL" OR tex = "LCOS" OR tex = "FS" THEN 0.46 ELSE IF tex = "S" THEN 0.44 ELSE IF  
tex = "SC" THEN 0.36 ELSE 0.4.
```

```
# Assume air entrapment ratio is 0.95
```

```
DEFINE air_entrap INITIAL 0.95.
```

```
# Determine coefficients p and q for Gregson equation
```

```
DEFINE p if tex=="CL" or tex=="L" or tex=="SICL" or tex=="SIL" then 1.415 else if tex=="COSL"  
or tex=="FSL" or tex=="LVFS" or tex=="SCL" or tex=="SI" or tex=="SL" or tex=="VFS" or  
tex=="VFSL" or tex=="LCOS" or tex=="LFS" or tex=="LS" then 0.343 else if tex=="S" or tex=="SG" or  
tex=="G" or tex=="COS" or tex=="FS" then 0.541 else if tex=="C" or tex=="SC" or tex=="SIC" then  
0.879 else 1/0.
```

```
DEFINE q if tex=="CL" or tex=="L" or tex=="SICL" or tex=="SIL" then 0.839 else if tex=="COSL"  
or tex=="FSL" or tex=="LVFS" or tex=="SCL" or tex=="SI" or tex=="SL" or tex=="VFS" or  
tex=="VFSL" or tex=="LCOS" or tex=="LFS" or tex=="LS" then 1.072 else if tex=="S" or tex=="SG" or  
tex=="G" or tex=="COS" or tex=="FS" then 1.469 else if tex=="C" or tex=="SC" or tex=="SIC" then  
0.955 else 1/0.
```

```
# Compute particle density based on organic matter
```

```
#ASSIGN om_r if isnull(om_r) then 0 else om_r.
```

```
DEFINE Dp 100 / ((om_r / 1.4) + (100 - om_r)/2.65).
```

```
# Compute weight percent of rock fragments based on sieves
```

```
ASSIGN fraggt10_r if isnull(fraggt10_r) then 0 else fraggt10_r.
```

```
ASSIGN frag3to10_r if isnull(frag3to10_r) then 0 else frag3to10_r.
```

```
DEFINE W_gt_2 fraggt10_r + frag3to10_r + (100 - sieveno10_r) * (100 - fraggt10_r - frag3to10_r) /  
100.
```

```
ASSIGN fraggt10_l if isnull(fraggt10_l) then 0 else fraggt10_l.
```

```
ASSIGN frag3to10_l if isnull(frag3to10_l) then 0 else frag3to10_l.
```

```
DEFINE W_gt_2_l fraggt10_l + frag3to10_l + (100 - sieveno10_h) * (100 - fraggt10_l - frag3to10_l) /  
100.
```

Title 430 – National Soil Survey Handbook

```

ASSIGN fraggt10_h if isnull(fraggt10_h) then 0 else fraggt10_h.
ASSIGN frag3to10_h if isnull(frag3to10_h) then 0 else frag3to10_h.

DEFINE W_gt_2_h    fraggt10_h + frag3to10_h + (100 - sieveno10_l) * (100 - fraggt10_h -
frag3to10_h) / 100.

# Adjust bulk density for rock fragments
DEFINE D_b        100 / (W_gt_2/D_p_gt_2 + (100 - W_gt_2)/db_r).
DEFINE D_b_l      100 / (W_gt_2_l/D_p_gt_2 + (100 - W_gt_2_l)/db_r).
DEFINE D_b_h      100 / (W_gt_2_h/D_p_gt_2 + (100 - W_gt_2_h)/db_r).

# Compute volume percent of rock fragments
DEFINE V_gt_2     (W_gt_2 * D_b) / D_p_gt_2.
DEFINE V_gt_2_l   (W_gt_2_l * D_b_l) / D_p_gt_2.
DEFINE V_gt_2_h   (W_gt_2_h * D_b_h) / D_p_gt_2.

# ----- 15 Bar Water-----

# Compute 15 bar water content uncorrected (by volume and by weight)
DEFINE theta_1500_uc ((claytotal_r * (1 - om_r/100) * F + om_r) * db_r) / 100.
DEFINE theta_1500_uc_l ((claytotal_l * (1 - om_l/100) * F_l + om_l) * db_r) / 100.
DEFINE theta_1500_uc_h ((claytotal_h * (1 - om_h/100) * F_h + om_h) * db_r) / 100.

DEFINE theta_1500_uc_w (claytotal_r * (1 - om_r/100) * F + om_r) / 100.
DEFINE theta_1500_uc_w_l (claytotal_l * (1 - om_l/100) * F_l + om_l) / 100.
DEFINE theta_1500_uc_w_h (claytotal_h * (1 - om_h/100) * F_h + om_h) / 100.

# Compute 15 bar water content corrected for rock fragments.
# Convert to percent.
DEFINE theta_1500    theta_1500_uc * (100 - V_gt_2).
DEFINE theta_1500_l  theta_1500_uc_l * (100 - V_gt_2_h).
DEFINE theta_1500_h  theta_1500_uc_h * (100 - V_gt_2_l).

DEFINE theta_1500_w   theta_1500_uc_w * (100 - W_gt_2).
DEFINE theta_1500_w_l theta_1500_uc_w_l * (100 - W_gt_2_h).
DEFINE theta_1500_w_h theta_1500_uc_w_h * (100 - W_gt_2_l).

#----- Satiated Water-----

# Compute saturated water content uncorrected
DEFINE wcs_uc    air_entrap * (1 - db_r / Dp).
DEFINE wcs_uc_l  air_entrap * (1 - db_h / Dp).
DEFINE wcs_uc_h  air_entrap * (1 - db_l / Dp).

# Compute saturated water content corrected for rock fragments.
# Convert to percent.
DEFINE wcs      ROUND((wcs_uc * (100 - V_gt_2)),0).
DEFINE wcs_l    ROUND((wcs_uc_l * (100 - V_gt_2_h)),0).
DEFINE wcs_h    ROUND((wcs_uc_h * (100 - V_gt_2_l)),0).

# -----1/3 Bar Water-----

# Compute RV values
# Compute slope and intercept for the Gregson equation
# Uses volumetric water content

```

```

DEFINE ln_1500 INITIAL 7.31322.
DEFINE ln_theta logn(theta_1500_uc).
DEFINE ln_wcs logn(wcs_uc).

DEFINE cpslope (ln_1500 - p) / (ln_theta + q).
DEFINE cpintercept ln_1500 - (cpslope * ln_theta).

# Compute field capacity uncorrected
DEFINE fc_uc_10 exp((logn(10) - cpintercept) / cpslope).
DEFINE fc_uc_33 IF tex == "C" THEN exp(0.237*LOGN(claytotal_r)-1.26*db_r+4.162)*db_r/100
ELSE exp((logn(33) - cpintercept) / cpslope).

# Monotonicity check: field capacity between theta_1500_uc and wcs_uc
DEFINE cpslope_adj IF not isnull(fc_uc_10) and (fc_uc_10 <= 1.1 * theta_1500_uc or fc_uc_10 >=
.95 * wcs_uc) then ln_1500 / (ln_theta - ln_wcs) else cpslope.

DEFINE cpintercept_adj IF not isnull(fc_uc_10) and (fc_uc_10 <= 1.1 * theta_1500_uc or fc_uc_10 >=
.95 * wcs_uc) then 0 - (cpslope * ln_wcs) else cpintercept.

ASSIGN fc_uc_10 exp((logn(10) - cpintercept_adj) / cpslope_adj).

ASSIGN cpslope_adj IF not isnull(fc_uc_33) and (fc_uc_33 <= 1.1 * theta_1500_uc or fc_uc_33 >= .95
* wcs_uc) then ln_1500 / (ln_theta - ln_wcs) else cpslope.

ASSIGN cpintercept_adj IF not isnull(fc_uc_33) and (fc_uc_33 <= 1.1 * theta_1500_uc or fc_uc_33 >=
.95 * wcs_uc) then 0 - (cpslope * ln_wcs) else cpintercept.

ASSIGN fc_uc_33 IF not isnull(fc_uc_33) AND claytotal_r > 40 THEN fc_uc_33 ELSE exp((logn(33) -
cpintercept_adj) / cpslope_adj).

# Correct field capacity for rock fragments.
# Convert to percent.
DEFINE wtenth_r if tex=="LCOS" or tex=="LFS" or tex=="LS" or tex=="S" or tex=="SG" or
tex=="G" or tex=="COS" or tex=="FS" THEN fc_uc_10 * (100 - V_gt_2) ELSE 1/0.
DEFINE wthird_r fc_uc_33 *(100 - V_gt_2).

# Compute low values -----
# Compute slope and intercept for the Gregson equation
# Uses volumetric water content
DEFINE ln_theta_l logn(theta_1500_uc_l).
DEFINE ln_wcs_l logn(wcs_uc_l).

DEFINE cpslope_l (ln_1500 - p) / (ln_theta + q).
DEFINE cpintercept_l ln_1500 - (cpslope_l * ln_theta_l).

# Compute field capacity uncorrected
DEFINE fc_uc_10_l exp((logn(10) - cpintercept_l) / cpslope_l).
DEFINE fc_uc_33_l IF tex == "C" THEN exp(0.237*LOGN(claytotal_l)-1.26*db_r+4.162)*db_r/100
ELSE exp((logn(33) - cpintercept_l) / cpslope_l).

# Monotonicity check: field capacity between theta_1500_uc_l and wcs_uc_l

```

```

DEFINE cpslope_adj_1 IF not isnull(fc_uc_10_1) and (fc_uc_10_1 <= 1.1 * theta_1500_uc_1 or
fc_uc_10_1 >= .95 * wcs_uc_1) then ln_1500 / (ln_theta_1 - ln_wcs_1) else cpslope_1.

DEFINE cpintercept_adj_1 IF not isnull(fc_uc_10_1) and (fc_uc_10_1 <= 1.1 * theta_1500_uc_1 or
fc_uc_10_1 >= .95 * wcs_uc_1) then 0 - (cpslope_1 * ln_wcs_1) else cpintercept_1.

ASSIGN fc_uc_10_1 exp((logn(10) - cpintercept_adj_1) / cpslope_adj_1).

ASSIGN cpslope_adj_1 IF not isnull(fc_uc_33_1) and (fc_uc_33_1 <= 1.1 * theta_1500_uc_1 or
fc_uc_33_1 >= .95 * wcs_uc_1) then ln_1500 / (ln_theta_1 - ln_wcs_1) else cpslope_1.

ASSIGN cpintercept_adj_1 IF not isnull(fc_uc_33_1) and (fc_uc_33_1 <= 1.1 * theta_1500_uc_1 or
fc_uc_33_1 >= .95 * wcs_uc_1) then 0 - (cpslope_1 * ln_wcs_1) else cpintercept_1.

ASSIGN fc_uc_33_1 IF not isnull(fc_uc_33_1) AND claytotal_1 > 40 THEN fc_uc_33_1 ELSE
exp((logn(33) - cpintercept_adj_1) / cpslope_adj_1).

# Correct field capacity for rock fragments.
# Convert to percent.
DEFINE wtent_1 if tex=="LCOS" or tex=="LFS" or tex=="LS" or tex=="S" or tex=="SG" or tex=="G"
or tex=="COS" or tex=="FS" THEN fc_uc_10_1 * (100 - V_gt_2_h) ELSE 1/0.
DEFINE wthird_1 fc_uc_33_1 * (100 - V_gt_2_h).

# Compute high values -----
# Compute slope and intercept for the Gregson equation
# Uses volumetric water content
DEFINE ln_theta_h logn(theta_1500_uc_h).
DEFINE ln_wcs_h logn(wcs_uc_h).

DEFINE cpslope_h (ln_1500 - p) / (ln_theta_h + q).
DEFINE cpintercept_h ln_1500 - (cpslope_h * ln_theta_h).

# Compute field capacity uncorrected
DEFINE fc_uc_10_h exp((logn(10) - cpintercept_h) / cpslope_h).
DEFINE fc_uc_33_h IF tex == "C" THEN exp(0.237*LOGN(claytotal_h)-1.26*db_r+4.162)*db_r/100
ELSE exp((logn(33) - cpintercept_h) / cpslope_h).

# Monotonicity check: field capacity between theta_1500_uc and wcs_uc
DEFINE cpslope_adj_h IF not isnull(fc_uc_10_h) and (fc_uc_10_h <= 1.1 * theta_1500_uc_h or
fc_uc_10_h >= .95 * wcs_uc_h) then ln_1500 / (ln_theta_h - ln_wcs_h) else cpslope_h.

DEFINE cpintercept_adj_h IF not isnull(fc_uc_10_h) and (fc_uc_10_h <= 1.1 * theta_1500_uc_h or
fc_uc_10_h >= .95 * wcs_uc_h) then 0 - (cpslope_h * ln_wcs_h) else cpintercept_h.

ASSIGN fc_uc_10_h exp((logn(10) - cpintercept_adj_h) / cpslope_adj_h).

ASSIGN cpslope_adj_h IF not isnull(fc_uc_33_h) and (fc_uc_33_h <= 1.1 * theta_1500_uc_h or
fc_uc_33_h >= .95 * wcs_uc_h) then ln_1500 / (ln_theta_h - ln_wcs_h) else cpslope_h.

ASSIGN cpintercept_adj_h IF not isnull(fc_uc_33_h) and fc_uc_33_h <= 1.1 * theta_1500_uc_h or
fc_uc_33_h >= .95 * wcs_uc_h) then 0 - (cpslope_h * ln_wcs_h) else cpintercept_h.

```

```
ASSIGN fc_uc_33_h IF not isnull(fc_uc_33_h) AND claytotal_h > 40 THEN fc_uc_33_h ELSE
exp((logn(33) - cpintercept_adj_h) / cpslope_adj_h).
```

```
# Correct field capacity for rock fragments.
```

```
# Convert to percent.
```

```
DEFINE wtenth_h   if tex=="LCOS" or tex=="LFS" or tex=="LS" or tex=="S" or tex=="SG" or
tex=="G" or tex=="COS" or tex=="FS" THEN fc_uc_10_h * (100 - V_gt_2_l) ELSE 1/0.
```

```
DEFINE wthird_h   fc_uc_33_h * (100 - V_gt_2_l).
```

```
#-----
```

```
# Additional calculations for when water contents exceed satiated water contents using the gregson
model.
```

```
# This generally occurs for compacted or dense soil layers.
```

```
ASSIGN wtenth_r   IF om_r > 20 OR ((wtenth_r >= wcs) AND (NOT ISNULL(wtenth_r) OR NOT
ISNULL(theta_1500) OR NOT ISNULL(wcs))) THEN 1/0 ELSE wtenth_r.
```

```
ASSIGN wthird_r   IF om_r <= 20 AND ((wthird_r >= wcs) AND (NOT ISNULL(wthird_r) OR NOT
ISNULL(theta_1500) OR NOT ISNULL(wcs))) THEN IF claytotal_r < 40 THEN
(exp(logn(theta_1500_uc_w*100)*0.515 - 0.619*db_r + 2.696))/100 * db_r * (100 - V_gt_2) ELSE
exp(0.237*LOGN(claytotal_r)-1.26*db_r+4.162)*db_r/100 * (100 - V_gt_2) ELSE IF om_r > 20 THEN
1/0 ELSE wthird_r.
```

```
ASSIGN wthird_r   IF ((wthird_r >= wcs) AND (NOT ISNULL(wthird_r) OR NOT
ISNULL(theta_1500) OR NOT ISNULL(wcs))) THEN wcs-(0.05*wcs) ELSE wthird_r. IF om_r <= 20
AND ((theta_1500 > wcs OR theta_1500 > wthird_r) AND (NOT ISNULL(wthird_r) OR NOT
ISNULL(theta_1500) OR NOT ISNULL(wcs))) THEN wthird_r-(0.1*wthird_r) ELSE IF om_r > 20
THEN 1/0 ELSE theta_1500.
```

```
ASSIGN wtenth_l   IF om_r > 20 OR ((wtenth_l >= wcs_l) AND (NOT ISNULL(wtenth_l) OR NOT
ISNULL(theta_1500_l) OR NOT ISNULL(wcs_l))) THEN 1/0 ELSE wtenth_l.
```

```
ASSIGN wthird_l   IF om_r <= 20 AND ((wthird_l >= wcs_l) AND (NOT ISNULL(wthird_l) OR NOT
ISNULL(theta_1500_l) OR NOT ISNULL(wcs_l))) THEN IF claytotal_l < 40 THEN
(exp(logn(theta_1500_uc_w_l*100)*0.515 - 0.619*db_r + 2.696))/100 * db_r * (100 - V_gt_2_h) ELSE
exp(0.237*LOGN(claytotal_l)-1.26*db_r+4.162)*db_r/100 * (100 - V_gt_2_h) ELSE IF om_r > 20
THEN 1/0 ELSE wthird_l.
```

```
ASSIGN wthird_l   IF ((wthird_l >= wcs_l) AND (NOT ISNULL(wthird_l) OR NOT
ISNULL(theta_1500_l) OR NOT ISNULL(wcs_l))) THEN wcs_l-(0.05*wcs_l) ELSE wthird_l.
```

```
ASSIGN theta_1500_l IF om_r <= 20 AND ((theta_1500_l > wcs_l OR theta_1500_l > wthird_l)
AND (NOT ISNULL(wthird_l) OR NOT ISNULL(theta_1500_l) OR NOT ISNULL(wcs_l))) THEN
wthird_l-(0.1*wthird_l) ELSE IF om_r > 20 THEN 1/0 ELSE theta_1500_l.
```

```
ASSIGN wtenth_h   IF om_r > 20 OR ((wtenth_h >= wcs_h) AND (NOT ISNULL(wtenth_h) OR NOT
ISNULL(theta_1500_h) OR NOT ISNULL(wcs_h))) THEN 1/0 ELSE wtenth_h.
```

```
ASSIGN wthird_h   IF om_r <= 20 AND ((wthird_h >= wcs_h) AND (NOT ISNULL(wthird_h) OR
NOT ISNULL(theta_1500_h) OR NOT ISNULL(wcs_h))) THEN IF claytotal_h < 40 THEN
```

```
(exp(logn(theta_1500_uc_w_h*100)*0.515 - 0.619*db_r + 2.696))/100 * db_r * (100 - V_gt_2_l) ELSE
exp(0.237*LOGN(claytotal_h)-1.26*db_r+4.162)*db_r/100 * (100 - V_gt_2_l) ELSE IF om_r > 20
THEN 1/0 ELSE wthird_h.
```

```
ASSIGN wthird_h IF ((wthird_h >= wcs_h) AND (NOT ISNULL(wthird_h) OR NOT
ISNULL(theta_1500_h) OR NOT ISNULL(wcs_h))) THEN wcs_h-(0.05*wcs_h) ELSE wthird_h.
```

```
ASSIGN theta_1500_h IF om_r <= 20 AND ((theta_1500_h > wcs_h OR theta_1500_h > wthird_h)
AND (NOT ISNULL(wthird_h) OR NOT ISNULL(theta_1500_h) OR NOT ISNULL(wcs_h))) THEN
wthird_h-(0.1*wthird_h) ELSE IF om_r > 20 THEN 1/0 ELSE theta_1500_h.
```

#-----Organic Soils, 1/3 and 15 bar Water-----

```
DEFINE theta_1500_org_w IF om_r <= 20 THEN 1/0 ELSE IF (lieutex1 == "mpt" OR lieutex1 ==
"mpm") THEN (2.019*oc_r+10.54) *0.75 ELSE IF (lieutex1 == "muck" OR lieutex1 == "hpm") THEN
(1.731*oc_r+8.863) *0.75 ELSE IF (lieutex1 == "peat" OR lieutex1 == "spm") THEN
(2.122*oc_r+10.539) *0.75 ELSE 1/0.
```

```
ASSIGN theta_1500 IF ISNULL(theta_1500_org_w) THEN theta_1500 ELSE
theta_1500_org_w*db_r / 100 *(100 - fragvol_r).
```

```
DEFINE theta_1500_org_w_l IF om_r <= 20 THEN 1/0 ELSE IF (lieutex1 == "mpt" OR lieutex1 ==
"mpm") THEN (2.019*oc_l+10.54) *0.75 ELSE IF (lieutex1 == "muck" OR lieutex1 == "hpm") THEN
(1.731*oc_l+8.863) *0.75 ELSE IF (lieutex1 == "peat" OR lieutex1 == "spm") THEN
(2.122*oc_l+10.539) *0.75 ELSE 1/0.
```

```
ASSIGN theta_1500_l IF ISNULL(theta_1500_org_w_l) THEN theta_1500_l ELSE
theta_1500_org_w_l*db_r / 100 *(100 - fragvol_h).
```

```
DEFINE theta_1500_org_w_h IF om_r <= 20 THEN 1/0 ELSE IF (lieutex1 == "mpt" OR lieutex1 ==
"mpm") THEN (2.019*oc_h+10.54) *0.75 ELSE IF (lieutex1 == "muck" OR lieutex1 == "hpm") THEN
(1.731*oc_h+8.863) *0.75 ELSE IF (lieutex1 == "peat" OR lieutex1 == "spm") THEN
(2.122*oc_h+10.539) *0.75 ELSE 1/0.
```

```
ASSIGN theta_1500_h IF ISNULL(theta_1500_org_w_h) THEN theta_1500_h ELSE
theta_1500_org_w_h*db_r / 100 *(100 - fragvol_l).
```

```
DEFINE ln_theta_1500 LOGN(theta_1500_org_w).
DEFINE ln_theta_1500_l LOGN(theta_1500_org_w_l).
DEFINE ln_theta_1500_h LOGN(theta_1500_org_w_h).
DEFINE ln_db_r LOGN(db_r).
DEFINE ln_oc_r LOGN(oc_r).
DEFINE ln_oc_l LOGN(oc_l).
DEFINE ln_oc_h LOGN(oc_h).
```

```
ASSIGN wthird_r IF om_r <= 20 THEN wthird_r ELSE IF (lieutex1 == "mpt" OR lieutex1 ==
"mpm") THEN EXP(0.360*ln_theta_1500-1.076*ln_db_r+2.236) * db_r / 100 *(100 - fragvol_r) ELSE
IF (lieutex1 == "muck" OR lieutex1 == "hpm") THEN EXP(0.142*ln_theta_1500-1.047*ln_db_r+3.340)
* db_r / 100 *(100 - fragvol_r) ELSE IF (lieutex1 == "peat" OR lieutex1 == "spm") THEN
EXP(0.427*ln_theta_1500-0.852*ln_db_r+2.282) * db_r / 100 *(100 - fragvol_r) ELSE 1/0.
```

```
ASSIGN wthird_l IF om_r <= 20 THEN wthird_l ELSE IF (lieutex1 == "mpt" OR lieutex1 == "mpm")
THEN EXP(0.360*ln_theta_1500_l-1.076*ln_db_r+2.236) * db_r / 100 *(100 - fragvol_h) ELSE IF
```

```
(lieutex1 == "muck" OR lieutex1 == "hpm") THEN EXP(0.142*ln_theta_1500_l-1.047*ln_db_r+3.340)
* db_r / 100 *(100 - fragvol_h) ELSE IF (lieutex1 == "peat" OR lieutex1 == "spm") THEN
EXP(0.427*ln_theta_1500_l-0.852*ln_db_r+2.282) * db_r / 100 *(100 - fragvol_h) ELSE 1/0.
```

```
ASSIGN wthird_h IF om_r <= 20 THEN wthird_h ELSE IF (lieutex1 == "mpt" OR lieutex1 ==
"mpm") THEN EXP(0.360*ln_theta_1500_h-1.076*ln_db_r+2.236) * db_r / 100 *(100 - fragvol_l)
ELSE IF (lieutex1 == "muck" OR lieutex1 == "hpm") THEN EXP(0.142*ln_theta_1500_h-
1.047*ln_db_r+3.340) * db_r / 100 *(100 - fragvol_l) ELSE IF (lieutex1 == "peat" OR lieutex1 ==
"spm") THEN EXP(0.427*ln_theta_1500_h-0.852*ln_db_r+2.282) * db_r / 100 *(100 - fragvol_l) ELSE
1/0.
```

```
ASSIGN theta_1500 IF om_r > 13 AND om_r <= 20 AND (lieutex1 == "mpt" OR lieutex1 == "mpm"
OR lieutex1 == "muck" OR lieutex1 == "hpm" OR lieutex1 == "peat" OR lieutex1 == "spm") THEN
(EXP(0.673*ln_oc_r + 1.618)*0.75) * db_r / 100 *(100 - fragvol_l) ELSE theta_1500.
```

```
ASSIGN theta_1500_l IF om_r > 13 AND om_r <= 20 AND (lieutex1 == "mpt" OR lieutex1 ==
"mpm" OR lieutex1 == "muck" OR lieutex1 == "hpm" OR lieutex1 == "peat" OR lieutex1 == "spm")
THEN (EXP(0.673*ln_oc_l + 1.618)*0.75) * db_r / 100 *(100 - fragvol_h) ELSE theta_1500_l.
```

```
ASSIGN theta_1500_h IF om_r > 13 AND om_r <= 20 AND (lieutex1 == "mpt" OR lieutex1 ==
"mpm" OR lieutex1 == "muck" OR lieutex1 == "hpm" OR lieutex1 == "peat" OR lieutex1 == "spm") THEN
(EXP(0.673*ln_oc_h + 1.618)*0.75) * db_r / 100 *(100 - fragvol_l) ELSE theta_1500_h.
```

```
DEFINE ln_theta_1500_A LOGN(EXP(0.673*ln_oc_r + 1.618) * 0.75). DEFINE
ln_theta_1500_A_l LOGN(EXP(0.673*ln_oc_l + 1.618) * 0.75). DEFINE
ln_theta_1500_A_h LOGN(EXP(0.673*ln_oc_h + 1.618) * 0.75).
```

```
ASSIGN wthird_r IF om_r > 13 AND om_r <= 20 AND (lieutex1 == "mpt" OR lieutex1 == "mpm"
OR lieutex1 == "muck" OR lieutex1 == "hpm" OR lieutex1 == "peat" OR lieutex1 == "spm") THEN
EXP(0.267*ln_theta_1500_A - 1.141*ln_db_r + 2.821) * db_r / 100 *(100 - fragvol_r) ELSE wthird_r.
```

```
ASSIGN wthird_l IF om_r > 13 AND om_r <= 20 AND (lieutex1 == "mpt" OR lieutex1 == "mpm"
OR lieutex1 == "muck" OR lieutex1 == "hpm" OR lieutex1 == "peat" OR lieutex1 == "spm") THEN
EXP(0.267*ln_theta_1500_A_l - 1.141*ln_db_r + 2.821) * db_r / 100 *(100 - fragvol_h) ELSE wthird_l.
```

```
ASSIGN wthird_h IF om_r > 13 AND om_r <= 20 AND (lieutex1 == "mpt" OR lieutex1 == "mpm"
OR lieutex1 == "muck" OR lieutex1 == "hpm" OR lieutex1 == "peat" OR lieutex1 == "spm") THEN
EXP(0.267*ln_theta_1500_A_h - 1.141*ln_db_r + 2.821) * db_r / 100 *(100 - fragvol_l) ELSE wthird_h.
```

#-----Oven Dry Bulk Denisty-----

Compute oven dry bulk density

```
DEFINE bdrdr IF NOT ISNULL(lep_r) THEN (((lep_r/100) / (1 - V_gt_2/100) + 1) ** 3) * db_r ELSE
1/0.
```

```
DEFINE bdrdl IF NOT ISNULL(lep_l) THEN (((lep_l/100) / (1 - V_gt_2/100) + 1) ** 3) * db_r ELSE
1/0.
```

```
DEFINE bdrdh IF NOT ISNULL(lep_h) THEN (((lep_h/100) / (1 - V_gt_2/100) + 1) ** 3) * db_r
ELSE 1/0.
```

```
ASSIGN bdrdl IF NOT ISNULL(lep_l) AND bdrdl > db_l THEN bdrdr - (db_r - db_l) ELSE bdrdl.
```

```
ASSIGN bdrdh IF NOT ISNULL(lep_h) AND bdrdh < db_h THEN bdrdr + (db_h - db_r) ELSE bdrdh.
```

```
# Values for median bulk density differences between 1/3 bar and oven-dry divided by the total clay.
DEFINE dbdiff    IF tex == "L" OR tex == "SCL" OR tex == "SIL" OR tex == "FSL" OR tex ==
"COSL" OR tex == "SL" OR tex == "VFSL" OR tex == "SI" OR tex == "LVFS" THEN 0.004 ELSE IF
tex == "CL" OR tex == "S" OR tex == "LFS" OR tex == "FS" OR tex == "LS" THEN 0.005 ELSE IF tex
== "SICL" OR tex == "LCOS" OR tex == "COS" THEN 0.006 ELSE IF tex == "C" OR tex == "SIC"
THEN 0.007 ELSE IF tex == "SC" THEN 0.002 ELSE IF tex == "VFS" THEN 0.003 ELSE 0.004.

ASSIGN bdrdr    IF (bdrdr - db_r) > 0.75 OR bdrdr > 2.1 THEN dbdiff*claytotal_r + db_r ELSE bdrdr.

ASSIGN bdrdl    IF ((bdrdl - db_r)*(-1)) > 0.75 OR bdrdl > 2.1 THEN dbdiff*claytotal_l + db_r ELSE
bdrdl.

ASSIGN bdrdh    IF (bdrdh - db_r) > 0.75 OR bdrdh > 2.1 THEN dbdiff*claytotal_h + db_r ELSE
bdrdh.

ASSIGN bdrdr IF bdrdr > 2.1 OR om_r > 20 THEN 1/0 ELSE bdrdr.
ASSIGN bdrdl IF bdrdl > 2.1 OR om_r > 20 THEN 1/0 ELSE bdrdl. ASSIGN
bdrdh    IF bdrdh > 2.1 OR om_r > 20 THEN 1/0 ELSE bdrdh.

DEFINE bdrdr2 IF bdrdr > bdrdh THEN bdrdh ELSE bdrdr.
ASSIGN bdrdh IF bdrdr > bdrdh THEN bdrdr ELSE bdrdh.
ASSIGN bdrdr bdrdr2.

DEFINE store2 IF bdrdl > bdrdr THEN bdrdl ELSE bdrdr.
ASSIGN bdrdl IF bdrdl > bdrdr THEN bdrdr ELSE bdrdl.
ASSIGN bdrdr store2.
```


618.106 References

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- C. X. Shi, L. Girod, R. Long, R. Dekett, J. Philippe, and T. Burke. 2012. A comparison of LiDAR- based DEMs and USGS-sourced DEMs in terrain analysis for knowledge-based digital soil mapping. *Geoderma* 170:217-226.
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Part 621 – Soil Potential Ratings

Subpart A – General Information

621.0 Definition and Purpose

- A. Soil potential ratings are classes that indicate the relative quality of a soil for a particular use as compared with those of other soils in a given area. The following are considered in soil potential ratings:
 - (1) Yield or performance level
 - (2) The relative cost of applying modern technology to minimize the effects of any soil restrictions
 - (3) The adverse effects of continuing limitations, if any, on social, economic, or environmental values
- B. The criteria for developing soil potential ratings for a particular use are established specifically for a given area. The criteria may be different in nearby areas, landforms, counties, groups of counties, groups of States, or regions.
- C. The purpose of soil potential ratings is to identify within an area the relative suitability of soils for a given use while considering economic, social, and environmental values.

621.1 Responsibilities

- A. NRCS is responsible for providing assistance to units of government and others in preparing and using soil potential ratings.
- B. The NRCS State soil scientist and assigned resource soil scientists assist local, State, and other units of government with soil potential ratings and how they can be used, takes leadership in the preparation of potential ratings by utilizing participation by technical experts within NRCS and other agencies in their development, and encourages their use.
- C. Soil conservationists, soil scientists, engineers, and others provide guidance in interpreting soil survey data and in establishing procedures for preparing potential ratings.
- D. The National Soil Survey Center is responsible for developing and implementing the procedures used to develop and apply soil potential ratings.

621.2 General

- A. Soil potential ratings are developed primarily for planning purposes and are not recommendations for soil use. They help decision makers to determine the relative suitability of soils for a given use. They are used with other resource information as a guide to make land use decisions.
- B. Soil potential ratings supplement other groupings and interpretations given in soil handbooks and technical guides.

- C. The procedures for rating soil potentials have been prepared as guides. The procedures should allow a maximum of flexibility.
- D. Soil potential ratings have been adopted as a form of soil interpretations to—
- (1) Provide a common set of terms, which are applicable to all kinds of land use, for rating the quality of a soil for a particular use relative to that of other soils in the area.
 - (2) Identify the corrective measures needed to overcome limitations and the degree to which the measures are feasible and effective.
 - (3) Allow for the preparation of soil interpretations and the use of local criteria to meet local needs;
 - (4) provide information about soils that emphasizes the feasibility of a use rather than avoidance of problems.
 - (5) Combine information on soils, corrective measures, and the relative costs of corrective measures.
 - (6) Make soil surveys and related information more applicable and easy to use in resource planning.
 - (7) Strengthen the resource planning effort by more effectively communicating the information provided by soil surveys and properly relating that information to modern technologies.

621.3 Developing Soil Potential Ratings

- A. The development of soil potential ratings requires procedures that identify soil performance levels, measures for overcoming soil limitations, and the limitations that remain after corrective measures have been applied. These procedures must also allow for a numerical system from which a soil potential index and soil potential ratings can be derived. The information is assembled and presented to users in the form of soil map unit descriptions and tables or maps.
- B. The number of soil uses for which potential ratings are prepared varies from area to area. The importance of the soil use and the number of people who would use information on it must be considered. If soil potential ratings are prepared for a specific soil use, all soils in the geographic area of interest should be rated for that same use.
- C. Soil potential ratings are prepared for any geographic or political area.
- D. Soil potential ratings are prepared regardless of map scale or kind of map unit. Components of multitaxa map units can be evaluated separately to supplement the overall evaluation of a map unit. The soil uses for which soil potential ratings are prepared should be consistent with the detail of mapping.
- E. Required, optional, and suggested aspects of NRCS preparation and procedures for preparing soil potential ratings are provided in part 612, subpart B, section 621.12.
- F. The evaluations of soil potential ratings must be made with the assistance of specialists in fields that are most closely related to the specific use.
- G. NRCS personnel provide leadership in the procedures and assist in identifying the soil properties, the soil qualities, and the composition of map units. Technical experts from outside NRCS should be consulted in decisions concerning performance standards, the means and feasibility of overcoming soil limitations, and the indices for the costs of corrective measures and the continuing limitations. They should also be consulted in decisions on the criteria, the numerical values derived, and the break points between rating classes.

621.4 Steps in Preparing Soil Potential Ratings

The following steps are suggested as a logical sequence for preparing and presenting soil potential ratings:

- (1) Acquaint users with soil potential ratings, determine user needs, and initiate action
- (2) Identify which technical specialists will participate
- (3) Review procedures and evaluate the adequacy of documented supporting data
- (4) Collect additional data as needed
- (5) Prepare soil potential ratings
- (6) Review and approve ratings as needed
- (7) Prepare ratings in final format
- (8) Distribute the ratings and train users

621.5 Collecting Data

A. Soil characteristics and performance data must be available before soil potential ratings can be prepared for a particular use. Data needs must be appraised before the soil potential ratings are prepared. If data are insufficient, a plan must be prepared for obtaining the needed information. The data needed, the individuals responsible for their collection, and the target dates for completion must be identified.

The data include but are not limited to—

- (1) Soil properties and qualities.
- (2) Limitations for the use that are caused by the soil properties and qualities and the composition of the soil map units.
- (3) The kinds of corrective measures needed to overcome the limitations.
- (4) The relative cost or difficulty of overcoming the limitations for the installation of a given practice.
- (5) The relative costs or difficulties of overcoming the limitations that continue after given practices are installed.
- (6) The level of performance.

B. Many of the data needs are documented and are available in technical guides and practice specifications.

C. Other data can be collected through observations that are made and recorded in the course of day-to-day activities or through the systematic efforts of NRCS personnel, cooperating agencies and institutions, local experts, or others.

621.6 Definition of Soil Potential Classes

A. Relative terms are assigned to classes to indicate the potential of a soil for a particular use as compared with that of other soils in the area. The same soils in a different area may have different ratings for a given use. The rating classes do not identify the most profitable soil use or imply a recommendation for a particular use. For example, a soil rated as having a high potential for both forest land and cropland may be much more profitable in one use than in the other.

B. Five classes are provided for comparative ratings of soil potential: very high, high, medium, low, and very low. Very high potential is assigned only to soils having properties that make them exceptionally well suited to the particular use. Very low potential is assigned only to soils having properties so unfavorable for the use that they are virtually unsuited. The number of classes used in the final ratings depends on the range of potentials in the area and the degree of refinement needed. Three classes are enough for many areas.

C. In a few geographic areas, only two classes of soil potential are needed because all soils in the area are either well suited or poorly suited to the use. If a wide array of potential is not present, only two rating classes may be needed, such as high and medium or medium and low. It may be important to prepare soil potential ratings, however, to identify widely different kinds of treatments that are needed for different soils. Ratings of the potential of individual soils generally are not needed in areas where all soils have the same rating for a given use.

D. The highest or lowest potential rating class in which a soil can be placed is determined by local standards that are established by users and specialists. For example, if corn is not well adapted in an area, the best rating class for that area may be no better than medium. However, wheat may be well adapted in the same area and may have very high as the best potential rating. As another example, the best soils for dwellings in a certain area may have medium potential because of high building costs. Thus, a rating of “high” would not be used because it might be misleading. Similarly, if all soils in an area are well suited to a use, a “low” potential rating may have an inaccurate connotation.

E. The rating classes are defined in terms of the production or performance expected of a soil if feasible measures are taken to overcome its limitations and in terms of the cost of such measures and the magnitude of the limitations that remain after the measures have been applied. The production or performance of each soil is compared with standards that are established locally for each soil use. The following class terms and definitions are used nationwide:

- (1) Very High Potential.—Production or performance is at or above local standards because soil conditions are exceptionally favorable, installation or management costs are low, and soil limitations are insufficient.
- (2) High Potential.—Production or performance is at or above the level of locally established standards, the cost of measures for overcoming soil limitations are judged locally to be favorable in relation to the expected performance or yields, and soil limitations that continue after corrective measures are installed do not detract appreciably from environmental quality or economic returns.
- (3) Medium Potential.—Production or performance is somewhat below locally established standards, the costs of measures for overcoming soil limitations are high, or soil limitations that continue after corrective measures are installed detract from environmental quality or economic returns.
- (4) Low Potential.—Production or performance is significantly below local standards, measures that are required to overcome soil limitations are very costly, or soil limitations that continue after corrective measures are installed detract appreciably from environmental quality or economic returns.
- (5) Very Low Potential.—Production or performance is much below locally established standards, severe soil limitations exist for which economically feasible measures are unavailable, or soil limitations that continue after corrective measures are installed seriously detract from environmental quality or economic returns.

F. The soil uses for which soil potentials ratings are prepared should be consistent with the detail of mapping. Soil potential ratings for broad categories of soil uses, such as cropland, forestland, rangeland,

or residential land, are appropriate for all levels of soil surveys regardless of the kinds of components that make up the soil map units. Ratings for the more specific soil uses, such as for strawberries or avocados or for dwellings or septic tank absorption fields, are appropriate for detailed soil surveys that have consociation and complex map units. Soil potential ratings for the more specific soil uses are seldom appropriate for general soil map units. The rule of restricting specific soil potential ratings to detailed consociation and complex map units should be generally followed. Soil potential ratings for broad categories of soil use are more appropriate for generalized soil map units, which are broadly defined and are used for broad base planning.

621.7 Soil Potential Index Concept

A. The soil potential index (SPI) is a numerical rating of the relative suitability or quality of a soil. It is used to rank soils from high to low, according to their potential. The SPI is derived from the indexes of soil performance, cost of corrective measures, and costs established for continuing limitations. The SPI is expressed by the equation:

$$\text{SPI} = \text{P} - (\text{CM} + \text{CL})$$

where—

P = Index of performance or yield as a locally established standard

CM = Index of costs of corrective measures to minimize the effects of soil limitations

CL = Index of costs resulting from continuing limitations

B. The index values used are of a general nature. A highly detailed economic analysis of costs and returns is not required. The values for CM and CL must be on the same basis. If CM is on an annual basis, CL must also be on an annual basis. If CM is based on the total initial cost of corrective measures and CL is known only on an annual basis, economic analysis is required to derive common values for comparison. After a common basis is established for the costs of CM and CL, the costs can be reduced to index values. The SPI can be based on a percentage of the cost or on any other index desired.

- (1) The Performance or Yield Standard (P).—P is a locally defined and determined standard that represents index of a performance or yield for the area. The actual yield or performance of each soil is compared to this local standard. For some soils, the yield or performance level exceeds the standard. In this case, the SPI is adjusted upward on worksheets to reflect the higher yield or performance for the soil. Substandard yield or performance is included as a continuing limitation (CL) cost. These values, or their equivalents if some other relative index is used, are entered on worksheets for calculating SPI. How often the crop is grown, either annually or less often because of needed crop rotations, must be considered when defining P. The rotation crops with low returns can be included by increasing CL as needed. P need not be an absolute measure, such as estimated yield.
 - (i) In most situations, the local standard chosen for P is above the performance level of the average soil in the area but may be lower than that achieved on the very best soils. A standard for corn yields in Alpha County, Any State, may be set at 120 bushels per acre per year; the SPI is adjusted up or down to reflect the expected yield relationship for any given soil. For example, for Alpha silt loam with an estimated yield of 132 bushels per acre:
 - Where the local standard yield is 120 bu/ac corn and the local standard SPI is equal to 100, Alpha silt loam with a corn yield of 132 bu/ac would have an SPI of 110.
 - $\text{SPI Alpha silt loam} = 132/120 \times 100$ (standard SPI)
 - $\text{SPI} = 110$

- In this example, an SPI value of 100 is used to represent a standard yield of 120 bushels per acre.
 - (ii) For soils with yields less than the standard, the lower yield is considered a CL, which is equal to a factor representing the amount the yield is below the standard. For example, for Beta silt loam with an estimated corn yield of 102 bushels per acre:
 - Where the local standard yield is 120 bu/ac corn and the local standard SPI is equal to 100, Beta silt loam with a corn yield of 102 bu/ac would have a SPI of 85.
 - $\text{SPI Beta silt loam} = 102/120 \times 100$ (standard SPI)
 - $\text{SPI} = 85$
 - In this example, an SPI value of 100 is used to represent a standard yield of 120 bushels per acre.
- (2) Cost of Corrective Measures (CM)
- (i) CM is an index of added costs, which are above those for a defined standard installation or management system that is commonly used, given that there are no soil limitations that must be overcome. At the standard level, the value of CM is zero and thus no deductions would be made in deriving SPI. In unusual situations where a soil is so uniquely suited that costs incurred to obtain the desired level of performance are less than the standard, CM may be a negative value and thus increase the SPI.
 - (ii) Examples of costs of corrective measures for agricultural uses are those for terraces or drainage systems. Costs for such measures can be converted to an annual basis for index values that are compatible with values for P and CL. Whether or not the corrective measures have already been installed is normally not considered, unless it is determined locally that costs already incurred for major irrigation, drainage, or flood control projects should be disregarded.
 - (iii) Added expenses for measures such as increasing the size of a septic tank absorption field, strengthening a foundation, or construction grading for site preparation are examples of corrective measure costs for nonagricultural uses. In many cases, these kinds of costs may be handled as total initial costs rather than as prorated annual costs.
 - (iv) Wherever possible, corrective measures that can at least partially overcome soil limitations should be identified. Management techniques, as well as agronomic or engineering practices, are considered corrective measures. For example, if wetness affects forestland harvest and drainage is not feasible, the corrective measure would be to schedule harvest operations during dry periods. An important aspect of the procedure for preparing soil potential ratings is that NRCS or cooperating agencies assist in identifying technologies that are or, according to local experts, should be considered workable local options. NRCS or cooperating agencies or institutions should assist the local experts in properly relating those technologies or measures to kinds of soil.
- (3) Cost of Continuing Limitations
- (i) Limitations that continue after corrective measures have been applied have adverse effects on social, economic, or environmental values. Distinctions between the three kinds of values need not be made. Continuing limitations that affect returns or profits are clearly economic. Those that result in the pollution of air or water are social and environmental effects. CL is an index of costs that result from such soil limitations.
 - (ii) Continuing soil limitations are grouped as three types: performance limitations, such as low yields, human inconvenience or discomfort, periodic failure, limitations resulting from the size, shape, or accessibility of an area, or associated soils that restrict the use of a soil or its period of use; annual or periodic maintenance costs, such as pumps that remove excess water, irrigation, maintenance of drainage or terrace systems, or pumping and removal of septic tank waste; and offsite damage from sediment or other forms of pollution.

(iii) The following examples illustrate the derivation of CL:

- If the local performance standard is 2,000 pounds per acre, a potential production of only 1,500 pounds per acre from rangeland in a normal year, as obtained through the use of all feasible corrective measures to increase yields, is substandard by 500 pounds. Where P is 100, an appropriate index value for CL is—
$$25 = \frac{(2,000 - 1,500 \times 100)}{2,000}$$
- If the flooding of a dwelling remains a probability after feasible measures are installed, an estimate of the damage and inconvenience resulting from a flood event divided by the frequency of flooding can provide an annual cost for conversion to index values. For example, damages of \$6,000 might be estimated to result from floods that occur 1 year in 10. The annual cost would be \$600 and thus constitutes a serious continuing limitation. An appropriate value for CL might be 60 if the index for P is 100.
- Other values for CL are estimated on the basis of costs to insure against damage, including flood insurance, costs of maintenance, costs for using substitute facilities during periods of malfunction, penalties that might result from offsite or environmental damages, or combinations of such costs. The assignment of a cost index to some continuing limitations is arbitrary out of necessity.

621.8 Procedures for Preparing Soil Potential Ratings

A. An early step in the procedures for preparing soil potential ratings is the assembly and evaluation of soil-related data on yields, performance levels, local corrective measures, and limitations that continue after treatments are applied. Published soil surveys, soil handbooks, technical guides, research data, and information from sanitarians, contractors, builders, developers, and others are potential sources of data. The amount of useful data varies from area to area, depending on the extent of soil used for a particular purpose.

B. If the soils have been used extensively for the purpose or crop being evaluated, the derivation of SPI is the most direct and most accurate. The needed corrective measures are well known. The actual performance or yield represents an integration of the effects of corrective measures and soil properties and is also well known. Thus, one does not need to infer or derive relationships among properties, measures, and yields to arrive at the indexes.

C. If soils are being evaluated for purposes for which they are not now used or are used in only a few places, the corrective measures and the other indexes that are needed must be inferred. In these cases, two basic approaches are used to derive SPI.

- (1) If soils similar to the soils being evaluated are used for the purpose being evaluated, the evaluations are based on the performance of the similar soils and the corrective measures needed to overcome their limitations. Adjustments can be made to slightly raise or lower the performance level or to modify the measures in order to account for properties of the soils being evaluated that are more or less favorable than those of the similar soils.
- (2) If information on corrective measures and the actual performance of similar soils is not available, the soil properties that affect the particular use are identified and the soils are evaluated on the basis of proved relationships between properties and performance. If this approach must be used, careful consideration should be given to whether or not the ratings are needed or appropriate.

621.9 Defining Soil Use, Performance Standards, and Criteria for Evaluation

A. Definition.—The soil use must be defined, evaluation criteria prepared, and a local performance standard established. Part 621, subpart B, sections 621.13 and 621.14, are examples. The definition of the use prescribes the conditions to which the soil potential ratings apply. In effect, the definition states the assumptions to which the ratings apply and it must be carefully considered.

- (1) Examples of definitions include:
 - (i) For cropland, the kinds of crops grown and the basic management systems used
 - (ii) For dwellings, the density or size of the lots
 - (iii) For septic tank absorption fields, whether or not a municipal water supply is assumed
 - (iv) For numerous uses, the kind or size of equipment used or the methods or procedures followed in the installation of corrective measures
- (2) A performance standard is established and included as a part of the definition.
- (3) Evaluation criteria are prepared that list the soil site and other factors that affect the intended use. Part 621, subpart B, sections 621.13 and 621.14, are examples. External features, such as size and shape of an area, relationship of soils to other soils, regulations, and significant map unit inclusions or miscellaneous areas, such as rock outcrops, that are characteristic of map units, may be included as factors.
- (4) The soil factors selected are those that affect yield or performance, require corrective measures, or cause limitations for the use. The factors that are considered in rating taxonomic units by degree of limitation are sufficient for some uses. For other uses, criteria for map units may be needed in addition to those for taxonomic units.
- (5) For each soil factor, a range of conditions that is related to the kind and relative cost of corrective measures that are needed to overcome or minimize the effect of the limitation is established. Part 621, subpart B, section 621.15, is an example. Assigning degrees of limitations to each factor may be helpful. If so, the coordinated ratings from the soil database are used. For some uses or for some factors that are selected as evaluating criteria, coordinated soil limitation ratings are not available. In these cases, the limitation ratings can be assigned locally. However, the ratings of degree of limitation that have not been coordinated are not presented to users in text or tables even though they may have been used in preparing soil potential ratings. For some factors, the ranges in properties that are used for rating soil limitations may need to be subdivided. For example, in evaluations for dwellings, the range for slopes greater than 15 percent may need to be subdivided into ranges for slopes 15 to 30 percent, 30 to 50 percent, and 50 to 80 percent. Even though all these slope classes present severe limitations, differences may exist in the kinds and costs of corrective measures and continuing limitations and be significant for soil potential ratings.

B. Approach.—One approach to a systematic procedure for preparing soil potential ratings is illustrated in Part 621, subpart B, sections 621.12, 621.16, and 621.17. Separate sheets are used for each map unit and for each soil use. The worksheets are prepared by states. Copies of completed worksheets are retained in NRCS offices as documentation of the procedures used.

C. Worksheets.—General guidance for completing worksheets is given in this section. Examples of completed worksheets are provided for forest land (part 621, subpart B, section 621.18), for septic tank absorption fields (part 621, subpart B, section 621.19), and for dwellings without basements (part 621, subpart B, section 621.20). Steps for completing the worksheet are as follows:

- (1) Enter the name of the map unit. Soil potential ratings are prepared for the map unit according to whether it is a multitaxa or a single taxon unit. Separate worksheets are suggested if two or more

- taxonomic units are named, but the final index for the unit depends on indexes of the components and the size, extent, and relationship of each component to another. Methods of properly integrating the ratings of two or more taxonomic units into one rating for the map unit are prepared locally and must be documented for each soil map unit.
- (2) Enter for each use the factors that affect the use, as identified in the criteria for evaluation. Part 621, subpart B, sections 621.13 and 621.14, provide examples.
 - (3) Enter for each soil the class or range of each soil property, class, or factor that is used as an evaluation factor, such as shrink-swell—high, textural class—loam or sandy loam, Unified soil classification—SM, and depth to bedrock—20 to 40 inches.
 - (4) If limitation ratings, which are optional, are assigned, they are entered on the worksheet. Such ratings may be of particular value to individuals outside NRCS who are assisting with the ratings. If limitations are not used, indicate in some way when a soil factor presents an adverse effect and requires further consideration in the evaluation.
 - (5) Factors rated as moderate or severe limitations, or those indicated by other means, impose one or more adverse effects on the performance or the installation of the facility. Such factors include erosion, surface seepage, equipment limitations, reduced yields, or foundation failure. Enter the nature of these effects on the use or installation if no precautions or corrective measures are applied. List only the major effects that require correction.
 - (6) For each soil limitation, list one or more kinds of corrective measures that can overcome or minimize its effect and enter the cost index. For example, measures that are needed to overcome the effect of a high water table on soybeans may include delaying planting until the water table recedes, installing drainage tile, or providing drainage through land grading. The same measure may overcome two or more limitations. Enter the cost index for that measure only once.
 - (i) For soils with slight limitations, it may be desirable to identify a measure or set of measures in order to provide users with a complete list of recommendations for all soils. “Conventional systems” for septic tank absorption fields and “conventional design” for foundations are examples of these measures. The standards for the conventions are provided in the definition of the soil use.
 - (ii) As a general rule, no corrective measures are given for soils that have a slight limitation because these soils generally represent the standard. For some uses, however, there are variations in conventional installations even though only slight limitations exist and it may be desirable to identify them. For example, because of variations in percolation rates, there is a significant difference in the size required for septic tank absorption fields among soils that have slight limitations. Entries on worksheets might show “conventional system, small field” or “conventional system, medium field” to make this distinction.
 - (iii) An index of the costs of corrective measures to overcome limitations is a major factor in assessing soil potential. Significant ranges of these costs can be established, and index numbers rather than actual dollar values can be assigned. Part 621, subpart B, section 621.14, provides an example. This procedure can provide adequate distinctions between the costs of corrective measures, make evaluation easier, and avoid becoming too precise. Cost indexes can be based on prorated annual costs, initial installation costs, or other systems, provided that they are expressed in units of the same scale that is used in the indexes for performance and continuing limitations.
 - (7) Regardless of the corrective measures applied, a soil limitation may continue to cause problems through maintenance cost, substandard performance, or offsite environmental effects. Low yields, the maintenance of water disposal systems for erosion control or drainage, use restrictions on steep slopes and maintenance or adequacy of flood control systems are examples of continuing problems. Identify continuing limitations that are associated with alternative measures and indicate by a key phrase the kind of limitation that remains. Assign an index number from a set

of values that are compatible with those used for P and CM. For some soils, the properties responsible for substandard yields may not be known. In this case, note the substandard yield as a continuing limitation without relating it to an evaluation factor and enter a cost index for CL. Part 621, subpart B, section 621.18, provides an example.

- (8) For each CM that is required to overcome an unfavorable soil factor, select the practical and locally accepted corrective measure and the local cost index for the measure and calculate the sum. Calculate the sum of the indexes for CLs in the same fashion. Deduct the cost index for the CM and the cost index for the CL from P to determine the SPI. Part 621, subpart B, section 621.16, gives an example. Increase SPI as necessary to account for a performance or yield level that is above the standard. Part 621, subpart B, section 621.18, provides an example.

D. Ranking and Rating Classes.—All map units are arrayed from high to low according to their soil potential index. The relative ranking of soils is evaluated against local knowledge. If inconsistencies exist, the values used to arrive at SPI should be reevaluated. To arrive at rating classes, divide the final numerical array on the basis of the definition of the rating classes. The tendency of numbers in the array to cluster around certain ranges or to show natural group separations help to subdivide the array into the required classes. Part 621, subpart B, sections 621.18, 621.19, and 621.20, give examples. It may not be desirable to indicate the numerical ratings to users because the ratings may indicate a greater degree of refinement than can be defined.

E. Broadly Defined Map Units.—For broadly defined soil map units, such as a soil association, soil potential ratings are generally prepared only for broad categories of soil use. In the evaluation for such uses, consideration is given to one or more of the individual elements that make up the use. For example, the elements of residential soil use may include dwellings, local roads and streets, and shallow excavations. The following steps are suggested:

- (1) List the elements of the use being evaluated
- (2) List significant component soils and their extent in each map unit
- (3) Rate each component for each element of the use according to the guides given for the phases of soil series
- (4) Evaluate the map unit for the use according to the evaluation of each element for each component, giving due consideration to the extent of and the landscape relationship of each of the components

F. Local regulations.—Local regulations can affect the development of soils for some uses. If the regulations apply uniformly, soil potential ratings for cropland may include the regulated conditions as one of the rating criteria. A preferred alternative is to prepare the ratings as if there were no regulations and to footnote worksheets and final presentations to indicate those soils on which the use is prohibited by regulations. Dealings with regulated uses, such as sanitary facilities, that require approval by regulatory agencies need not be troublesome. Consideration of the alternatives and agreement on the procedures with those individuals for whom the soil potential ratings are being developed can result in useful soil potential ratings.

621.10 Terminology for Limitations and Corrective Measures

Ratings of soil potentials should be accompanied by a statement of the corrective measures that are required to overcome soil limitations. Broad categories of corrective measures are suggested for use with ratings for broad categories of soil uses and more specific corrective measures for use with ratings for the more specific uses. The choice of phrases or terms can best be determined locally on the basis of the properties of the soils and the kinds of corrective measures needed. Figure 621-A1 contains examples of

limitations, broad categories of corrective measures, and more specific corrective measures illustrate differences but is not intended to dictate specific terms for use.

Figure 621-A1

Limitations	Broad Categories of Corrective Measures	More Specific Corrective Measures
Wetness	Drainage	Surface drainage Tile drainage Land grading
Steep slope	Construction grading	Cuts and fills
Erodes easily	Erosion control	Vegetation Grassed waterway Terraces Conservation tillage
High shrink-swell	Strengthened foundations	Reinforced slab Extended footings Moisture control
Floods	Flood control	Raised foundation Dikes Improved channels
Low strength	Supported foundation	Widened footings Extended footings Slab foundation
Droughty	Irrigation	Sprinkler irrigation Furrow irrigation Border irrigation Trickle irrigation

621.11 Format for Presenting Soil Potential Ratings

A. Soil potential ratings must be effectively presented. All presentations must include an explanation of the ratings and local definitions of the rating classes. Part 621, subpart B, section 621.21, provides an example. Definitions of soil uses must also be included. Regardless of the method of presentation, the worksheets and the criteria for evaluation that were used must be retained in the NRCS office as documentation of the procedures. The participating agencies, the technical specialists who participated, and the NRCS specialists are identified in all publications.

B. Presentation may be in the narrative form, as in soil map unit descriptions or in tables. As a minimum, all tables and discussions must identify the soil potential rating and the corrective measures that are needed to achieve the potential of each soil map unit. Part 621, subpart B, sections 621.22, 621.23, and 621.24, provide examples. The most desirable format identifies the soil factors that adversely affect the use, the corrective measures, and a statement on any continuing limitations. Part 621, subpart B, section 621.21, explains.

C. The tables in part 621, subpart B, sections 621.22, 621.23, and 621.24, may be modified to meet local needs and requirements.

D. An example of a narrative statement in a map unit description for a phase of a soil series is as follows:

“The soil has high potential for septic tank absorption fields if the field size is increased to compensate for the slow percolation rate.”

E. A narrative statement in the description of a map unit or an association might be as follows:

“This association (or map unit) has high potential for residential use if foundations are strengthened and drainage is provided on Alpha soils or if dwellings are constructed only on Beta soils.”

F. Ratings for soil potential can be shown on colored maps; however, they must be supported by tabular or narrative presentations that identify the corrective measures needed to achieve the potential and that provide definitions of the soil uses and rating classes.

Part 621 – Soil Potential Ratings

Subpart B – Exhibits

621.12 Analysis of Preparations and Procedures for Soil Potential Ratings

PREPARATIONS OF SOIL POTENTIAL RATINGS

Design

Prepare and design with interdisciplinary input

- agricultural uses ----- required
- nonagricultural uses ----- required

Prepare and design ratings for map units ----- required

Prepare and design ratings for named

components of map units ----- required

Follow a systematic procedure ----- required

Procedures

Rate all soils in area for a given use ----- required

Give size of area for which ratings are prepared, such as

town, county, state, and MLRA. ----- optional

Follow given steps in preparation ----- required

Have data available on soils, corrective measures,

performance, and continuing limitations ----- required

Prepare plan for obtaining data if data are

inadequate ----- required

Give values for P, such as magnitude of base number ----- optional

Define soil use ----- required

Prepare evaluation criteria ----- required

Use regulations as rating criteria ----- optional

Title 430 – National Soil Survey Handbook

Establish performance standard -----	required
Assign limitation ratings to criteria -----	optional
Use a worksheet -----	required
Use sample worksheet -----	optional
Use index numbers not dollars, and bushels. -----	optional
Retain worksheet as documentation of procedures -----	required
Prepare key phrases for corrective measures and continuing limitations -----	suggested

Presentation to Users

--Provide in maps and tables, or in map unit descriptions -----	optional
--Use definitions of soil potential ratings -----	required
--Use terms and definitions of rating classes -----	required
--Provide definition of rated use -----	required
--Identify agencies and give names of participating local experts -----	required
--Show corrective measures (except on maps)-----	required
--Show continuing limitations-----	optional/suggested
--Avoid presentation of uncoordinated ratings-----	required
--Avoid repetition of limitation ratings for same soil use in other tables in same report-----	suggested
--Provide users with numerical indices -----	optional
--Use given format of tables -----	optional

621.13 Soil Potential Ratings for Forest Land (Beta County)

Definition:

Soils managed for maximum average yearly growth per acre (cubic feet), assuming established stands for loblolly pine if adapted, otherwise the best adapted hardwood, not fertilized or irrigated.

Yield standard:

130 cubic feet per acre average yearly growth. The yield standard of 130 cubic feet per acre per year is set on the basis of the production of a locally preferred forest land species on productive soils that are common to the area.

Evaluating Criteria:

Depth to water table (inches)
Flooding

Slope (percent)
Surface texture
Available water capacity

Cost Index:

A percentage of the value of the harvested crop rounded to the nearest whole number is used. Cost classes representing ranges of values are not used.

Performance Index:

100 (equivalent to the yield standard of 130 cubic feet per acre per year)

621.14 Soil Potential for Dwellings Without Basements

Definition:

Single-family residences; 1,400 to 1,800 square feet of living area; without basements; spread footings, slab construction, or both; life span of 50 years; and intensive use of yard for lawns, gardens, landscaping, and play areas. Ratings assume adequate waste disposal and lot sizes of one-fourth acre or less.

Evaluating Criteria:

Depth to water table (inches)
Flooding
Slope (percent)
Shrink-swell potential

Cost Index:

Cost classes for corrective measures

Index value^{1/} and continuing limitations (dollars)^{2/}

^{1/} Index values in this example are arbitrarily set at 0.4 percent of the upper limit of each cost class.

^{2/} To be compatible with costs of corrective measures, the cost of continuing limitations is established for the 50-year life span of the dwelling.

1	-----<250
2	-----250-500
4	-----500-1,000
8	-----1,000-2,000
12	-----2,000-3,000
16	-----3,000-4,000
20	-----4,000-5,000

621.15 List of Corrective Measures and Cost

This exhibit shows how local data might be summarized and made available as a ready reference for preparing soil potential ratings. Corrective measures likely to be needed can be anticipated and costs established for each. As soil potential ratings are prepared, additional measures may be identified that should be added to the list. The general technique applies to both agricultural and nonagricultural soil uses.

This example is only to illustrate a procedure. The corrective measures and costs that are shown are examples only and should not be used without modification to fit local situations.

The following list gives the corrective measures and costs for dwellings without basements. Corrective measures are those that overcome or minimize soil limitations identified in evaluating criteria. Costs are based on an arbitrary foundation area of local standards that is approximately 1,200 square feet. The costs are in excess of those for standard design where no soil limitations are identified. Index values are 1 percent of the range midpoint of estimated costs.

<u>Corrective Measures</u>	<u>Cost (dollars)</u>	<u>Index</u>
Drainage of footing	300-500	4
Drainage of footing and slab	600-800	7
Excavation and grading		
8-15 percent slope	100-300	2
15-30 percent slope	300-500	4
Rock Excavation and disposal (fractured limestone)		
0-8 percent slope	1,000-1,400	12
8-15 percent slope	700-900	8
Reinforced slab		
moderate shrink-swell potential	1,500-2,000	17
high shrink-swell potential	3,600-4,200	39
Area wide surface drainage (per lot)	100-200	2
Importing topsoil for garden and lawn	1,000-1,400	11

Examples of the application of cost index are:

- (a) Soil on 8 to 15 percent slopes with high shrink-swell potential requires:

$$\begin{array}{r}
 \text{Reinforced slab} \quad 39 \\
 \text{Excavation and grading} \quad 2 \\
 \text{CM} = 41
 \end{array}$$

- (b) Soil on 0 to 1 percent slope with high water table requires:

$$\begin{array}{r}
 \text{Areawide surface drainage} \quad 2 \\
 \text{Drainage for footing and slab} \quad 7 \\
 \text{CM} = 9
 \end{array}$$

621.16 Reserved (Worksheet for Preparing Soil Potential Ratings)

621.17 Explanation of Worksheets for Preparing Soil Potential Ratings for Forest Land (Beta County)

- (a) A worksheet is prepared for each soil map unit.
- (b) The yield standard (130) is adjusted to a standard performance index of 100 to provide a range of soil potential indexes from 0 to 100. Productivity of 130 cubic feet per acre (loblolly pine, site index 90) meets the standard performance index of 100, such as in the Alpha and Beta map units. Productivity of 110 cubic feet per acre (loblolly pine, site index 80) is substandard performance $SPI = 110/130 \times 100$ ($SPI = 85$), and is considered a continuing limitation if corrective measures fail to overcome the yield limitation, such as in the Gamma and Sigma map units. Productivity of 152 cubic feet per acre (loblolly pine, site index 100) is performance above the yield standard, $SPI = 152/130 \times 100$ ($SPI = 117$), and SPI increases, such as in the Omega map unit.
- (c) Enter evaluation factors from the table of rating criteria prepared for the soil use, as in part 621, subpart B, section 621.12.
- (d) Enter soil and site conditions for the map unit for each evaluation factor. Enter the degree of limitation from the table of evaluation criteria, as in part 621, subpart B, section 621.12.
- (e) Enter the effects of the soil and site conditions to provide a basis for the identification of corrective measures.
- (f) Enter feasible alternative measures for overcoming the effects of limiting soil or site conditions. Technical guides are useful references. Note that measures are identified wherever possible to overcome the effects of limitations in preference to leaving the problem as an unresolved continuing limitation.
- (g) In this example, index values for measures and continuing limitations are a percentage of the value of the harvested crops. Whether the costs occur only one time or several times in the period between planting and harvest is considered.
- (h) The factor that accounts for substandard yield of the Sigma soil is not known. The substandard yield is noted as a continuing limitation without relation to a soil factor.
- (i) Index values for corrective measures (CM) and continuing limitations (CL) are summed and deducted from the performance standard index (P) to determine the soil potential index (SPI).
- (j) The soil potential indexes are arrayed and the ratings are assigned as follows:

117	Very high	Omega silt loam
100	High	Beta fine sandy loam, 1 to 3 percent slopes
85	High	Alpha silt loam
78	Medium	Gamma loamy fine sand, 8 to 13 percent slopes
77	Medium	Sigma fine sandy loam, 15 to 25 percent slopes

621.18 Reserved (Worksheet for Preparing Soil Potential Ratings for Forest Land (Beta County))

621.19 Reserved (Worksheet for Preparing Soil Potential Ratings for Septic Tank Absorption Fields (Sigma County))

621.20 Reserved (Worksheet for Preparing Soil Potential Ratings for Dwellings Without Basements (Alpha County))

621.21 Explanation of Soil Potential Ratings for Maps or Reports

(a) The soil potential ratings indicate the comparative quality of each soil in the county for the specified uses. Because comparisons are made only among soils in this county, ratings for a given soil in another county may differ.

(b) Potential ratings are based on a system developed for a given county and include consideration of yield or performance levels, the difficulty or relative cost of corrective measures that can improve soil performance or yield, and any adverse social, economic, or environmental consequence that cannot be easily overcome.

(c) The ratings do not constitute recommendations for soil use. They are to assist individuals, planning commissions, and others in arriving at wise land use decisions. Treatment measures are intended as a guide to planning and are not to be applied at a specific location without onsite investigations for design and installation.

(d) The soil potential ratings used are defined as follows: (the definitions of those soil potential ratings used are inserted.)

621.22 Soil Potential Ratings for Septic Tank Absorption Fields

Soil Name and Map Symbol	Limitations and Restrictions	Soil Potential and Corrective Treatment	Continuing Limitations
1--Grenada silt loam, 0 to 2 percent slopes	Severe: percs slowly.	Medium: conventional system, alternate valve, large field, pump tank in wet season.	Monitor system for need to pump.
2--Jefferson gravelly loam, 5 to 10 percent slopes	Slight	Very high: conventional system, small field.	None.
3--Linsdale silt loam, 0 to 2 percent slopes	Severe: wetness.	High: conventional system, medium field, area-wide subsurface drainage.	Maintain drainage system.
4--Memphis silt loam, 2 to 6 percent slopes	Slight	High: conventional system, medium field.	None.
5--Memphis silt loam, 12 to 20 percent slopes	Moderate: slope.	High: conventional system, medium field, slope design.	None.
6--Memphis silt loam, 25 to 30 percent slopes	Severe: slope.	Very low: no known system.	---
7--Talbott silt loam, 8 to 12 percent slopes	Severe: percs slowly, depth to rock.	Low: mound system.	None.
8--Waverly silt loam, 0 to 2 percent slopes	Severe: wetness.	Low: mound system.	None.

621.23 Soil Potential Ratings for Cropland

Soil Name and Map Symbol	Soil Potential and Corrective Treatment	Continuing Limitations
1--Caddo silt loam, 0 to 1 percent slopes	High: drainage, high fertilization rate.	Maintenance of drainage system.
2--Gore fine sandy loam 8 to 12 percent slopes	Low: erosion control.	Maintenance of erosion control system, substandard yield.
3--Guyton silt loam	Medium: drainage, high fertilization rate	Maintenance of drainage system.
4--Guyton silt loam, frequently flooded	Very low: project-type flood control, drainage	Maintenance of drainage and flood control system.
5--Kisatchie soils, 15 to 30 percent soils	Very low: erosion control, high fertilization rate.	Maintenance of erosion control system, equipment limitations substandard yield.
6--Norwood silt loam	Very high: drainage.	Maintenance of drainage system.
7--Ruston fine sandy loam, 3 to 5 percent slopes	High: erosion control.	Maintenance of erosion control system.
8--Ruston fine sandy loam, 8 to 12 percent slopes	Low: erosion control.	Maintenance of erosion control system, substandard yield.

621.24 Soil Potential Ratings and Corrective Measures for Cropland, Pastureland, Forest Land, and Residential Land

Soil Name	Cropland	Pastureland	Forest land	Residential land
1--Caddo silt loam, 0-1 percent slopes	High: drainage.	High: drainage, scheduled grazing avoid wet conditions.	High: scheduled operations to avoid wetness.	Medium: drainage
2--Core fine sandy loam, 8 to 12	Low: erosion control.	Medium: erosion control.	Medium: scheduled operations to avoid wet conditions.	Medium: construction grading, water disposal, strengthened foundation.
3--Guyton silt loam	Medium: drainage.	Medium: drainage, scheduled grazing to avoid wet conditions.	High: scheduled operations to avoid wet conditions.	Low: drainage diversions.
4--Guyton silt loam, frequently flooded	Very low: project-type flood control.	Low: drainage, adapted water tolerant plants, scheduled grazing to avoid wet conditions.	High: scheduled operations to avoid wet conditions.	Very low: project type flood control, drainage.
5--Kisatchie soils, 15 to 30 percent slopes	Very low $\frac{1}{2}$:	Low: reduced stocking rates.	Low: erosion control during site preparation and logging.	Low: construction grading, water disposal excavate rock.
6--Norwood silt loam	Very high:	Very high:	Very high	Very high

Title 430 – National Soil Survey Handbook

7--Ruston fine sandy loam, 3 to 8 percent slopes	High: erosion control.	Very high:	High	Very high
8--Ruston fine sandy loam, 8 to 12 percent slopes	Low: erosion control.	Very high:	High	High: construction grading, water disposal.

^{1/} Soil conditions are such that treatments are generally not warranted for this use.

Soil Use:

Area:

Mapping Unit:

Evaluation Factors	Soil and Site Conditions	Degree of Limitation	Effects On Use	Corrective Measures		Continuing Limitations	
				Kinds	Index	Kind	Index
				Total		Total	

$$\frac{\text{Performance Standard Index}}{\text{Measure Cost Index}} - \frac{\text{Continuing Limitation Cost Index}}{\text{Soil Potential Index}} = \frac{\text{Soil Potential Index}}{\text{Soil Potential Index}}$$

1/ If performance exceeds the standard increase SPI by that amount.

Soil Use: Forest Land

Area: Beta County

Yield standard 130 ft³ /ac/yr

Mapping Unit: Sigma fine sandy loam, 15 to 25 percent slopes

Yield estimate 110 ft³ /ac/yr

Evaluation Factors	Soil and Site Conditions	Degree of Limitation	Effects On Use	Corrective Measures		Continuing Limitations	
				Kinds	Index	Kind	Index
Slope (percent)	15-25%	Moderate	Equipment limitation, Erosion	Safety Precautions ^{2/} Road design	4 3	None Road Maintenance	1
Depth to high water table (ft.)	>2'	Slight	None				
Flooding	None	Slight	None				
Available water capacity (5 ft. depth)	>8"	Slight	None				
Surface texture	Loamy	Slight	None			Moderate yield ^{3/}	15
				Total	7	Total	16

^{2/} Special equipment not considered practical.^{3/} Substandard yield not accounted for in evaluation factors. Corrective measures not known. Yield is 15% below standard.

$$\frac{100}{\text{Performance Standard Index}} - \frac{7}{\text{Measure Cost Index}} - \frac{16}{\text{Continuing Limitation Cost Index}} = \frac{77}{\text{Soil Potential Index}^1}$$

^{1/} If performance exceeds the standard increase SPI by that amount.

Soil Use: Septic tank absorption fields

Area: Sigma County

Mapping Unit: Alpha silt loam, 12 to 20 percent slopes

Evaluation Factors <u>2/</u>	Soil and Site Conditions	<u>2/</u> Degree of Limitation	Effects On Use	Corrective Measures		Continuing Limitations	
				Kinds	Index	Kind	Index
Percolation rate	45 min/in	Slight	None	Conventional system medium field <u>3/</u>	0	None	0
Water table	>6'	Slight	None				
Flooding	None	Slight	None				
Slope	12-20%	Moderate	Surface seepage	Slope design	10 <u>4/</u>	None	0
Stoniness	None	Slight	None				
Depth to rock or other impervious material	>6'	Slight	None				
				Total	10	Total	0

2/ Local factors and ratings.3/ This system is the standard installation.4/ Index number is percent above standard installation cost.

$$\frac{100}{\text{Performance Standard Index}} - \frac{7}{\text{Measure Cost Index}} - \frac{0}{\text{Continuing Limitation Cost Index}} = \frac{90}{\text{Soil Potential Index}^1}$$

1/ If performance exceeds the standard increase SPI by that amount.

Title 430 – National Soil Survey Handbook

Soil Use: Dwellings without basements

Area: Alpha County

Mapping Unit: Beta silt loam

Evaluation Factors ^{2/}	Soil and Site Conditions	^{2/} Degree of Limitation	Effects On Use	Corrective Measures		Continuing Limitations	
				Kinds	Index	Kind	Index
Depth to high water table	0-2' (perched)	Severe	Wet lawns Construction Problems	Surface drainage Special drainage during construction	2 4	Maintain drainage yard use restrictions in wet seasons	1 6
Flooding	None	Slight	None				
Slope	0-1%	Slight	None	Slope design	10	None	0
Shrink-swell	Low	Slight	None				
				Total	6	Total	7

$$\frac{100}{\text{Performance Standard Index}} - \frac{6}{\text{Measure Cost Index}} - \frac{7}{\text{Continuing Limitation Cost Index}} = \frac{87}{\text{Soil Potential Index}^{1/}}$$

Performance Standard Index Measure Cost Index Continuing Limitation Cost Index Soil Potential Index^{1/}

^{1/} If performance exceeds the standard increase SPI by that amount.

Part 622 – Interpretive Groups

Subpart A – General Information

622.0 Definition and Purpose

A. Definition.—Interpretative groups are specified land use and specific management groupings that are assigned to soil areas because combinations of soils have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil.

B. Purpose.—Interpretative groups allow users of soil surveys to plan and compare reasonable alternatives for the use and management of soils.

622.1 Procedures and Responsibilities

A. Procedures.—The soil criteria used to determine the rating are coordinated nationally. Data elements, classes, or groups that are used in national legislation have strict adherence to national procedures. Guides that are developed locally or by States to rate soil survey land classification and groups are reviewed according to the procedure discussed in Part 617, Section 617.03 of this handbook. Prime farmland, hydrologic soil groups, and other interpretative groups important to many different users are published in the soil survey report.

B. Responsibilities.—The state soil scientist is responsible for program-specific and State interpretative group assignments to map units and soil components, as appropriate. The state soil scientist ensures that all nationally significant interpretative group assignments to map units and soil components are included in the official soil survey database.

622.2 Land Capability Classification

A. Definition.—Land capability classification is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time.

B. Classes.—Land capability classification is subdivided into capability class and capability subclass nationally. Some States also assign a capability unit.

C. Significance.—Land capability classification has value as a grouping of soils. National Resource Inventory information, and many field office technical guides have been assembled according to these classes. The system has been adopted in many textbooks and has wide public acceptance. Some State legislation has used the system for various applications. Users should reference Agriculture Handbook No. 210 (available online at: <https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/ref/> under Technical References) for a listing of assumptions and broad wording used to define the capability class and capability subclass.

D. Application.—All map unit components, including miscellaneous areas, are assigned a capability class and subclass. Agriculture Handbook No. 210 provides general guidance, and individual State guides provide assignments of the class and subclass applicable to the State. Land capability units can be used to differentiate subclasses at the discretion of the State. Capability class and subclass are assigned to map unit components in the official soil survey database.

Part 618, Subpart B, Exhibits, Section 622.16 provides an overall schematic of some of the soil properties and qualities that can be used to assign land capability classes (LCC) to all map unit

components. Part 618, Subpart B, Exhibits, Sections 622.17 and 622.20 are State-specific guides used to assign land capability classes to all map unit components in the States of California and Indiana, respectively. They provide examples of the soil properties and qualities used to determine assignments of LCC. Part 618, Subpart B, Exhibits, Sections 622.18 and 622.21 are examples of guides used to assign land capability subclasses to soil map unit components in the States of California and Indiana, respectively. Part 618, Subpart B, Exhibits, Section 622.19 is an example of a State-specific guide used to assign land capability units to soil map unit components in the State of California. None of these guides contains detailed information that applies to all soils of the United States. Criteria for the assignment of land capability classifications to map unit components should be developed for each State within national standards.

For map unit components that occur wholly within a State for a major land resource area (MLRA) that does not extend into another State, the state soil scientists should work with the MLRA soil survey leaders in developing land capability class and subclass criteria that are within Agriculture Handbook No. 210. Where the same kind of map unit component extends beyond State boundaries, the soil survey regional director will provide technical leadership to state soil scientists, MLRA soil survey leaders, and others to achieve uniform land capability class and subclass criteria between the States, soil survey offices, and MLRA soil survey areas. The Soil and Plant Science Division (SPSD) national staff provides technical assistance to the state soil scientists and the MLRA soil survey leaders in writing land capability class and subclass criteria and coordinates assignment of capability class and subclass to map unit components. This includes reviewing assigned class and subclass to lists of soils and miscellaneous areas and resolving coordination problems that may occur among States, soil survey offices, and soil survey regional offices.

E. Categories

(1) Capability Class

- (i) Definition.—Capability class is the broadest category in the land capability classification system. Class codes I (1), II (2), III (3), IV (4), V (5), VI (6), VII (7), and VIII (8) are used to represent both irrigated and nonirrigated land capability classes.
- (ii) Classes and definitions.—The following definitions, from Agriculture Handbook No. 210, have been slightly altered.
 - Class I (1) soils have slight limitations that restrict their use.
 - Class II (2) soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.
 - Class III (3) soils have severe limitations that reduce the choice of plants or require special conservation practices, or both.
 - Class IV (4) soils have very severe limitations that restrict the choice of plants or require very careful management, or both.
 - Class V (5) soils have little or no hazard of erosion but have other limitations, impractical to remove, that limit their use mainly to pasture, rangeland, forestland, or wildlife habitat.
 - Class VI (6) soils have severe limitations that make them generally unsuited to cultivation and that limit their use mainly to pasture, rangeland, forestland, or wildlife habitat.
 - Class VII (7) soils have very severe limitations that make them unsuited to cultivation and that restrict their use mainly to rangeland, forestland, or wildlife habitat.
 - Class VIII (8) soils and miscellaneous areas have limitations that preclude their use for commercial plant production and limit their use mainly to recreation, wildlife habitat, water supply, or esthetic purposes.

(2) Capability Subclass

- (i) Definition.—Capability subclass is the second category in the land capability classification system. Class codes e, w, s, and c are used for land capability subclasses.
- (ii) Subclasses and definitions
 - Subclass e is made up of soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use. Erosion susceptibility and past erosion damage are the major soil factors that affect soils in this subclass.
 - Subclass w is made up of soils for which excess water is the dominant hazard or limitation affecting their use. Poor soil drainage, wetness, a high water table, and overflow are the factors that affect soils in this subclass.
 - Subclass s is made up of soils that have soil limitations within the rooting zone, such as shallowness of the rooting zone, stones, low moisture-holding capacity, low fertility that is difficult to correct, and salinity or sodium content.
 - Subclass c is made up of soils for which the climate (the temperature or lack of moisture) is the major hazard or limitation affecting their use.
- (iii) Application.—The subclass represents the dominant limitation that determines the capability class. Within a capability class, where the kinds of limitations are essentially equal, the subclasses have the following priority: e, w, s, and c. See the rules (shown below) on appropriate entries for capability subclass.

(3) Capability Unit

- (i) Definition.—Capability unit is the first category described in the land capability classification system. It is a grouping of one or more individual soil map units having similar potentials and continuing limitations or hazards.
- (ii) Application.—Use of this category and definition of codes are State options.

F. Entries.—Enter the appropriate land capability class for each map unit component, including miscellaneous areas. Enter the land capability subclass only for soil map unit components which are assigned to capability classes 2 through 7. Capability subclasses are not assigned to soil components in capability class I (1) and are not assigned to soil or miscellaneous area components in capability class VIII (8). Subclass e is not used with soil components assigned to capability class V (5). Enter the appropriate capability unit code, if one is to be used in the area. Allowable entries for capability class are I (1), II (2), III (3), IV (4), V (5), VI (6), VII (7), or VIII (8). Allowable entries for subclass are e, w, s, or c. Valid entries for capability unit are integers ranging from 1 to 99. Enter the nonirrigated land capability class for all map unit components, including miscellaneous areas. Enter the irrigated land capability class and subclass if the soil map unit component is irrigated or potentially will be irrigated.

622.3 Farmland Classification

A. Definition.—The farmland classification designates map units as prime farmland, farmland of statewide importance, farmland of local importance, or farmland of unique importance. Soil map units with components of prime farmland are classified as *prime* where 50 percent or more of the components in the map unit composition are prime; *of statewide importance* where less than 50 percent of the components in the map unit are prime but a combination of lands of prime or statewide importance is 50 percent or more of the map unit composition; *of local importance* where less than 50 percent of the components in the map unit are of prime or statewide importance but the total of land of prime, statewide, and/or local importance is 50 percent or more of the map unit composition. All other soil map units are shown as not farmland unless they are designated as unique.

- (1) *Prime farmland* (<https://www.gpo.gov/fdsys/granule/CFR-2012-title7-vol6/CFR-2012-title7-vol6-part657/content-detail.html>) is defined as land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and that

is available for these uses. It has the combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economic manner if it is treated and managed according to acceptable farming methods. In general, prime farmland has an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, an acceptable level of acidity or alkalinity, an acceptable content of salt or sodium, and few or no rocks. Its soils are permeable to water and air. Prime farmland is not excessively eroded or saturated with water for long periods of time, and it either does not flood frequently during the growing season or is protected from flooding. Users of the lists of prime farmland map units should recognize that soil properties are only one of several criteria that are necessary. Other considerations for prime farmland are the following:

- (i) Land use.—Prime farmland is designated independently of current land use, but it cannot be areas of water or urban or built-up land. Map units that are complexes or associations containing components of urban land or other miscellaneous areas, as defined in the *Soil Survey Manual* as part of the map unit name (i.e., major components), cannot be designated as prime farmland. The soil survey memorandum of understanding determines the scale of mapping, and local land use interests should be considered in designing map units.
- (ii) Flooding frequency.—Some map units may include both prime farmland and land not prime farmland because of variations in flooding frequency.
- (iii) Irrigation.—Some map units have areas with a developed irrigation water supply that is dependable and of adequate quality while other areas do not have such a supply. In these map units, only the irrigated areas meet the prime farmland criteria.
- (iv) Water table.—Most map units are drained but a few undrained areas are included. Only the drained areas meet the prime farmland criteria.
- (v) Wind erodibility.—The product of I (soil erodibility) x C (climate factor) cannot exceed 60 to meet prime farmland criteria.
- (2) *Unique farmland* is land other than prime farmland that is used for the production of specific high-value food and fiber crops. It has the special combination of soil quality, location, growing season, and moisture supply needed to economically produce sustained high-quality and/or high yields of a specific crop when treated and managed according to acceptable farming methods. Examples of such crops are citrus, tree nuts, olives, cranberries, fruit, and vegetables.

The specific characteristics of unique farmland are the following:

- (i) It is used for a specific high-value food or fiber crop;
- (ii) It has a moisture supply that is adequate for the specific crop (the supply is from stored moisture, precipitation, or a developed irrigation system); and
- (iii) It combines favorable factors of soil quality, growing season, temperature, humidity, air drainage, elevation, aspect, or other conditions, such as nearness to market, that favor the growth of a specific food or fiber crop.

B. Significance.—Farmland classification identifies the location and extent of the most suitable land for producing food, feed, fiber, forage, and oilseed crops. The Natural Resources Conservation Service (NRCS) has national leadership for the management and maintenance of the resource base that supports the productive capacity of American agriculture. This management and maintenance includes identifying, locating, and determining the extent of the most suitable land for producing food, feed, fiber, forage, and oilseed crops. Prime farmland information is one of the four designations of farmland. An NRCS state conservationist can approve and have recorded in the field office technical guide (FOTG) a list of soil map units that meet soil information-based criteria, as determined by the appropriate State agency, for *additional farmland of statewide importance*. The state conservationist also can approve and have recorded in the FOTG a list of soil map units

identified as *additional farmland of local importance* by the local agency or agencies if the units are capable of producing crops but do not meet criteria for prime farmland, unique farmland, or farmland of statewide importance.

C. Measurement.—NRCS policy and procedures on farmland are published in the Code of Federal Regulations 7CFR657. This regulation is reproduced in Part 618, Subpart B, Exhibits, Section 622.15 for convenience. It is also available online at:

<https://www.federalregister.gov/documents/2000/09/25/00-24525/prime-and-unique-farmlands-important-farmlands-inventory>.

D. Policy.—State soil scientists prepare and maintain a current list of soil survey map units that meet the soil criteria for farmland classification. The list given in field office technical guides is for users concerned with only a single part of a subset of the State list. The state soil scientist ensures that farmland soil interpretations are made for all soil map units in the State. Soil map units that qualify as prime farmlands are coordinated with adjacent States.

E. Entries.—Enter the numerical code for the classification of each map unit. Soils of unique, statewide, or local importance are not prime farmland. Allowable entries and numerical choice codes are the following:

- 0 – Not prime farmland.
- 1 – All areas are prime farmland.
- 2 – Prime farmland if drained.
- 3 – Prime farmland if protected from flooding or not frequently flooded during the growing season.
- 4 – Prime farmland if irrigated.
- 5 – Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season.
- 6 – Prime farmland if irrigated and drained.
- 7 – Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season.
- 8 – Prime farmland if subsoiled, completely removing the root-inhibiting soil layer.
- 9 – Prime farmland if irrigated and the product of I (soil erodibility) × C (climate factor) does not exceed 60.
- 10 – Prime farmland if irrigated and reclaimed of excess salts and sodium.
- 30 – Farmland of statewide importance.
- 32 – Farmland of statewide importance, if drained.
- 33 – Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season.
- 34 – Farmland of statewide importance, if irrigated.
- 35 – Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season.
- 36 – Farmland of statewide importance, if irrigated and drained.
- 37 – Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season.
- 38 – Farmland of statewide importance, if subsoiled, completely removing the root-inhibiting soil layer.
- 39 – Farmland of statewide importance, if irrigated and the product of I (soil erodibility) × C (climate factor) does not exceed 60.
- 40 – Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium.
- 41 – Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season.

- 42 – Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season.
- 43 – Farmland of statewide importance, if warm enough.
- 44 – Farmland of statewide importance, if thawed.
- 50 – Farmland of local importance.
- 54 – Farmland of local importance, if irrigated.
- 70 – Farmland of unique importance.

F. Quality Control of Prime Farmland Map Units

- (1) NRCS policy and procedures on important farmlands are published in 7 CFR Part 657. Determination of prime farmland map units in each State is based on guidelines provided by Soil and Plant Science Division (SPSD) national staff. The *National LESA Handbook* includes methodology for evaluating soils for prime farmland that applies the criteria established in 7 CFR Part 657.5. A NASIS report has been developed to identify concerns in the classification of prime farmland based on soil properties. The report can be used for guidance but does not suffice as the sole determinant for prime farmland map units.
- (2) Each prime farmland map unit must be documented, by either use of the report or criteria as defined in 7 CFR Part 657, or by a statement of reasons that explain the decision.
- (3) Some soil survey map units may meet the soil criteria for prime farmland, but additional investigation is needed before a final determination is made. The measures needed to qualify the soil as prime farmland are indicated by an appropriate footnote or in a parenthetical statement of explanation that follows the map unit name on the list.

622.4 Highly Erodible Land – Highly Erodible Soil Map Unit List

A. Definition.—Highly erodible land is defined by the Sodbuster, Conservation Reserve, and Conservation Compliance parts of the Food Security Act of 1985 and the Food, Agriculture, Conservation, and Trade Act of 1990. Determinations for highly erodible land are based on an erodibility index as defined in the *National Food Security Act Manual*.

B. Policy.—Lists of highly erodible and potential highly erodible map units are maintained in the field office technical guide (available online at http://efotg.sc.egov.usda.gov/efotg_locator.aspx?map). Policy and procedures for developing and maintaining the lists are given in Part 511 of the *National Food Security Act Manual*, 5th edition, November 2010 (available at <http://directives.sc.egov.usda.gov/RollupViewer.aspx?hid=29362>).

622.5 Hydric Soils

A. Definition.—A hydric soil is a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. Hydric soils along with hydrophytic vegetation and wetland hydrology are used to define wetlands.

B. Policy.—The current criteria for generating a list of hydric soils is in the Federal Register, February 29, 2012, volume 77, number 40, page 12234: <https://www.gpo.gov/fdsys/pkg/FR-2012-02-29/pdf/2012-4733.pdf>. The reference for field identification of hydric soils and their delineation is *Field Indicators of Hydric Soils of the United States: A Guide for Identifying and Delineating Hydric Soils*. The latest version is available online at <https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/ref/> under Field Guides.

C. Procedures.—Hydric soil determinations are made in the field and not in the office. The state soil scientist is responsible for program-specific and State interpretative group assignments to map units and soil components, as appropriate, including component hydric ratings and component hydric

criteria. The following rules are for populating hydric soil rating and component hydric criteria in NASIS:

Hydric Rating

- (1) All major or minor components should be assigned a hydric rating of yes, no, or unranked.
- (2) All soil components should be rated either as hydric rating=yes or hydric rating=no.
- (3) All miscellaneous area components, should be assigned hydric rating=no. Miscellaneous area components (including water) are by definition, non-soil, and therefore cannot be hydric soils.
- (4) Whenever there is doubt about the hydric soil rating for any soil component based on the criteria, the assignment should be hydric rating=unranked. When unranked is the hydric rating, an on-site investigation is required to determine component hydric rating, and component hydric criteria.

Hydric Criteria

- (1) If a component is populated with hydric rating =yes, then appropriate component hydric criteria should be populated also.
- (2) If a component is populated with hydric rating =no or is unranked, then no component hydric criteria should be populated.

622.6 Ecological Sites

A. Definition.—An ecological site is a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation. An ecological site is recognized and described on the basis of the characteristics that differentiate it from other sites in its ability to produce and support a characteristic plant community. For details on developing ecological site descriptions refer to the *National Ecological Site Handbook*.

B. Policy.—Soil-ecological site correlation establishes the relationship between soil components and ecological sites. Ecological sites are correlated on the basis of soils and the resulting differences in species composition, proportion of species, and total production of the reference plant community. In some cases it is necessary to extrapolate data on the composition and production of a plant community on one soil to describe the plant community on a similar soil for which no data are available. The separation of two distinct soil taxonomic units does not necessarily delineate two ecological sites. Likewise, some soil taxonomic units occur over broad environmental gradients and may support more than one distinctive historic climax plant community. Changes may be brought about by other influences, such as an increase or decrease in average annual precipitation. Ecological sites are correlated within MLRAs or LRUs. Refer to the *National Ecological Site Handbook* (<https://directives.sc.egov.usda.gov/>) for details on the policy for correlating ecological sites.

C. Responsibilities.—Soil scientists and the responsible discipline specialists work together to map soils and ecological sites. Essential activities include developing a soil survey memorandum of understanding, including an ecological site component in all soil survey project plans, determining the composition of map units, preparing map legends, determining mapping intensity, and conducting necessary field reviews. Soil survey regional directors have the final responsibility for correlating ecological sites to the map unit component to ensure coordination among States and land use areas.

622.7 Windbreaks

D. Definition.—A windbreak is a living barrier of trees or a combination of trees and shrubs that is located adjacent to a farmstead, field, feedlot, or other area. It is established to protect soil resources, reduce wind erosion, conserve energy or moisture, control snow deposition, provide shelter for livestock or wildlife, or increase the natural beauty of an area. It is also called a field windbreak,

feedlot windbreak, or farmstead windbreak, depending upon its intended use. Field windbreaks, often called shelterbelts, are long, narrow strips of trees and shrubs that are planted in a variety of patterns to check the movement of wind.

E. Policy.—Soil interpretations are made for all soils in all areas where windbreaks are a present or potential practice. These interpretations are to be included in field office technical guides, soil handbooks, and published soil surveys. Soil scientists work with foresters in preparing windbreak interpretations. Refer to the *National Forestry Manual*) for forestland interpretations. Conservation Tree/Shrub Group is a forestland interpretation useful for windbreak planning (see Part 537.4, Exhibit 537-15 of manual).

622.8 Wildlife Habitat

A. Definition.—The habitat of a particular animal is defined as the place where the animal lives. Each habitat is the entire environmental complex, both living and nonliving, that is present at the place occupied by the animal species. Ratings are based on soils in their described condition and do not consider existing vegetation, water sources, or the presence or absence of wildlife in the area. These factors need to be considered during the site evaluation and planning process in order to obtain total habitat quality.

B. Policy.—Soil interpretations can be developed for all soils that have the potential to provide some form of habitat to locally adapted wildlife species. Soil scientists and biologists work together to identify specific wildlife habitat elements and to develop the categorical lists for the local area. This information is based on the inherent capabilities of the soil to produce certain kinds of vegetation for use as wildlife habitat or as habitat that meets the specific requirements of an animal species. Part 512 of the *National Biology Manual* (available online at: <http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17895.wba>) provides more information.

622.9 Plant Name, Common

A. Definition.—The common plant name is the common name, accepted by the State or region, for the plant species or general .

B. Entries.—None required. The common plant name used in a specific State will be provided by the system from the PLANTS database (available online at: <http://plants.usda.gov/>) to match the plant symbol entered elsewhere. Adjustment or additions can be made.

622.10 Plant Name, Scientific

A. Definition.—Scientific plant name is the full genus and species name with author. Refer to *PLANTS*, Plant List of Accepted Nomenclature, Taxonomy, and Symbols.

B. Significance.—This information is important for technology transfer and interchange.

C. Entries.—None required. The system will provide the scientific plant name to match the plant symbol entered elsewhere.

622.11 Ecological Site ID

A. Definition.—Ecological site ID integrates a coding scheme for labeling LRRs, MLRA, LRUs, and ecological sites to achieve the following four objectives:

- (1) To represent the hierarchy.
- (2) To provide flexibility for expanding and contracting subdivisions.
- (3) To provide a code that retains current and familiar symbols.
- (4) To be intuitive and easily discernable at a quick glance.

B. Entries.—Enter the unique ID for the ecosystem for each map unit component where needed. Valid entries are combinations of numbers and/or letters up to 10 characters in length.

622.12 Ecological Site Name

A. Definition.—Ecological site name is the descriptive name of a particular ecological site. For example, "Loamy Upland" is a name of an ecological site.

B. Entries.—Enter the appropriate name of the ecological site for each map unit component where needed.

622.13 Earth Cover, Kind

A. Definition.—Earth cover, kind, is the natural or artificial material that is observed to cover a portion of the earth's surface. It is determined (at least conceptually) as a vertical projection downward. There are two levels of categories.

B. Significance.—Earth cover, kind, is useful in assessing soils for use and management and monitoring for soil health. Identifying earth cover, kind, is important when linking to National Resources Inventory (NRI) data. Soil data ranges included in the map unit records in NASIS may be narrowed by indicating the cover type present for each map unit component. Significant differences for interpretations between the major cover types can be shown by designating each map unit component with the appropriate cover types. Earth cover, kind, is divided into two levels. The second is a subdivision of the first.

C. Earth Cover Kind Level One Classes.—The seven Level One classes correspond to the Level One categories used in the National Resources Inventory.

- (1) Crop cover.—The cover lasting the full cropping cycle (which includes land preparation, leaving a post-harvest residue cover of annual or perennial herbaceous plants that are cultivated or harvested or both) in the production of food, feed, oil, and fiber other than wood and excluding hay and pasture.
- (2) Grass/herbaceous cover.—Non-woody vegetative cover (>50% grass, grass-like, or forb cover) composed of annual or perennial grasses, grass-like plants (sedges/rushes), forbs (including alfalfa and clovers), mosses, lichens, and ferns.
- (3) Tree cover.—Vegetative cover (>25% tree canopy cover) recognized as woody plants which usually have one perennial stem, a definitely formed crown of foliage, and a mature height of at least 4 meters. This category contains all trees, even those planted for the purpose of producing food or ornamentals, including Christmas trees. It also includes those lands which have been harvested of trees, even those that have been clear cut but will return to tree cover.
- (4) Shrub cover.—Vegetative cover (>50% shrub canopy cover) composed of multi-stemmed, woody plants, and single-stemmed species that attain less than 4 meters in height at maturity. This category contains all shrubs and woody vines, even those planted for the purpose of producing food.
- (5) Barren land.—Nonvegetative (<5% vegetated cover) natural cover on soils that commonly have a limited capacity to support vegetation and have a surface layer of sand, rock, thin soil,

or permanent ice or snow. This category also includes bare soil resulting from construction activities and extractive activities, such as mining.

- (6) Artificial cover.—Nonvegetative cover either made or modified by human activities that prohibit or restrict vegetative growth and water penetration. Examples include highways, rooftops, road surfaces, paved and stone surface parking areas, sidewalks, and driveways.
- (7) Water cover.—Earth covered by water in a fluid state. This category includes seasonally frozen areas.

<u>CODE</u>	<u>CLASS</u>
C	Crop cover
G	Grass/herbaceous cover
T	Tree cover
S	Shrub cover
B	Barren land
A	Artificial cover
W	Water cover

D. Earth Cover Kind Level Two Classes.—The 28 Level Two classes are grouped as subdivisions of Level One classes (except water cover) as follows:

Level 1: **Crop cover**
Level 2

- (1) Row crops.—Examples are corn, soybeans, cotton, tomatoes, and tulips.
- (2) Close-grown crops.—Examples are wheat, rice, oats, and rye.

Level 1: **Grass/herbaceous cover**
Level 2

- (3) Rangeland, grassland (<10% trees, <20% shrubs).—This subdivision includes rangeland used for hayland, with plants such as bluestems, mixed midgrasses, and shortgrasses.
- (4) Rangeland, savanna.—10 to 25% tree cover
- (5) Rangeland, shrubby.—20 to 50% shrub cover. (e.g., sumac, sagebrush, mesquite)
- (6) Rangeland, tundra
- (7) Pastureland, tame.—Examples are fescues, brome grass, timothy, and lespedeza.
- (8) Hayland.—Examples are fescues, brome grass, timothy, and alfalfa.
- (9) Marshland.—Examples are grasses and grass-like plants.
- (10) Other grass/herbaceous cover

Level 1: **Tree cover**
Level 2

- (11) Crop trees.—Examples are apples, pecans, date palms, citrus, ornamental nursery stock, and Christmas trees.
- (12) Conifers.—Examples are spruce, pines, and Douglas-fir.
- (13) Hardwoods.—Examples are oak, hickory, elm, and aspen.
- (14) Intermixed conifers and hardwoods.—An example is an oak-pine mix.
- (15) Tropical.—Examples are mangrove and royal palms.
- (16) Swamp.—Trees and shrubs.
- (17) Other tree cover

Level 1: **Shrub cover**

Title 430 – National Soil Survey Handbook

Level 2

- (18) Crop shrubs.—Examples are filberts, blueberry, and ornamentals used as nursery stock.
- (19) Crop vines.—Examples are grapes, blackberries, and raspberries.
- (20) Native shrubs.—Examples are creosote bush, shrub live oak, sagebrush, and mesquite. (Includes rangeland with >50% shrub cover.)
- (21) Other shrub cover.

Level 1: Barren land

Level 2

- (22) Rock
- (23) Sand and gravel
- (24) Culturally induced barren.—Examples are saline seeps, mines, quarries, and oil-waste land.
- (25) Permanent snow and ice
- (26) Other barren.—Examples are playas and badland. Excludes areas with culturally induced earth cover.

Level 1: Artificial cover

Level 2

- (27) Rural transportation.—Examples are highways and railroads.
- (28) Urban and built-up.—Examples are cities, towns, farmsteads, and industrial sites.

E. Entries.—Enter the applicable Earth Cover Kind Level One class for each map unit component. Enter the applicable Earth Cover Kind Level Two class as appropriate.

Part 622 – Interpretive Groups

Subpart B – Exhibits

622.20 Prime and Unique Farmlands

7 CFR Part 657 is maintained in the following web site: <https://www.gpo.gov/fdsys/pkg/CFR-2000-title7-vol6/xml/CFR-2000-title7-vol6-part657.xml>

Latest version is <https://www.gpo.gov/fdsys/pkg/CFR-2017-title7-vol6/xml/CFR-2017-title7-vol6-part657.xml>

Final Rule is located here: <https://www.federalregister.gov/documents/2000/09/25/00-24525/prime-and-unique-farmlands-important-farmlands-inventory>

The January 1, 1999 version was amended on September 25, 2000 with the changes published in the Federal Register as follows:

[Federal Register: September 25, 2000 (Volume 65, Number 186)]

[Rules and Regulations]

[Page 57537-57538]

From the Federal Register Online via GPO Access [wais.access.gpo.gov]

[DOCID:fr25se00-2]

DEPARTMENT OF AGRICULTURE

Natural Resources Conservation Service

7 CFR Part 657

Prime and Unique Farmlands--Important Farmlands Inventory

AGENCY: Natural Resources Conservation Service, Agriculture.

ACTION: Final rule.

SUMMARY: The Natural Resources Conservation Service is amending its regulations regarding responsibilities for conducting important farmland inventories under the Federal Crop Insurance Reform and Department of Agriculture Reorganization Act of 1994 (the 1994 Act). The amendments reflect changes to individual and organizational titles made since the regulations were originally drafted.

EFFECTIVE DATE: September 25, 2000.

FOR FURTHER INFORMATION CONTACT: Horace Smith, Division Director, Soil Survey Division, Natural Resources Conservation Service, P.O. Box 2890, Washington, D.C. 20013; 202-720-1820.

SUPPLEMENTARY INFORMATION: This final rule makes corrections to nomenclature in the regulations for conducting important farmland inventories (7 CFR

[[Page 57538]]

Part 657, Subpart A.) Since the implementing legislation was passed, the names of the offices and titles of officials charged with conducting important farmland inventories have changed. This amendment reflects those changes. In addition, this rule amends the authority citation to clarify the list of statutory authorities for the inventories.

These rules are not expected to have significant economic impact under the criteria of the Regulatory Flexibility Act. They will not impose information collection requirements under the provisions of the Paperwork Reduction Act of 1980, 44 U.S.C. Chapter 35.

List of Subjects in 7 CFR Part 657

Farmlands.

For the reasons set forth above, Subpart A, Part 657 of Chapter VI of Title 7 of the Code of Federal Regulations is amended as follows:

PART 657--PRIME AND UNIQUE FARMLAND

Subpart A--Important Farmlands Inventory

1. The authority citation for Subpart A, Part 657 is revised to read as follows:

Authority: 7 U.S.C. 1010a; 16 U.S.C. 590a-590f; 42 U.S.C. 3271-3274.

Sec. 657.4 [Amended]

2. Section 657.4(a)(3)(iii) is amended by revising ``NRCS Technical Service Centers (TSC's). (See 7 600.3, 600.6)'' to read ``National Soil Survey Center. (see 7 CFR 600.2(c), 600.6)''.

3. Section 657.4(a)(4) is amended by revising the first sentence to read as follows: ``Coordinate soil mapping units that qualify as prime farmlands with adjacent States, including Major Land Resource Area Offices (see 7 CFR 600.4, 600.7) responsible for the soil series.''

4. Section 657.4(a)(6) is amended by revising ``Administrator'' to

read ``Chief".

5. Section 657.4(b) is amended by revising the heading and the first sentence to read as follows: ``National Soil Survey Center. The National Soil Survey Center is to provide requested technical assistance to State Conservationists and Major Land Resource Area Offices in inventorying prime and unique farmlands (see 7 CFR 600.2(c)(1), 600.4, 600.7)."

6. Section 657.4(c) is amended by revising ``Assistant Administrator for Field Services (See 7 CFR 600.2)" to read ``Deputy Chief for Soil Survey and Resource Assessment (see 7 CFR 600.2(b)(3))".

Signed in Washington, D.C. on September 14, 2000.
Pearlie S. Reed,
Chief.
[FR Doc. 00-24525 Filed 9-22-00; 8:45 am]
BILLING CODE 3410-16-P

Title 7--Agriculture

CHAPTER VI--NATURAL RESOURCES CONSERVATION SERVICE, DEPARTMENT OF AGRICULTURE

PART 657--PRIME AND UNIQUE FARMLANDS

[Code of Federal Regulations]
[Title 7, Volume 6, Parts 400 to 699]
[Revised as of January 1, 1999](Amended September 25, 2000)
From the U.S. Government Printing Office via GPO Access
[CITE: 7CFR657.1; 7CFR657.2; 7CFR657.3; 7CFR657.4; 7CFR657.5.]

[beginning Page 699]

TITLE 7--AGRICULTURE

DEPARTMENT OF AGRICULTURE

PART 657--PRIME AND UNIQUE FARMLANDS--Table of Contents

Subpart A--Important Farmlands Inventory

Section 657.1 Purpose.

Section 657.2 Policy.

Section 657.3 Applicability.

Section 657.4 NRCS Responsibilities.

Section 657.5 Identification of important farmlands.

Sec. 657.1 Purpose.

NRCS is concerned about any action that tends to impair the productive capacity of American agriculture. The Nation needs to know the extent and location of the best land for producing food, feed, fiber forage, and oilseed crops. In addition to prime and unique farmlands, farmlands that are of statewide and local importance for producing these crops also need to be identified.

Sec. 657.2 Policy.

It is NRCS policy to make and keep current an inventory of the prime farmland and unique farmland of the Nation. This inventory is to be carried out in cooperation with other interested agencies at the National, State, and local levels of government. The objective of the inventory is to identify the extent and location of important rural lands needed to produce food, feed, fiber, forage, and oilseed crops.

Sec. 657.3 Applicability.

Inventories made under this memorandum do not constitute a designation of any land area to a specific land use. Such designations are the responsibility of appropriate local and State officials.

Sec. 657.4 NRCS responsibilities.

- (a) State Conservationist. Each NRCS State Conservationist is to:*
- (1) Provide leadership for inventories of important farmlands for the State, county, or other subdivision of the State. Each is to work with appropriate agencies of State government and others to establish priorities for making these inventories.*
 - (2) Identify the soil mapping units within the State that qualify as prime. In doing this, State Conservationists, in consultation with the cooperators of the National Cooperative Soil Survey, have the flexibility to make local deviation from the permeability criterion or to be more restrictive for other specific criteria in order to assure the most accurate identification of prime farmlands for a State. Each is to invite representatives of the Governor's office, agencies of the State government, and others to identify farmlands of statewide importance and unique farmlands that are to be inventoried within the framework of this memorandum.*
 - (3) Prepare a statewide list of:*
 - (i) Soil mapping units that meet the criteria for prime farmland;*
 - (ii) Soil mapping units that are farmlands of statewide importance if the criteria used were based on soil information; and*
 - (iii) Specific high-value food and fiber crops that are grown and, when combined with other favorable factors, qualify lands to meet the criteria for unique farmlands. Copies are to be furnished to NRCS Field Offices and to National Soil Survey Center. (see 7 CFR 600.2(c), 600.6)*
 - (4) Coordinate soil mapping units that qualify as prime farmlands with adjacent States, including Major Land Resource Area Offices (see 7 CFR 600.4, 600.7) responsible for the soil series.*

Since farmlands of statewide importance and unique farmlands are designated by others at the State level, the soil mapping units and areas identified need not be coordinated among States.

(5) Instruct NRCS District Conservationists to arrange local review of lands identified as prime, unique, and additional farmlands of statewide importance by Conservation Districts and representatives of local agencies. This review is to determine if additional farmland should be identified to meet local decision making needs.

(6) Make and publish each important farmland inventory on a base map of national map accuracy at an intermediate scale of 1:50,000 or 1:100,000. State Conservationists who need base maps of other scales are to submit their requests with justification to the Chief for consideration.

(b) National Soil Survey Center. The National Soil Survey Center is to provide requested technical assistance to State Conservationists and Major Land Resource Area Offices in inventorying prime and unique farmlands (see 7 CFR 600.2(c)(1), 600.4, 600.7). This includes reviewing statewide lists of soil mapping units that meet the criteria for prime farmlands and resolving coordination problems that may occur among States for specific soil series or soil mapping units.

(c) National Office. The Deputy Chief for Soil Survey and Resource Assessment (see 7 CFR 600.2(b)(3)) is to provide national leadership in preparing guidelines for inventorying prime farmlands and for national statistics and reports of prime farmlands.

Sec. 657.5 Identification of important farmlands.

(a) Prime farmlands--(1) General. Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is also available for these uses (the land could be cropland, pastureland, rangeland, forest land, or other land, but not urban built-up land or water). It has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when treated and managed, including water management, according to acceptable farming methods. In general, prime farmlands have an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks. They are permeable to water and air. Prime farmlands are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding. Examples of soils that qualify as prime farmland are Palouse silt loam, 0 to 7 percent slopes; Brookston silty clay loam, drained; and Tama silty clay loam, 0 to 5 percent slopes.

(2) Specific criteria. Prime farmlands meet all the following criteria: Terms used in this section are defined in USDA publications: ``Soil Taxonomy, Agriculture Handbook 436"; ``Soil Survey Manual, Agriculture Handbook 18"; ``Rainfall-erosion Losses From Cropland, Agriculture Handbook 282"; ``Wind Erosion Forces in the United States and Their Use in Predicting Soil Loss, Agriculture Handbook 346"; and

“Saline and Alkali Soils, Agriculture Handbook 60.”

(i) The soils have:

(A) Aquic, udic, ustic, or xeric moisture regimes and sufficient available water capacity within a depth of 40 inches (1 meter), or in the root zone (root zone is the part of the soil that is penetrated or can be penetrated by plant roots) if the root zone is less than 40 inches deep, to produce the commonly grown cultivated crops (cultivated crops include, but are not limited to, grain, forage, fiber, oilseed, sugar beets, sugarcane, vegetables, tobacco, orchard, vineyard, and bush fruit crops) adapted to the region in 7 or more years out of 10; or

(B) Xeric or ustic moisture regimes in which the available water capacity is limited, but the area has a developed irrigation water supply that is dependable (a dependable water supply is one in which enough water is available for irrigation in 8 out of 10 years for the crops commonly grown) and of adequate quality; or,

(C) Aridic or torric moisture regimes and the area has a developed irrigation water supply that is dependable and of adequate quality; and,

(ii) The soils have a temperature regime that is frigid, mesic, thermic, or hyperthermic (pergelic and cryic regimes are excluded). These are soils that, at a depth of 20 inches (50 cm), have a mean annual temperature higher than 32 deg. F (0 deg. C). In addition, the mean summer temperature at this depth in soils with an O horizon is higher than 47 deg. F (8 deg. C); in soils that have no O horizon, the mean summer temperature is higher than 59 deg. F (15 deg. C); and,

(iii) The soils have a pH between 4.5 and 8.4 in all horizons within a depth of 40 inches (1 meter) or in the root zone if the root zone is less than 40 inches deep; and,

(iv) The soils either have no water table or have a water table that is maintained at a sufficient depth during the cropping season to allow cultivated crops common to the area to be grown; and,

(v) The soils can be managed so that, in all horizons within a depth of 40 inches (1 meter) or in the root zone if the root zone is less than 40 inches deep, during part of each year the conductivity of the saturation extract is less than 4 mmhos/cm and the exchangeable sodium percentage (ESP) is less than 15; and,

(vi) The soils are not flooded frequently during the growing season (less often than once in 2 years); and,

(vii) The product of K (erodibility factor) x percent slope is less than 2.0, and the product of I (soils erodibility) x C (climatic factor) does not exceed 60; and

(viii) The soils have a permeability rate of at least 0.06 inch (0.15 cm) per hour in the upper 20 inches (50 cm) and the mean annual soil temperature at a depth of 20 inches (50 cm) is less than 59 deg. F (15 deg. C); the permeability rate is not a limiting factor if the mean annual soil temperature is 59 deg. F (15 deg. C) or higher; and,

(ix) Less than 10 percent of the surface layer (upper 6 inches) in these soils consists of rock fragments coarser than 3 inches (7.6 cm).

(b) Unique farmland--(1) General. Unique farmland is land other than prime farmland that is used for the production of specific high value food and fiber crops. It has the special combination of soil quality, location, growing season, and moisture supply needed to economically

produce sustained high quality and/or high yields of a specific crop when treated and managed according to acceptable farming methods. Examples of such crops are citrus, tree nuts, olives, cranberries, fruit, and vegetables.

(2) Specific characteristics of unique farmland. (i) Is used for a specific high-value food or fiber crop; (ii) Has a moisture supply that is adequate for the specific crop; the supply is from stored moisture, precipitation, or a developed-irrigation system; (iii) Combines favorable factors of soil quality, growing season, temperature, humidity, air drainage, elevation, aspect, or other conditions, such as nearness to market, that favor the growth of a specific food or fiber crop.

(c) Additional farmland of statewide importance. This is land, in addition to prime and unique farmlands, that is of statewide importance for the production of food, feed, fiber, forage, and oil seed crops. Criteria for defining and delineating this land are to be determined by the appropriate State agency or agencies. Generally, additional farmlands of statewide importance include those that are nearly prime farmland and that economically produce high yields of crops when treated and managed according to acceptable farming methods. Some may produce as high a yield as prime farmlands if conditions are favorable. In some States, additional farmlands of statewide importance may include tracts of land that have been designated for agriculture by State law.

(d) Additional farmland of local importance. In some local areas there is concern for certain additional farmlands for the production of food, feed, fiber, forage, and oilseed crops, even though these lands are not identified as having national or statewide importance. Where appropriate, these lands are to be identified by the local agency or agencies concerned. In places, additional farmlands of local importance may include tracts of land that have been designated for agriculture by local ordinance.

622.21 Example of Soil Properties and Qualities Used to Assign Land Capability Classes

Soil Properties	Land Capability Class — Degree of Limitations, Restrictions, or Hazards							
	I (1)	II (2)	III (3)	IV (4)	V (5)	VI (6)	VII (7)	VIII (8)
Minimum depth to lithic or paralithic contact (in)	40	20	20	10	40	20	10	<10
Soil reaction (pH)	Favorable reaction: easy to modify		Unfavorable reaction: high lime or difficult to modify	Unfavorable reaction: very difficult to modify	Not generally class-determining			Cat clays; unfavorable reaction: impractical to modify
Surface texture class or term used in lieu of texture	SL, FSL, VFCL, L, SIL, SCL, CL, SICL; or LS, LFS, S, FS (if less than 20 in. thick)	LS, LFS, S, FS; or SIC, SC, C (<60% clay); or MUCK, PEAT, PEAT	C (≥60% clay)	COS, LCOS	Same criteria as class I	Same criteria as class II	Same criteria as class III	Not class-determining
Available water capacity (in inches to a depth of 48 inches)	>9	>6 to ≤9	>3 to ≤6	≤3	Same criteria as class I	Same criteria as class II	Same criteria as class III	Not class-determining
Permeability	Moderately slow to moderately rapid	Slow or rapid	Very slow or very rapid	Not class-determining	Same criteria as class I	Same criteria as class II	Same criteria as class III	Not class-determining
Drainage class	Well or moderately well	Moderately well or somewhat poorly	Somewhat poorly or poorly	Poor	Not class-determining			
Water table during the growing season (minimum depth in inches)	48— Does not interfere with crop production	30— Delays planting or harvesting	18— Crop selection moderately affected	12— Crop selection severely affected	48	<12— Ponding Class II or III after drainage	<12— Ponding Class IV after drainage	<12— Ponding Cannot be drained

Title 430 – National Soil Survey Handbook

	Land Capability Class — Degree of Limitations, Restrictions, or Hazards							
Soil Properties	I (1)	II (2)	III (3)	IV (4)	V (5)	VI (6)	VII (7)	VIII (8)
Flooding (overflow)	None during growing season. Crop selection not restricted	Rare – Occasional. Slight crop damage; 0 to 20% yield reduction or crop selection slightly affected	Occasional. Moderate crop damage; 20-35% yield reduction or crop selection moderately affected	Frequent. Severe crop damage; 35-50% yield reduction or crop selection severely affected	Frequent - Prevents normal production of crops If protected from flooding: Class V equals Class I Class VI equals Class II or III Class VII equals Class IV If landform is a tidal flat: Class VIII			
Salinity (mmhos/cm)	<2	≥2 to ≤4	>4 to ≤8	>8 to ≤16	<2	>16 to ≤30	>30 to ≤40	>40
Stones or boulders only on surface (%)	<0.1	≥0.1 to <3.0	≥3.0 to <15.0	≥3.0 to <15.0	≥15.0 to <50.0	≥15.0 to <50.0	≥50.0 to <90.0	≥90.0
All rock fragments in surface and control section (%)	<15	≥15 to <35	≥35 to <60	≥35 to <60	<15	Not class-determining		
Rock outcrop (%)	<0.1	≥0.1 to <2.0	≥2 to <10	≥2 to <10	<0.1	≥10 to <50	≥50 to <90	≥90
Frost-free period (days)	>140	>100 to ≤140	>70 to ≤100	50 to ≤70	Not class-determining			
Effective precipitation (inches)	≥44	≥31 to <44	≥25 to <31	≥19 to <25	Not class-determining	≥10 to <19	<10	Not class-determining
Cumulative days dry in soil moisture control sect.	<135	≥135 to <180	≥180 to <220	≥180 to <220	Not class-determining	≥220 to <270	≥270	≥270
Taxonomic moisture subclass & moisture class (regime)	Typic Udic or Udic Ustic	Typic Ustic	Aridic Ustic	Aridic Ustic	Not class-determining	Ustic Aridic	Typic Aridic	
Slope: K factor of >32	2	5	8	12	2	25	Not class-determining	
Slope: K factor of ≥20 to ≤32	3	6	12	18	3	25	Not class-determining	
Slope: K factor of <20	4	8	15	25	4	35	Not class-determining	
Erosion hazard	None or slight	Moderate	Severe	Very severe	None or slight	Not class-determining		

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622.22 Guide for Assigning Land Capability Classes to All Map Unit Components in California* Climate Thornthwaite 1948 Indices (inches) 32 °F; ** Slope Gradient (%) ^{5/, 6/, 7/}

Land Capability Class	Soil Depth (inches) ^{1/}	Irr* ETP	Nirr* 4ETa	Surface Texture Class	Surface Texture Class	Permeability ^{2/}	Drainage Class and Depth to Water Table (inches) ^{3/}	Available Water Capacity ^{4/}	A**	B**	Erosion Hazard	Flooding Frequency	Salinity (mmhos/cm at 25 °C) ^{8/}	Exchangeable Sodium (%) ^{8/}	Toxic Substances ^{9/}	Frost-Free Period (days)
I (1)	>40	>20	>20	SL through CL	SL through CL	Mod. Rapid through Mod. low	Well or Mod. Well; >60	>7.5 in. avg. AWC >0.13 in/in.	<2	<2	None or Slight	None or Rare	<4	None	None	>140
II (2)	>40	>14	>16	LS through C (may be gravelly)	SL through C (may be gravelly)	Rapid through Slow	Somewhat Poor through Somewhat Excessive; >36	>5.0 in. avg. AWC >0.08 in/in.	<5	<8	None through Moderate	None through Occasional	<8	<25	None or Slight	>100
III (3)	>20	>10	>12	Any (may be gravelly or cobbly)	SL through C (may be gravelly or cobbly)	Rapid through Very slow	Poor through Excessive; >20	>3.5 in. avg. AWC >0.06 in/in.	<8	<15	None through High	None through Occasional	<16	<50	None through Moderate	>80
IV (4)	>10	>6	>8	Any (may be very gravelly, very cobbly or stony) ^{10/}	LS through C (may be very gravelly, very cobbly or stony) ^{10/}	Any	Poor through Excessive; >20	>2.5 in. avg. AWC >0.04 in/in.	<15	<25	Any	None through Frequent ^{11/}	<16	<50	None through Moderate	>50
V (5)	>20	>6	>8	Any (may be extremely gravelly, extremely cobbly, or very stony)	Any (may be extremely gravelly, extremely cobbly, or very stony)	Any	Any	>3.0 in. avg. AWC	<2	<2	None or Slight	Any	<8	<25	None or Slight	Any
VI (6) ^{12/}	>10	>4	>6	Any (may be extremely gravelly, extremely cobbly, or very stony)	Any (may be extremely gravelly, extremely cobbly, or very stony)	Any	Any	>2.0 in. avg. AWC	<25	<50	Any	Any	Nirr: <16 Irr: Any	Nirr: <25 Irr: <50	Nirr: Slight Irr: Slight through Moderate	Any

Title 430 – National Soil Survey Handbook

Land Capability Class	Soil Depth (inches) ^{1/}	Climate Thornthwaite 1948 Indices (inches)		Surface Texture Class		Permeability ^{2/}	Drainage Class and Depth to Water Table (inches) ^{3/}	Available Water Capacity ^{4/}	Slope Gradient (%)		Erosion Hazard	Flooding Frequency	Salinity (mmhos/cm at 25 °C) ^{8/}	Exchangeable Sodium (%) ^{8/}	Toxic Substances ^{9/}	Frost-Free Period (days)
		Irr ETp	Nirr 4ETa 32 °F						A ^{5/, 6/, 7/}	B ^{5/, 6/, 7/}						
VII (7) ^{13/}	Any	>2		Any	Any	Any	Any	>1.0 in. avg. AWC	<50	<75	Any	Any	Any	Any	Any	Any
VIII (8) ^{14/}	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any

^{1/} Claypans with permeability less than 0.06 in/hr will be treated as limiting the effective depth.

^{2/} Permeability of the least permeable subsurface horizon.

^{3/} Depth to water table during growing season.

^{4/} Available moisture between field capacity and wilting point.

^{5/} Use erosion hazard to help determine upper slope percent.

^{6/} In existing map units, 9% and 30% can be substituted for 8% and 25%.

^{7/} Column A is used for soils with K factors of 0.37 or greater and soils subject to rill and gully erosion, such as soils formed from granitic parent material or with claypans. Other soils are rated in column B.

^{8/} For soluble salts and sodium to be a major limitation, there should be other soil limitations, such as slow permeability or a high water table.

^{9/} Examples are boron and magnesium that leach with difficulty.

^{10/} Rock fragments interfere with tillage but do not prevent cropping.

^{11/} Frequent flooding that does not prevent normal cropping.

^{12/} Rangeland and forestland. Mechanical practices can be applied to class 6 land.

^{13/} Rangeland and forestland. Mechanical practices can be applied to class 7 land.

^{14/} Class 8 lands have limitations that preclude their use for commercial plant production and restrict their use to recreation, water supply, or esthetic purposes.

622.23 Guides for Assigning Land Capability Subclasses to Soil Map Unit Components in California

(Only soil map unit components designated in land capability classes 2 through 7 are assigned a subclass.)

Soil Properties	Guide A – For assigning land capability subclasses where wind velocities are low and/or soils are irrigated						Guide B – For assigning land capability subclasses where high wind velocities occur and the soil is not irrigated				
	Subclass by Slope Gradient (%) 1/						Subclass by Slope Gradient (%) 1/				
	0-2	2-9	9-15	≥15			0-2	2-9	9-15	≥15	
1. Moderately slowly, moderately, moderately rapidly, rapidly, and very rapidly permeable; moderately well, well, somewhat excessively, and excessively drained soils (over 20" deep) with the following general texture terms for the surface:											
a. Fine textured	s	e	e	e			s	e	e	e	
b. Moderately fine textured	s 2/,3/	e	e	e			e	e	e	e	
c. Medium textured	s 2/,3/	e	e	e			e	e	e	e	
d. Moderately coarse textured, with or without textural B horizon	s 2/,3/	e	e	e			e	e	e	e	
e. Coarse textured with textural B horizon	s	e	e	e			e	e	e	e	
f. Coarse textured with little or no textural B horizon	s	s	s	e			e	e	e	e	
2. Slowly and very slowly permeable soils (over 20" deep): 4/											
a. Well and moderately well drained	s	e	e	e			s	e	e	e	
b. Somewhat poorly drained	w	e	e	e			w	e	e	e	
3. Wet, poorly and very poorly drained soils:											
a. Moderately coarse to fine textured surface soils, including claypans and fragipans	w	w	w	e			w	w	w	e	
b. Coarse textured soils with little or no textural B horizon 5/	w	w	w	e			w	w	w	e	
c. Deep organic soils 5/	w	w	w	e			w	w	w	e	
4. Excessively, somewhat excessively, well, and moderately well drained, shallow and very shallow soils:				15-50	≥50					15-50	≥50
a. 10 to 20 inches to bedrock	s	e	e	e	e		s	e	e	e	e
b. 0 to 10 inches to bedrock	s	e	e	e	e		s	s	s	s	e
5. Somewhat excessively, excessively, well, and moderately well drained saline and sodic soils	s	e	e	≥15 e			s	e	e	≥15 e	

Title 430 – National Soil Survey Handbook

(moderate to severe salinity and sodicity)											
6. Very and extremely cobbly, very and extremely gravelly, and very and extremely stony surface layers	s	s	s	15-30 s	≥30 e		s	s	s	15-30 s	≥30 e
7. Soils subject to damaging overflow	w	w	w	e			w	w	w	e	

- 1/ For soils in capability classes 2 through 7. Class-1 land is excluded.
- 2/ These soils over 40" deep are generally class 1.
- 3/ Assign subclass c to nonirrigated soils only if the soils are assigned capability class 1 when irrigated.
- 4/ Permeability of the B horizon or control section.
- 5/ Including somewhat poorly drained soils.

622.24 Guide for Assigning Land Capability Units to Soil Map Unit Components in California

Capability Unit	Principal Soil Property or Limitation
1	Potential or actual wind or water erosion hazard
2	Drainage or overflow hazard (somewhat poorly drained or poorly drained, flooded, or ponded)
3	Slowly or very slowly permeable subsoil or substrata
4	Coarse or gravelly textures
5	Fine textured (i.e., fine or very fine particle-size classes)
6	Salinity or sodicity, sufficient to constitute a continuing limitation or hazard
7	Stones, cobbles, or other rock fragments sufficient to interfere with tillage
8	Hardpan or hard unweathered bedrock within the root zone
9	Low inherent fertility, associated with strong acidity and low calcium
10	High organic matter and/or fiber content (i.e., peat, mucky peat, and muck)
11	Coarse sandy or very gravelly substrata that limit root penetration and moisture retention

622.25 Guide for Assigning Land Capability Classes to All Map Unit Components in Indiana

LCC	Soil Depth 1/	Surface Texture Class 2/	Available Water Capacity 3/	Permeability 4/	Residual Wetness 5/	Slope Gradient (max %)	Flooding Frequency	Salinity or Sodicity	Length of Growing Season	ETp 6/	Stoniness	Erosion Hazard
I (1)	40	SL, FSL, VFSL, L, SIL, SCL, CL, SICL	≥9	Moderately rapid, Moderate, or Moderately slow	Moderately well drained	3	None or Rare	Nonsaline; Nonsodic (SAR <5)	Row crops	44+	Class 1	None or Slight
II (2)	20	LS, LFS, SC, SIC, C (<60 % clay), MUCK	≥6 to <9	Rapid or Slow	Moderately well drained – Slow; Somewhat poorly drained – Slow; Poorly drained – Rapid	6	Occasional	Slightly saline; Slightly sodic (SAR 5-<13)	Row crops do not mature	31-44	Class 1	Moderate
III (3)	10	S, C (with ≥60% clay), PEAT	≥3 to <6	Very slow or Very rapid	Moderately well drained – V. slow; Somewhat poorly drained – V. slow; Poorly drained – V. slow	14		Moderately saline; Moderately sodic (SAR 13-<30)	Small grains frequently do not mature	25-31	Class 1	Severe
IV (4)			<3		Drainage not feasible but pasture and limited cropping possible	20	Frequent	Strongly saline; Strongly sodic (SAR ≥ 30)	Small grains seldom mature		Class 1 and 2	Very severe
V (5)	20				Wetness limits choice of crops to permanent vegetation of good quality	3	Cropping not feasible		Small grain does not mature		Class 3 and 4	None or Slight
VI (6)	10				Kind and quality of permanent vegetation is limited	35	Channeled	Limits use to permanent vegetation				
VII (7)					Wetness limits vegetation		Ponding limits vegetation to water-tolerant species	Limited to salt-tolerant species	Grasses and trees will grow			
VIII (8)					Ponding prevents economical production of plants		No useful vegetation					

Title 430 – National Soil Survey Handbook

- 1/** Minimum soil depth in inches to a root-limiting layer.
- 2/** These are codes for texture classes (e.g., SL for sandy loam) and terms used in lieu of texture (e.g., MUCK for muck).
- 3/** Capacity in inches within a 48-inch-thick soil profile.
- 4/** Permeability of the least permeable subsurface horizon.
- 5/** Limitations for use due to residual wetness are represented by drainage class or combinations of drainage and permeability classes.
- 6/** Potential evapotranspiration (ETp) in inches.

622.26 Guide for Assigning Land Capability Subclasses to Soil Map Unit Components in Indiana

Soil Properties				Subclass by Slope Classes 1/			
				A	B	C	D 2/
I. Very deep through moderately deep soil depth classes							
	1. Moderate through rapid permeability						
		A. Excessively through rapidly permeable with the following general texture terms for the surface:		—	—	—	—
			1. Fine textured	s	e	e	e
			2. Moderately fine textured	s 2,3	e	e	e
			3. Medium textured	s 2,3	e	e	e
			4. Moderately coarse textured, with or without textural B horizon	s 2,3	e	e	e
			5. Coarse textured with textural B horizon 3/	s	s	e	e
			6. Coarse textured with little or no textural B horizon	s	e	s	s
		B. Poorly and very poorly drained		w	w	w	w
		C. Somewhat poorly drained with the following general texture terms for the surface:		—	—	—	—
			1. Fine through moderately coarse textured	w	e	e	e
			2. Coarse textured with textural B horizon	w	e	e	e
			3. Coarse textured with little or no textural B horizon	w	s	s	s
	2. Moderately slow permeability						
		1. Well drained and moderately well drained		s	e	e	e
		2. Somewhat poorly drained		w	e	e	e
		3. Poorly drained and very poorly drained		w	w	w	—
	3. Slow and very slow permeability						
		1. Well drained through excessively drained		s	e	e	e
		2. Moderately well drained		w	e	e	e
		3. Somewhat poorly drained		w	e	e	e
		4. Poorly drained and very poorly drained		w	w	w	w
II. Shallow soil depth class							
	1. Well drained and moderately well drained						
		a. 10 to 20 inches to bedrock		s	e	e	e
		b. Less than 10 inches to bedrock		s	s	s	s
	2. Somewhat poorly drained through very poorly drained			w	w	w	w
III. Saline and sodic soils (moderate or severe salinity or sodicity)				s	s	e	e
IV. Stony soils				s	s	s	s
V. Soils subject to damaging overflow				w	W	—	—

^{1/} For soils in capability classes 2 through 7. Map unit components in capability classes 1 and 8 are excluded.

^{2/} Same subclass applicable for E, F, and G slopes where they occur.

^{3/} Includes normally droughty, fine to medium textured soils underlain by sand and gravel at depths of less than 20 inches.

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Part 624 – Soil Quality

Subpart A – General Information

624.0 Definition and Purpose

- A. Definition.—“Soil quality” is the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.
- B. Purpose.—Considering that soil quality is the capacity of a soil to function, specific functions of concern should be clear when applying the concept. Common examples of specific soil functions are—
- (1) Sustaining biological activity, diversity, and productivity.
 - (2) Regulating and partitioning water and solute flow.
 - (3) Filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal byproducts and atmospheric deposition.
 - (4) Storing and cycling nutrients and other elements within the earth’s biosphere.
 - (5) Providing support of socioeconomic structures (i.e., buildings and roads) and protection for archeological treasures associated with human habitation.
- C. Components.—Soil quality integrates the biological, chemical, and physical components and processes of a soil with its surroundings. Whether a research plot, field, watershed, or the earth; the concept that soil functions within a larger system remains a key consideration in assessment of soil quality.
- D. Views and Concepts.—Views differ on soil quality depending on the background of individuals and their relationship to the land.
- (1) Some of these views and concepts include—
 - (i) Inherent properties of soil as determined by the soil forming factors.
 - (ii) Highly productive land, sustaining or enhancing productivity, maximizing profits, or maintaining the soil resource for future generations.
 - (iii) Plentiful, healthful, and inexpensive food for present and future generations.
 - (iv) Soil in harmony with the landscape and its surroundings.
 - (v) Soil functioning at its potential in an ecosystem.
 - (2) The concept of soil quality is also viewed from various scales of concern:
 - (i) For the land manager, productivity and sustainability are important.
 - (ii) For members of a community, the health or the ability of the watershed to maintain a healthy neighborhood and environment is important.
 - (iii) For national policy makers, an assessment of the overall quality and trends of the Nation’s soil resources are important for sustaining and ensuring food and water supply and national security.

624.1 Quality Concepts

Soils naturally vary in their capacity to function; therefore, an important part of the definition is the concept that quality is *specific to each kind of soil (soil map unit component)*. The quality of a soil has two distinct but related parts, inherent and dynamic qualities.

- (1) Inherent Quality.—Inherent quality represents intrinsic properties (qualities) of soils as determined by the factors of soil formation—climate, topography, biota, parent material, and time. The inherent quality of soils is often used to compare the capabilities of one soil against another and to evaluate the worth or suitability of soils for specific uses. For example, given all other determining properties being equal, a loam soil will have a higher water holding capacity

than a sandy soil. Thus, the loam soil will have a higher inherent quality for storing water and lower inherent quality for producing a freely drained condition.

- (3) **Use-Invariant Properties.**—Many properties that have traditionally been recorded in the interpretive and taxonomic databases of the National Cooperative Soil Survey Program are not subject to change by commonly practiced soil use. They are use-invariant. Particle size distribution (texture) is an example of a use-invariant property. Since common land practices only disturb the soil to a depth of about 30 centimeters, the properties below this depth are normally use-invariant.
- (4) **Dynamic Quality.**—Dynamic quality is determined by soil properties that are influenced by human use and management decisions. These properties are *use-dependent* properties and may be *temporal (dynamic)* of the soil. Bulk density near the surface and organic matter content are two such properties.
- (5) **Use-Dependent Properties.**—Use-dependent properties most often manifest in surface and subsurface layers. These properties include physical, chemical, and biological properties. Certain management practices and uses of the land have a positive effect on specific soil properties such as increasing organic matter content. Other management practices may negatively impact the soil by causing compaction, erosion, or acidification. Collectively, management will either improve or reduce health of the soil. This dynamic aspect of soil quality is the focal point of the concern for assessing the state (or quality) of the soil resource.
- (6) **Reference Condition.**—The reference condition is defined by a range of values for key soil properties (indicators) that represent conditions of the soil functioning at full capacity such as soil conditions under management systems that use best management practices. Values for the reference condition can eventually be used as criteria in the Field Office Technical Guide for evaluating the soil condition (quality).
- (7) **Soil Health Evaluation.**—Soil health can be evaluated relative to a standard or reference condition that represents the full capacity of a soil to function for a specific use. The reference condition is often based on use-invariant properties in conjunction with the dynamic properties. Soil properties are used to group soils that function similarly. Reference values are developed for the key properties of soils that reflect the capacity of the soil to function. Evaluation of soil quality or health must be tied to soil functions and the specific use of the soil.

Soil health can also be evaluated by establishing a baseline condition for the use-dependent properties (indicators). After a period of years, the use-dependent properties are measured again and compared to the baseline.

Part 624 – Soil Quality

Subpart B – Exhibits

624.10 Soil Quality Test Kit (Instruction Manual)

Information on the Soil Quality test kit, and instructions on how to build one are available on the following website:

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/health/assessment/?cid=nrcs142p2_053873

624.11 References

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Part 627 – Legend Development and Data Collection

Subpart A – General Information

627.0 Definition and Purpose

- A. Soil survey legend development and documentation are those activities conducted in the field that organize, gather, describe, and delineate data needed to provide current and accurate soil maps and interpretations.
- B. The purpose of soil survey legend and documentation procedures is to ensure the collection of meaningful and essential field data in the course of field activities. These data ensure that the objectives of the soil survey are met.

627.1 Policy and Responsibilities

The soil survey office (SSO) is responsible for legend development and field data collection. The SSO also initiates studies for soil performance data collection.

627.2 Field Studies for Legend Development

A. Field studies include—

- (1) Studying the survey area in detail especially in relation to other survey areas within the same major land resource area.
- (2) Delineating major landforms, climatic zones, vegetation, and lithology within the major land resource area and the survey area.
- (3) Identifying and studying the components within the major land resource area.
- (4) Test mapping.
- (5) Developing a descriptive legend.

B. Studying the Survey Area.—Initial soil survey field studies begin with study of the survey area and adjoining survey areas. Field studies follow the collection and review of available reference material. Visit survey areas in the same major land resource area as short reconnaissance trips. These trips ensure an adequate understanding of the relationship between the survey being designed and those already completed and maintained. Join map units from adjacent soil surveys with the new survey.

C. Identifying and Delineating Major Units

- (1) The SSO staff observes and delineates climatic zones, areas of contrasting vegetation patterns, unique landforms, such as a till plain, a terrace, a lake plain, a flood plain, or fan, and other broad ecological areas. The scientists record the delineations on a small-scale map, such as a county road map, a topographic map, a photo index map, or with use of digital imagery and geographic information systems (GIS).
- (2) Next identify the components of the broad ecological areas, such as the side slope, toe slope, and foot slope components of hills, aspect differences, areas of runoff and run on, and other subdivisions of broad ecological zones. Include current and historical land use. The specifications for map unit size detailed in the memorandum of understanding dictate if these components can be delineated. Identify, describe, and classify the kinds of soils that are associated with the components. Using multiple observations, identify a

preliminary range in characteristics for all the identified components in the delineated areas. Soil patterns commonly coincide with broad ecological areas and individual soils correspond with individual ecological components. The objective of identifying and understanding the relationship between broad ecological areas and soils is to enable a soil scientist to predict the kind of soil before examining the soil profile. Expose sufficient soil profiles to ensure that the pattern is consistent. When an exposed soil profile is not what is expected, undertake additional study to understand the anomaly and variability. Further clarify the soil pattern and the relationship to ecological components. Prepare diagrams to illustrate the models.

D. Test Mapping Sample Areas

- (1) Design map units that represent sets of soil properties repeated on characteristic components. Map units must represent areas that can be delineated on maps and they must satisfy the objectives of the survey as detailed in the memorandum of understanding or long-range plan. Select sample areas that are representative of repeating patterns. Studying these sample areas in detail helps to determine the nature of the soil map unit components, their pattern of occurrence, and their size and shape. Outlining and evaluating combinations of soil characteristics create an understanding of their effect on soil behavior.
 - (i) Mapping sample areas helps to test the design of the map units and to develop the descriptive legend. This process begins in the preliminary stages of the survey and continues throughout the progressive survey.
 - (ii) Check the following:
 - The predictive value of soil-ecological area features
 - The properties of the soil on either side of natural boundaries to determine if they differ significantly
 - The slope gradient and shape, vegetation, and position on the landform relative to surrounding soils to determine if they help predict the kind of soil
 - The complexity of the soil pattern
 - The composition of mappable delineations of map units
 - The degree that concepts of map units furnish soil data required for soil interpretations
 - Other visual features, such as vegetation patterns, areas of rock, and photograph signature
 - (iii) Describe the map units that meet these tests. These map units in conjunction with the map units of joined surveys form the first draft of the descriptive legend.
- (2) Information and data collected from farmers, planners, agronomists, sanitarians, engineers, foresters, range conservationists, soil consultants, environmental scientists, and others guide the development and separation of map units. However, it is important for the map units to join the adjacent soil survey areas (refer to part 609 of this handbook). An engineer assists the soil scientists to determine the interpretations for soils as a construction material, a foundation for a structure, or other engineering use. A range scientist, forester, or other discipline specialist studies the relationship among landform, soil, and vegetation with the soil scientists when rangeland or forestland areas are important. The various disciplines work as a team in data collection and documentation.

E. Developing Provisional Soil Survey Map Units.—The soil survey regional office (SSR) or appropriate lead agency reviews and approves the first draft of the descriptive legend during the initial field review. Any soil survey project member may propose provisional map units during the course of the survey. Describe and test the provisional map units to determine if there is justification and need for the unit in the legend. When the SSO staff are satisfied that the unit

is needed, they request the SSR or appropriate lead to tentatively approve the unit. The approving office adds the provisional map unit to the legend object in the National Soil Survey Information System (NASIS). This office also assures that the map unit description and information that justifies the map unit's addition to the legend is documented in the data mapunit object in NASIS. The SSO keeps a complete record on all provisional map units. They record the acres mapped, the exact locations where the units were mapped, results of field studies, results of testing, and records of soil behavior and interpretive data. The signature on the field review report and identification legend officially approves the change of the provisional map units to approved map units.

F. Developing a Provisional General Soil Map

- (1) Generally, the Digital General Soil Map of the U.S. (formerly called STATSGO) is the provisional and final general soil map. This general soil map serves as a guide for the soil scientists during all stages of the survey. It assists in the joining of surveys within MLRAs. The Digital General Soil Map of the U.S. serves as the final general soil map.
- (2) Soil scientists refine the Digital General Soil Map of the U.S. as map unit concepts become clear and boundaries stabilize each year. States request a base map for each survey area from the National Geospatial Center of Excellence, at a scale of 1:250,000, to use in refining their general soil map. Topographic quadrangle sheets that were photographically reduced to a workable scale and joined provide contour information. Satellite imagery is also helpful. Sometimes the copy of the index map of the soil survey field sheets at the publication scale helps the refinement process. The SSO staff updates the general soil map each year to correspond with completed soil survey field sheets. By the end of the survey, the general soil map becomes final.

627.3 Map Units of Soil Surveys

A. Definition.—A map unit is a collection of areas defined and named the same in terms of their soil components or miscellaneous areas or both. Each map unit differs in some respect from all others in a survey area and each map unit has a symbol that uniquely identifies the map unit on a soil map. Each individual area, point, or line so identified on the map is a delineation. The SSO staff specially designs map units to meet the needs of the major users in each major land resource area. Map units in adjoining survey areas are comparable especially within the same major land resource area.

Use any category of soil taxonomy, miscellaneous areas, and accompanying terms to name map units. A map unit has specified kinds of soil or miscellaneous areas (map unit components), each with a designated range in proportionate extent. Map units include one or more kinds of soil or miscellaneous area. See section 627.4 for more information on miscellaneous areas.

B. Design of Map Units

- (1) Design map units to meet the objectives of the soil survey as stated in the memorandum of understanding or long-range plan. Consider the following items in designing a map unit:
 - (i) Kinds of map units
 - (ii) Phase criteria used to identify map units
 - (iii) Kind and intensity of field investigation and documentation
 - (iv) Soil properties for which data are required
 - (v) Minimum size management unit relevant to the various uses
 - (vi) Signature in the landscape that can be recognized from imagery, maps, or field observation

- (2) When map units consistently associate with landforms, landform segments, vegetation, slope gradient, slope aspect, geomorphic position, or other surface observable feature, the consistency of delineations improves. The correlation of map units with these surface features reduces the number of observations and samples needed to obtain a stated degree of confidence.
- (3) The design of map units is flexible but should correspond to the other surveys within the MLRA. A map unit is defined by the important different kinds of soil and miscellaneous areas (components) and their proportionate extent within delineations of the map unit. Map units can have a single component or they can have many components. Chapter 4 of the Soil Survey Manual further discusses the design of map units.
- (4) The components of a map unit are soils or miscellaneous areas.
 - (i) The following groups of components can help name map units:
 - Named soils or miscellaneous areas that are dominant and co-dominant in extent
 - Similar soils or miscellaneous areas that are less extensive than the named components
 - Dissimilar soils or miscellaneous areas that are minor in extent
 - (ii) Similar soil or miscellaneous area components are those that differ so little from the named components that their soil interpretations for most uses are very similar. The differences for management are small.
 - (iii) Dissimilar soil or miscellaneous area components are those that differ enough from the named components to affect major interpretations. The differences for management are large.
 - (iv) Soil components are minor in extent when they occupy a small percentage of the map unit. The percentage varies depending on how they affect the use and management of the map unit.
 - (v) Generally, dissimilar components are considered minor if they are less than 15 percent and limiting to management of the map unit. If they are not limiting to the management, they can occupy up to 25 percent of the map unit and still considered minor in extent. A single component that is dissimilar and limiting should not exceed 10 percent and remain as minor extent. Also see chapter 4 of the Soil Survey Manual.
 - (vi) Components, whether major or minor, meet the following criteria:
 - Exist in most delineations
 - Add to the understanding of the map unit
 - Are contrasting to all other components in the map unit (do not list similar soils as separate components, unless it helps in understanding the map unit.)
 - Allow for useful and significant soil data and interpretations to the users
 - (vii) Documented components that do not meet the above criteria are similar or nonrecurring or isolated features of the map unit. If appropriate, recognize nonrecurring, contrasting components with special or ad hoc features, or point or linear map unit delineations.
- (5) The composition and purity of map units are important in the interpretation of soil maps. Most delineations of a map unit include dissimilar soils or miscellaneous areas of minor extent that are not identified in the map unit name but may be included in the database for the unit. Practical field mapping methods cannot delineate these components at the selected scale of mapping. But they may be associated with a specific landform segment different from that of the named components of the map unit. Some of these components could be delineated if smaller management units were needed.
- (6) Group soils that have properties similar to named components (similar soils) with the named soils. Likewise, minor components that are contrasting with the named major components, but that are similar to one another, should be correlated to one minor soil

component. By doing so, the number of components listed for any map unit is kept to a minimum.

- (7) Attain a defined standard or level of confidence in the interpretative purity of map unit delineations by adjusting the kind and intensity of field investigations. If the objective of the survey requires delineation of areas of dissimilar soils as small as 2 acres in size, the soil scientist must carry out the field investigations in sufficient detail to identify accurately and consistently map 2-acre areas. Investigations that observe map unit boundaries directly and thoroughly provide greater control than those that observe map unit boundaries at moderately spaced intervals.

C. Minimum Size Delineation.—The memorandum of understanding for the survey area states the minimum size map unit delineation. It represents the size of an area most users would agree is the smallest area that is managed for an intended land use. The memorandum of understanding also states the map scale. The scale must accommodate legible delineations of the smallest size map unit. A legible delineation is the smallest area on the map that reasonably accommodates a map unit symbol (about 1/2 cm square).

D. Kinds of Map Units.—Soils differ in the size and shape of their areas, in their degree of contrast with adjacent soils, and in their geographic relationships due to soil formation or land use. Soil surveys use four kinds of map units to distinguish the different relationships: *consociations*, *complexes*, *associations*, and *undifferentiated groups*. Figure 627-A1 describes and compares these relationships.

- (1) Consociations.—In a consociation, delineated areas use a single name from the dominant component in the map unit. Dissimilar components are minor in extent. The soil component in a consociation may be identified at any taxonomic level (category). Soil series is the lowest taxonomic level. A consociation map unit that is named for a miscellaneous area is dominantly that kind of area and any minor components present do not significantly affect the use of the map unit.
- (2) Complexes and Associations.—Complexes and associations consist of two or more dissimilar components that occur in a regularly repeating pattern. The total amount of other dissimilar components is minor in extent. The following arbitrary rule determines whether “complex” or “association” is used in the name. The major components of a complex cannot be delineated separately at the scale of mapping. The major components of an association can be delineated separately at the scale of mapping. In either case, because the major components are sufficiently different in morphology or behavior, the map unit cannot be called a consociation. In each delineation of a complex or an association, each major component is normally present though their proportions may vary appreciably from one delineation to another.
- (3) Undifferentiated Groups.—Undifferentiated groups consist of two or more components that are not consistently associated geographically and, therefore, do not always occur together in the same map delineation. These components are included in the same named map unit because their use and management are the same or very similar for common uses. Generally, they are grouped together because some common feature, such as steepness, stoniness, or flooding, determines their use and management. If two or more very steep soils that are geographically separated are so similar in their potentials for use and management that defining two or more additional map units would serve no useful purpose, they may be included in the same unit. Each delineation has at least one of the major components, and some may have all of them. The same principles regarding the proportion of minor components that apply to consociations also apply to undifferentiated groups.

Figure 627-A1: Description of Kind of Map Unit

Kind of Map Unit	Number of Major Components in the Map Unit Name	Percentage of Dissimilar Components not Included in the Map Unit Name (Minor Components)	Other Criteria
Consociation	One soil or misc. area (similar soils or similar misc. areas included with the percentage of the named component).	<15% limiting, <25% nonlimiting <10% of any one, limiting, very contrasting component	
Complex	Two or more soils or misc. areas (similar soils or similar misc. areas included with the percentage of the named components).	<15% limiting, <25% nonlimiting <10% of any one, limiting, very contrasting component	Cannot separately delineate the named soils or misc. area components on the map at the scale used.
Association	Two or more soils or misc. areas (similar soils or similar misc. areas included with the percentage of the named components).	<15% limiting, <25% nonlimiting <10% of any one, limiting, very contrasting component	Can separately delineate the named soils or misc. area components on the map at the scale used.
Undifferentiated Group	Two or more soils or misc. areas (similar soils or similar misc. areas included with the percentage of the named components).	<15% limiting, <25% nonlimiting <10% of any one, limiting, very contrasting component	A limitation (e.g., slope or salinity), overrides the primary uses to such an extent that a separate map unit is not used for each component.

627.4 Map Unit Components

A. Map unit components of soil survey consist of soils or miscellaneous areas. Components may be major components or minor in extent as previously defined in section 627.3. Major components are used in the map unit name. Minor components are not used in the map unit name. If minor components are contrasting to the named soils, the minor components are named and populated in the database. All map unit components recorded in NASIS are fully populated with data (see part 617 of this handbook). Classify all soil components at the appropriate level of soil taxonomy. For soil components of minor extent that do not fit into or are not similar to an existing soil series, a new series may be established or a higher level of soil taxonomy may be used to name the soil component.

- (1) Soil components of minor extent do not need to have a typical pedon. They may be listed in the classification table in the correlation document.
- (2) The use of the series or higher level of soil taxonomy in the name does not imply that the component includes the full range of the taxonomic category. The range of characteristics of each soil component is separately determined and recorded for each specific map unit. For minor soils, the range will likely be based on limited observations and will need to include inferences from other similar soils nearby.

B. Soil Series.—The soil series is the lowest categorical level of soil taxonomy. The most commonly used name for soil map unit components is the soil series name.

C. Families.—The family is the categorical level immediately above the soil series. It is intended to group soils within a subgroup that have similar physical and chemical properties that affect their

response to management. Designate the map unit component as a family in the “Component Kind” data element in the NASIS “Component” table. Family level components are named as follows:

- (1) Name the component for a soil series (if one exists) that represents the needed family. An example component name is “Jocity family” for soils that classify in the family of fine-loamy, mixed, superactive, calcareous, mesic Typic Torrifluvents.
- (2) Use the polynomial spelling as given in Soil Taxonomy combining the subgroup name with the appropriate family class differentiae. An example is “Loamy-skeletal, mixed, superactive Vitrandic Argicryolls.”

D. Taxonomic Categories Above the Family.—Soil components classified in taxonomic categories above the family level use the classification as a soil reference term with the following conditions:

- (1) Designate the map unit component as a taxon above family in the “Component Kind” data element in the NASIS “Component” table.
- (2) Use the proper spelling given in Soil Taxonomy for the names of components, if used as reference terms (e.g., Ustic Torriorthents).
- (3) A taxonomic name used as a reference term for a map unit component implies no specific range of properties beyond that which is represented in the map unit description and database.
- (4) Use local phases, such as “Ustic Torriorthents, shallow,” as reference terms if needed.

E. Taxadjuncts.—A taxadjunct is a soil (map unit component) that is correlated (named) as a recognized, existing soil series for the purpose of expediency. Taxadjuncts use a soil series name as a reference name but the soils have one or more differentiating characteristics that are outside the taxonomic class limits of the family or higher category for the named soil series. These properties in the aggregate, give responses to use and management similar to those of the named soil series.

- (1) Use taxadjuncts in lieu of establishing a soil series that would be of limited use. Part 614 of this handbook provides information on soil series.
- (2) To use a taxadjunct to assign a name to a map unit component, designate the map unit component as a taxadjunct in the “Component Kind” data element in NASIS. Populate the actual taxonomic classification of the taxadjunct in the Component table. The representative soil properties entered for the taxadjunct must support this classification. Component text notes may be used to explain why a component is correlated as a taxadjunct.
- (3) In the final correlation memorandum, include a statement to identify that one or more map unit components using the series name is a taxadjunct.
- (4) In the soil survey manuscript section titled “Classification of the soils,” place an asterisk in the classification table for each map unit component that is named as a taxadjunct to direct the reader to a statement explaining the taxadjunct. Include the actual classification of the taxadjunct in the classification table. List the official series classification for those components that are not taxadjuncts. Also, in the manuscript, include a statement in the range in characteristics of the taxonomic unit description identifying the map units and components that are taxadjunct to the soil series and an explanation of their properties that cause them to be outside the classification of the named series.
- (5) If a map unit component has properties that are slightly outside the official series range

but is in the same family as the official series, it is not a taxadjunct. Take one of two alternative actions:

- (i) Widen the official series range to include the properties of the component as correlated.
- (ii) Place a statement in the final correlation memorandum to explain how the component differs from the official series and why the official series was not revised to include the aberrant property or properties

F. Miscellaneous Areas

- (1) Definition.—Miscellaneous areas are map unit components that have essentially no identifiable soil as defined in Soil Taxonomy or are bodies of soil that are heavily contaminated by toxic substances.
- (2) Application.—Use the names of miscellaneous areas as reference terms for map unit components as they are given in section 627.10. Only use approved names. The soil survey regional office (SSR) requests additions to the list of miscellaneous areas in section 627.10 or requests changes in the concepts of these areas. The National Soil Survey Center is responsible for approval.
- (3) Correlation.—Design and delineate map units that contain miscellaneous areas the same as other soil map units. Less documentation is generally needed for map units having only miscellaneous areas as major components.
 - (i) The distinction between soils and miscellaneous areas is not always straightforward. Urban land and water are two miscellaneous areas that present correlation issues. In many instances, areas of urban land are underlain by recognizable soils. Similarly, some areas covered by water also support rooted subaquatic vegetation and meet the definition of soil (subaqueous soils). Judgment must be used to decide whether to recognize the soil or the miscellaneous area. In the case of urban land, the miscellaneous area is typically recognized when naming the map unit because it is the predominant determining factor for land use and management considerations. In the case of subaqueous soils, because the nature of the soils may be a critical consideration in the management of the resource, the map unit component chosen for correlation is a soil. In other instances where the management of the resource is not determined by an underlying subaqueous soil or where subaqueous soils do not occur (just non-vegetated sediment), the map unit component is correlated as the miscellaneous area water. The data needs of soil survey users are always a critical factor to consider when making basic correlation decisions about soils or miscellaneous areas.
 - (ii) The concepts of some miscellaneous areas have changed with time. For example, rock outcrop is currently applied to areas of bedrock that possess a significant amount of geologic cementation to the point that exposures form distinctly angular surface profiles. When cementation is less, exposures of bedrock tend to form less angular but more sloping surface profiles due to geologic erosion processes acting upon softer rock. Such softer bedrock exposures are better correlated as badland to help eliminate confusion.
- (4) Phases.—Miscellaneous areas may be phased in order to provide necessary interpretive information.
 - (i) Some common phase terms for miscellaneous areas include, but are not limited to, those presented in the following examples:
 - Beaches, cobbly
 - Dumps, sanitary landfill
 - Lava flows, pahoehoe
 - Mined land, copper

- Pits, quarry
 - Playas, occasionally ponded
 - Rock outcrop, limestone
 - Urban land, loamy till substratum
 - Water, saline
- (ii) The component name entered in the component table of the NASIS database is just the term for the miscellaneous area (“Rock outcrop,” “Playas,” “Pits,” etc.). Terms for locally defined phases are entered separately in the column for the “Local Phase” data element.
- (5) Data Population
- (i) The minimum data set is tailored to the type of miscellaneous area and includes the following:
- Component Table.—Component percent, component name, taxon kind, major component flag, and land capability class.
 - Component Child Tables.—Geomorphic feature where applicable.
- (ii) Some existing miscellaneous area components may have soil properties populated in NASIS. These should be evaluated as future projects and either correlated to soil components or updated to meet current definitions of miscellaneous areas given in section 627.10. Additional information related to miscellaneous area components can be entered into component text (i.e., kinds of bedrock lithology, nature of recent sediment, or drainage characteristics, if applicable).
- (6) Map Unit Descriptions.—Describe miscellaneous areas in the map unit description in terms of characteristics of the local area. Follow the generalized definitions given in section 627.10 but do not reproduce prewritten descriptions.
- (i) The descriptions of miscellaneous areas include—
- At least a rough composition of miscellaneous area (nonsoil) and soil components, where applicable.
 - Identification of minor soil components.
 - The geomorphology (landscape, landform, etc.).
 - The kinds of bedrock lithology.
 - The nature of recent sediment.
 - Drainage and runoff characteristics, if appropriate.
- (ii) If a survey legend includes miscellaneous areas, measure the components, tabulate their acreages, and list their names in the interpretative tables for the survey publication. If the total acreage of map units composed mainly of miscellaneous areas is so small or of so little importance that they are not retained in the legend, combine these map units with adjoining map units in the correlation document. Populate the miscellaneous areas as minor components in the data mapunit or use special symbols on the map, as appropriate.
- (7) Spot Symbols.—Some miscellaneous areas are too small to be delineated as polygons on soil maps. Their presence can be shown with standard or ad hoc “spot” symbols, provided they are identified consistently. Standard landform and miscellaneous surface features or ad hoc features are special map symbols that locate miscellaneous areas when these areas are less than the minimum size for a map unit. See section 627.14 for a list of these features that includes their names, symbols, digital labels, and descriptions. Their primary use is for orienting and locating features on the map to those on the ground. Point or linear map units can also be used for bodies of miscellaneous areas which are cartographically too small or narrow to delineate on soil maps with a traditional, closed polygon.

G. Phasing Components.—Occasionally, it is necessary to distinguish a map unit component
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when multiple components of the same taxonomic or miscellaneous area occur within the same map unit. Because soil properties and interpretations are shown by component, the phase helps to distinguish the correct component. Phases can be used at a local level to help identify soil components. Do not modify the map unit component name in the database. Use the local phase descriptor to separate components with the same name. Use a single term such as “saline” or “steep” or “sandy.” It is best not to use a property, such as surface texture, that is entered elsewhere.

627.5 Terms Used in Naming Map Units

A. Each map unit has a name that accurately and uniquely identifies the unit within the legend used. Consistent nomenclature provides understanding to the relationships and differences among map units. Conventions for naming map units provide consistency. The SSO staff names and defines map units according to the procedures in this handbook and the descriptions in the Soil Survey Manual.

The SSR approves map unit names and descriptions progressively with the progress of the survey and in the final correlation memorandum. The soil survey regional director signs the final correlation memorandum. This certifies that the soil survey is complete and accurate.

B. Naming Consociations

- (1) The term for the reference component or kind of miscellaneous area appears first in the map unit name. Consociations use components at all levels of soil taxonomy and kinds of miscellaneous areas as reference names.
- (2) List the surface texture or any term that designates the degree of decomposition of an organic surface layer after the reference name without a comma. Examples are Alpha loam and Beta muck.
- (3) If a map unit also contains a surface texture modifier, insert the appropriate term between the name of the series and the texture class or term used in lieu of texture. Examples are Alpha gravelly loam, Beta woody peat, or Gamma very parachannery ashy sandy loam.
- (4) Precede all other terms with a comma. Examples are Fluvents loamy, frequently flooded; Alpha loam, 3 to 8 percent slopes, eroded; and Beta silt loam, gravelly substratum, 3 to 8 percent slopes, eroded.
- (5) Separate two or more terms, other than a surface texture modifier for fragments, by commas. An example is Alpha gravelly loam, 3 to 8 percent slopes, eroded.
- (6) The last term in the name is the designation for erosion, deposition, flooding, rockiness, or classes of surface stones and boulders. Examples are Alpha loam, flooded and Beta gravelly loam, 0 to 3 percent slopes, stony.
- (7) A designation for slope follows all other terms except those for erosion, deposition, flooding, rockiness, or classes of surface stones or boulders. An example is Alpha loam, gravelly substratum, 3 to 8 percent slopes, eroded.
- (8) With the exception of the word “slopes” and the terms for some texture groups, the nouns used in map unit names are singular. Chapter 4 of the Soil Survey Manual provides more information about consociations. Examples of appropriate names for consociations are:
 - (i) Beta silt loam, 0 to 7 percent slopes
 - (ii) Rock outcrop
 - (iii) Alpha family, 0 to 10 percent slopes

C. Naming Complexes

- (1) The reference names of the components form the first part of the name of a complex.

Complexes use components at all levels of soil taxonomy and kinds of miscellaneous areas as reference names. Chapter 4 of the Soil Survey Manual gives a discussion of complexes.

Two or three names that are joined by a hyphen usually form this first part. In some cases, just one reference component is named in the first part, as in map units that are named for one taxon but have contrasting phase criteria. An example is Alpha complex, 0 to 3 percent slopes.

- (2) If the surface textures of the components are different, the second part of the name is the word “complex,” as in Alpha-Beta complex, 0 to 3 percent slopes. If the surface textures of the named components are the same, the second part of the name can be either “complex” or the common surface texture, as in Alpha-Beta silt loams, 0 to 3 percent slopes.
- (3) A third part may be necessary for uniquely naming other map units. Examples are Alpha-Beta complex, rarely flooded; Beta-Theta loams, 10 to 20 percent slopes; and Beta-Rock outcrop complex, 20 to 40 percent slopes.
- (4) An example of a complex named using the short family name is Alpha-Beta families, complex, 10 to 20 percent slopes.

D. Naming Associations

- (1) The reference names of the components form the first part of the name of an association. Associations use components at all levels of soil taxonomy and kinds of miscellaneous areas as reference names. Chapter 4 of the Soil Survey Manual gives additional information on soil associations. Two or three names that are joined by hyphen form the first part. In some cases, just one reference component is named in the first part, as in a map unit consisting of one soil that has contrasting surface texture. Examples of appropriate names are Alpha-Beta association and Alpha association, 0 to 15 percent slopes.
- (2) The second part of the name is the word “association.” Examples of appropriate names are Beta association, Alpha-Beta-Theta association, and Alpha-Beta families, association.
- (3) A third part may be necessary for separating other phases. Examples are Beta association, 10 to 30 percent slopes, and Beta-Theta association, stony.

E. Naming Undifferentiated Groups

- (1) The first part of the name of an undifferentiated group uses the reference name of the components. Undifferentiated groups use components at all levels of soil taxonomy and kinds of miscellaneous areas as reference names. Two names separated by “and” or three names separated by a comma and “and,” respectively, form the first part. Chapter 4 of the Soil Survey Manual gives additional information on undifferentiated groups.
- (2) The second part of the name generally is the word “soils.” However, the following convention is optional. If the surface texture of the components is the same, the second part of the name is the common surface texture. Examples of appropriate names are the preferred Alpha and Beta soils and the optional Alpha and Beta silt loams, 0 to 10 percent slopes.
- (3) A third part may be necessary for separating other phases. An example is Alpha, Beta, and Theta soils, moderately saline, 0 to 3 percent slopes.

F. Naming Human-Altered and Human-Transported Soils.—The soils represented by this category include a great variety of culturally disturbed earthy materials. If these materials are capable of supporting plants, the components are identified as taxa of the lowest category that provides an

appropriate name. For example, a large earthen dam might be large enough to be a complex map unit that does not use a named component of Dams. The components may instead be a taxon such as a series which formed in human-transported material for the soil component and Rubble land for a rippapped miscellaneous area of the map unit. Name map units according to the conventions used for other categories of soils. If the earthy material does not qualify as soil, it receives an appropriate name for a miscellaneous area.

G. Naming With Miscellaneous Areas.—Use normal conventions for naming map units when these map units contain components which are miscellaneous areas. Miscellaneous areas generally are capitalized in map units, but those consisting of two words have only the first word capitalized. Examples are Gullied land and Alpha-Badland complex, 15 to 45 percent slopes.

H. Naming Areas Not Completed and Areas of Denied Access.—Areas not yet mapped or digitized are assigned a map unit named “No digital data available” and are labeled with the National mapunit symbol “NOTCOM” through a linkage in the NASIS Legend Mapunit table. Areas of denied access are assigned a map unit named “Area not surveyed, access denied” as described in more detail in part 608 of this handbook.

I. Ecological Units.—An ecological unit is a mapped landscape unit used for ecosystem classification and mapping.

- (1) The ecological map unit uses one or more ecological types as parts of the map unit name. An ecological type has a unique combination of potential natural community, soil, geology and geomorphology, climate, and differs from other ecological types in its ability to produce vegetation and respond to management. The soil component of the ecological type must be described and correlated using the standards and guidelines described elsewhere in this handbook.
- (2) The ecological map unit name consists of the names of one or more ecological types as consociations, complexes, associations, or undifferentiated map units.
- (3) Name ecological types using a minimum of two-part soils and plant community name. Use classes of soil taxonomy with or without accompanying terms to name the soil portion. Incorporate geologic, geomorphic, and/or landform names, either by phases of soils or otherwise. Use the level of soil taxonomy (series, family, or higher category) which is needed to meet the objectives of the survey. Name the plant community portion according to potential natural community.

627.6 Phases Used to Name Soil Map Units

A. Two or more phase terms are commonly part of most soil map unit names. A phase term conveys important connotations, such as soil properties and surface attributes, about the map unit and distinguishes it from other map units. The classes (i.e., taxa) in any category of the taxonomic system that are used in naming map unit components may be subdivided to make a phase distinction. Examples are Fluvents, rarely flooded; Typic Medisaprists, clayey substratum; and Gamma fine sandy loam, saline, 0 to 1 percent slopes, occasionally flooded.

Phases are not a category of the classification system, nor are they an interpretive group. Chapter 4 of the Soil Survey Manual provides a discussion of phases. The kinds of phases most commonly used in naming map units are listed below.

B. Surface Layer Texture Phases

- (1) Texture phases of mineral surface layers help to name map units. The texture phase name is consistent with the surface texture listed in the data mapunit in the National Soil Information System. The surface texture for the map unit name corresponds to the surface
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texture of the representative map unit component for the dominant land use of the map unit. Use the basic texture class names, such as sand, clay, and silt loam. Make fine distinctions in the sand fraction for the basic texture classes of sand, loamy sand, and sandy loam if both of the following apply:

- (i) These distinctions are reasonably easy to recognize.
 - (ii) These distinctions serve a useful purpose.
- (2) Do not use general texture groups, such as coarse textured and medium textured, to name surface texture phases. Do not use surface texture phases if map units include components named for taxonomic categories above the soil series. Chapter 4 of the Soil Survey Manual provides the texture terms used in the names of phases.
 - (3) Use terms in lieu of texture for organic surface phases, such as muck, peat, and mucky peat, to name surface layers of organic soils. Examples are Alpha muck, Beta peat, and Gamma mucky peat. Chapter 4 of the Soil Survey Manual describes these terms.
 - (4) Chapter 4 of the Soil Survey Manual gives a detailed discussion of fragment phases of map units. Part 618 of this handbook provides more information on both artifacts and fragments in the soil.
 - (i) Modify the surface layer texture phase with a suitable texture modifier if rock fragments exceed critical values such as Alpha gravelly loam in the case of a horizon equaling or exceeding 15 percent by volume. Texture modifiers are available to reflect various soil properties of surface horizons such as rock fragments, pararock fragments, artifacts, fine- earth composition, carbon content, fiber content, and presence of limnic materials. See part 618 of this handbook for more detailed information on the proper use of texture modifiers in surface horizons of mineral and organic soils.
 - (ii) Use surface phases if stones, boulders, or smaller fragments constitute more than 0.01 percent of the soil surface and they are needed to separate map units or denote important information about the map unit. Do not confuse these phases with the use of fragments as texture modifiers. For example, Alpha loam, 10 to 20 percent slopes, bouldery, is a bouldery surface phase. Part 618 of this handbook provides more information on surface fragments.
 - (iii) Use a rockiness phase if desired to name map units where rock outcrops make up 10 percent or less of the surface area. An example is Alpha very gravelly loam, 10 to 25 percent slopes, rocky. If rock outcrop makes up more than 10 percent of the surface area, name the map units as soil and rock outcrop. An example is Alpha-Rock outcrop complex, 0 to 25 percent slopes. Where rockiness phases are used, both “rocky” and “very rocky” phases can be named. Commonly units with less than 2 percent rock outcrop are named “rocky” and those with 2 to 10 percent are named “very rocky.”

C. Slope Phases

- (1) Soil map units that have simple slopes commonly have the slope gradient range in percent following their name. Map units that have complex slopes are sometimes named in a similar manner. Use slope gradient in percent to name consociations, complexes, and undifferentiated soil groups if soil series provide the reference name. Examples are Alpha silt loam, 4 to 8 percent slopes, cool; Alpha-Beta complex, 8 to 15 percent slopes; and Alpha, Beta, and Gamma soils, saline, 0 to 2 percent slopes.
- (2) Use adjective slope terms for designating phases of map units that have complex slopes or that are named in reference to any taxonomic category above the soil series, in associations, and in some undifferentiated soil groups. Examples are Paleudalfs, steep; Alpha-Beta association, hilly; and Alpha and Beta soils, rolling.
- (3) The slope phase designation follows the name of the reference taxon and other phase

terms that are based on internal soil properties and is separated from them by a comma. Use the plural “slopes” if the gradient is specified in percent but omit the term if adjective names of slope classes are used.

D. Eroded Phases

- (1) Base eroded phases of a soil on significant differences in land use suitability, conservation needs, input requirements, or yields resulting from accelerated erosion. The potential for erosion is not a criterion for phases of eroded soil. Base phases of eroded soil on a comparison between the suitability for use and management needs of the eroded soil and those of the uneroded soil. Identify the phase of the eroded soil on the basis of the properties of the soil that remains. Describe an estimate of the amount of soil lost. Degree Classes of erosion are shown in table 2-12 in chapter 2 of the Soil Survey Manual, and chapter 4 gives guidelines for naming eroded soils. The degree classes given in chapter 2 of the Soil Survey Manual are useful but make phase separations on the basis of relative differences in soil properties and the use and management of the soil as a result of erosion and not on the basis of class definitions.
- (2) Identify erosion even if genetic soil horizons have been removed throughout most of the area and the soil is a different series than it was before erosion occurred. If the original soil taxon is no longer identifiable except in isolated spots, change the reference taxon. The soil properties that exist after erosion determine the characteristic of the taxon. Designate the unit as a phase of eroded soil of the taxon as currently classified, or designate it as a complex of eroded and uneroded taxa. Examples are Udorthents-Alpha complex, eroded and Alpha, eroded-Beta complex.
- (3) In many map units of eroded soils, the surface layer has not been uniformly eroded from the site. Instead, the texture, color, and thickness of the surface layer vary over short distances. Use the dominant texture to name the map unit. Describe the variability of the surface layer in the map unit description. The term designating the eroded soil phase is the last term in the name of the map unit. An example is Alpha loam, 8 to 15 percent slopes, moderately eroded. Chapter 2 of the Soil Survey Manual describes the classes for map units eroded by water as slightly, moderately, and severely eroded and the term gullied. Typically, the slightly eroded phase should be used when the map unit is dominated by class-1 erosion, the moderately eroded phase should be used when the map unit is dominated by class-2 erosion, and the severely eroded phase should be used when the map unit is dominated by class-3 erosion.

E. Depositional Phases.—In some places, the soil material that was removed by wind or water deposits on other soils in amounts great enough to influence the management of the soil. If the recently deposited material is thick, consider the soil as a buried soil and do not use a depositional phase term. Refer to Soil Taxonomy for the definition of a buried soil. If the deposit is thinner than those limits and has not acquired the properties characteristic of the epipedon of the covered soil, name it as a depositional phase. Depositional phases are overblown, wind hummocky, and overwash. Place terms designating depositional phases last in map unit names. Examples are Alpha sandy loam, 2 to 8 percent slopes, overwash; and Beta loam, overblown. Chapter 4 of the Soil Survey Manual provides information about deposits on the surface.

F. Depth Phases

- (1) Measure depth phases from the surface of the soil down. Use depth phases to subdivide map units on the basis of depth to a component feature that is significant for purposes of the survey. A depth term, such as deep or shallow, refers to depth to bedrock unless another feature is specified. Chapter 3 of the Soil Survey Manual discusses root-restricting depth.

- (2) Terms for depth phases identify the depth to a variety of features. The terms and their meanings are as follows:
 - (i) Very shallow, less than 25 cm (<10 inches)
 - (ii) Shallow, 25 cm to less than 50 cm (10 to <20 inches)
 - (iii) Moderately deep, 50 to less than 100 cm (20 to <40 inches)
 - (iv) Deep, 100 to less than 150 cm (40 to <60 inches)
 - (v) Very deep, 150 cm or more (≥ 60 inches)
- (3) Examples of phases for depth to a specified bedrock or strongly contrasting material are as follows:
 - (i) Deep over basalt
 - (ii) Moderately deep over gravel
 - (iii) Moderately deep over sand
 - (iv) Shallow over clay
 - (v) Shallow over schist
- (4) Only specify the kind of rock in the name if it has some special value for interpretation.
- (5) “Very shallow” soils are often included in “shallow.” Do not give a depth designation to the most extensive phase.
- (6) Place the depth terms after surface soil texture in the map unit name and separate from them by a comma. Depth precedes any terms for slope, erosion, deposition, or surface phases of soils that have stones or boulders. An example is Alpha silt loam, shallow, 6 to 8 percent slopes, moderately eroded.

G. Substratum Phases.—If material in the substratum contrasts sharply with that which is normal for the taxa, identify it by specifying it in the name. The identifying terms follow the name of the taxon and surface soil texture. It precedes any terms for slope, erosion, deposition, or surface phases of soils that have stones or boulders. An example is Alpha silt loam, gravelly substratum, 6 to 20 percent slopes, eroded. Chapter 4 of the Soil Survey Manual lists common substratum names.

H. Soil Water Phases.—Soil water terms follow terms for surface soil texture and are separated from them by a comma. They precede any terms for slope, erosion, deposition, or surface phases of soils that have stones or boulders. Soil water phases include internal water terms such as “slightly wet,” “drained,” and “ponded.” Ponding is considered a soil water phase since ponded water commonly represents the level of the water table. Examples are Alpha silt loam, high water table; Beta silt loam, ponded, 0 to 1 percent slopes; and Gamma clay loam, somewhat poorly drained, 2 to 5 percent slopes, moderately eroded. Chapter 3 of the Soil Survey Manual gives additional information and examples of soil water states.

I. Salinity Phases.—Salinity phases distinguish the degrees of salinity that are important for soil use or management. In some instances, observed plant growth is evidence for salinity phases. Electrical conductivity values can be used as a guide. The general salinity phase term used is “saline.” See chapter 3 of the Soil Survey Manual for detailed information on salinity classes. The terms for salinity phases use the salinity class following any terms for surface soil texture and are separated from them by a comma. They precede any terms for slope, erosion, deposition, soil water, or surface phases of soils that have stones or boulders. An example is Alpha silt loam, saline, 1 to 3 percent slopes, very stony. Chapter 3 of the Soil Survey Manual gives additional information on salinity and electrical conductivity.

J. Sodicity Phases.—For some soils, recognizing a sodicity phase is useful. For example, a “sodic” phase designation added to a salinity phase designation may differentiate a sodic part of a normally saline soil. Use the term “sodic” as a phase designation without terms for degrees of sodicity. The term for a sodicity phase follows surface soil texture in map unit names. Separate

the terms and are separated from them with a comma. It precedes any terms for slope, erosion, deposition, soil water, or surface phases of soils that have stones or boulders. An example is Alpha silt loam, strongly saline, sodic, 0 to 3 percent slopes. Chapter 3 of the Soil Survey Manual gives additional information on sodicity and sodium adsorption ratio (SAR).

K. Physiographic Phases.—Landform or physiographic position can distinguish map units of a single taxon. Do not name the most common physiographic phase. Chapter 2 of the Soil Survey Manual gives additional information on landform or physiographic position and examples of physiographic phases and part 629, subpart A, section 629.2, of this handbook contains a glossary of recommended terms that are used to designate physiographic phases. Do not use terms not present in section 629.2 unless they are approved by the National Soil Survey Center. The terms for physiographic phases follow surface soil texture in map unit names. Separate the terms with a comma. They precede any terms for slope, erosion, deposition, or surface phases of soils that have stones and boulders. An example is Alpha gravelly loam, rock pediment, 0 to 8 percent slopes. State physiographic areas (e.g., Des Moines Lobe) may be useful phase terms within an MLRA to distinguish otherwise identically named map units. Names of MLRAs (e.g., Central Rolling Red Plains, Eastern Part) may be useful map unit phase terms within an initial survey area, when phasing on soil properties or other factors alone does not adequately separate map unit names.

L. Climatic Phases.—Use climatic phases to distinguish air and soil temperature, potential evaporation, wind exposure, soil moisture, and precipitation. Be sure the phases are identifiable and mappable and that the differences are significant for the purposes of the survey. These are useful for differentiating map units that differ only in crop yields or ecological sites and are preferred over using crop yields or plant interpretive groups to name phases. The appropriate term is connotative only in reference to the common atmospheric climate for the reference taxon. Describe it specifically for each map unit to which it applies. Give the appropriate climatic phase term after texture for the soil component of a consociation map unit. An example is Alpha silt loam, cool, 4- to 8-percent slopes.

For map units which are a complex, association, or undifferentiated group and all taxa share the same climatic distinction use the appropriate climate phase term immediately following the words “complex,” “association,” or “soils,” respectively. An example is Gamma-Beta complex, cool, 30- to 70-percent slopes. For multiple component map units with taxa that do not share the same climatic distinction, enter the climate phase to reference the appropriate taxon. An example is Sigma, warm- Theta association, 25 to 50 percent slopes. Chapter 4 of the Soil Survey Manual gives additional information and examples of climatic phases.

M. Other Phases.—If a taxon has too wide a range in properties for the interpretations needed or if some feature outside the soil itself is significant for management, then other phases terms are needed in a map unit name. Other phase terms commonly include only part of the range of features exhibited by a taxon, but phases can be based on attributes such as flooding, frost hazard, character of the soil surface, and differences in mapunit composition. Although there is a great variety of phase distinctions available, only identify those that are useful for the purposes of the survey, can be mapped consistently, and are needed to distinguish similarly named map units. Some examples of other phase terms are “burned,” “calcareous surface,” “[taxon name] minor component,” “hydric minor component,” “occasionally flooded,” and “1-to-2-meter water depth.” A burned phase, for example, might be used to name a map unit of organic soils that have lost enough of their organic material by fire to alter their potential use or their management requirements. This kind of phase term appears last in the map unit name. An example is Gamma fine sandy loam, saline, 0 to 1 percent slopes, occasionally flooded. Chapter 4 of the Soil Survey Manual gives additional information and examples of other phases.

627.7 Soil Performance Data Collection

A. Planning.—Soil performance data collection begins by requesting assistance of discipline specialists, such as foresters, agronomists, range conservationists, engineers, soil consultants, environmental engineers, and wildlife biologists for planning and scheduling.

B. Field Study.—Soil survey areas that have important riparian areas, rangeland, or forestland require field study by an interdisciplinary team. The team selects and studies sites on each important landform that has typical soils producing range plants or forestland plants. The soil scientists later study the same landforms in other land uses to determine if the soils are significantly different as a result of use. These studies may result in the development of new map units to meet user needs for soil interpretations and management decisions.

C. Requirements.—Specific requirements to adequately document rangeland, forestry, agronomy, or other soil performance are in the various discipline manuals, such as the National Forestry Manual and National Ecological Site Handbook. The actual data collection responsibilities are to be addressed in the soil survey memorandum of understanding. Section 627.9 discusses ecological site and soil correlation.

D. Crop Yields

- (1) Crop yield data from research plots and field trials are valuable in estimating yields for individual soils. Classifying and describing the soil at the plot enables the transfer of information to other sites. Always record the management practices that were used. This information goes into a data file by soil map unit component.
- (2) Crop yield data that are collected from farmers' fields are a good source of data. Data entirely from one soil map unit component are especially useful.
 - (i) Sequential testing refers to measuring crop yields on several kinds of soil within selected farm fields. It provides valuable data because the management and weather variables are essentially held constant within a given field. Thus, the effect of soil on crop yield is easier to determine.
 - (ii) Select fields for study to improve the understanding of soil performance on key soils. For example, to study the impacts of soil erosion, choose fields with eroded and uneroded soils of the same soil series. Obtain replications and narrow variables such as slope to a minimum.
 - (iii) Select sites carefully within each field to represent the soils intended for study. Randomization to better understand soil variability is not one of the purposes of sequential studies. The area of the site selected to represent a given soil map unit component should be sufficiently large to ensure that the yield test will be entirely on that soil component.
 - (iv) At selected sites, obtain sufficient data on soil properties to complete Form NRCS-SOI-1. In addition, consider laboratory analysis of samples to measure organic matter content, clay content, or other important properties.
 - (v) At the selected sites, carefully locate the boundaries or center point to enable visitations to the sites each year. Use geographic coordinates in distance from fixed points or a global positioning system. Collect yield tests over a period of several years. Multiyear data provides a better understanding of the probabilities of given yield levels. This helps in assessing the impact of erosion on yields in various weather conditions for various crops. Multiyear data also aids the evaluation of the impact of management practices on yields in crop seasons that are wetter, dryer, or

shorter than normal, and for other purposes.

- (3) Establish estimated yields for benchmark soils based on thorough review of yield data from all sources. Make such estimates for defined levels of management. Assembly and analyses of crop yield data for benchmark soils is an important state and major land resource area activity for NCSS agencies. Know the management practices and systems used for all yield data included in such analyses.
 - (i) Obtain enough yield data to evaluate various technologies in the productivity of given soils. For example, the differences in probable corn yields for no-till versus conventional tillage or for cropping systems with continuous corn, corn-soybeans, or corn following meadow in a rotation are very important. Soil scientists help assemble the needed data.
 - (ii) Estimate yields for crops most commonly produced on the soil. Do not give yields for crops that are not grown. The needed data are lacking for such soils. After estimating yield for benchmark soils, develop them for other soils by comparing key soil properties such as available water capacity and slope. Use multiple judgments of informed soil scientists, agronomists, and conservationists. Use caution with schemes for calculating yields.
 - (iii) Place yield estimates in the soil databases only after review by all States in which the map unit occurs. This is to ensure that the scientists consider all yield data and all experience with a soil map unit component. Yield estimates in the soil database reflect the representative values of the soil properties that are the most important for productivity. Normally, the results are estimated yields that are applicable throughout a major land resource area. Where such applicability is not achieved, the correlation of the soil map unit component may be in error or the range in climate of the resource area may be too wide.
 - (iv) Yields in the soil database are for a high level of management. This is a level obtained by leading farmers that produce the highest economic returns per acre. It includes the best varieties; balancing plant populations and added nutrients to the potential of the soil; control of erosion, weeds, insects, and diseases; maintenance of optimum soil tilth; adequate soil drainage; and timely operations.
- (4) USDA agencies developed an interagency USDA Soil-Crop Yield Database. Entering data into this nationwide database greatly extends the value of the data.
 - (i) Use Form NRCS-SOI-1 data and instructions for entering data into the database. Sections 627.11 and 627.12 provide this information. Each State has a small supply of the form. The States reproduce this form as needed. NRCS supplies copies of the form to other agencies and instructions for its use.
 - (ii) If the needed soil, management, and weather data are supplied, the following kinds of crop yield data are eligible for the database:
 - Yield measurement from commercial farm fields
 - Yield measurements from field trials of special treatment practices (fertilizer trials, variety trials, and conservation tillage trials)
 - Yield measurements from small research plots at experiment stations or other research institutions
 - (iii) Submit completed NRCS-SOI-1 forms to the National Soil Survey Center. The center arranges data entry, storage, and access.
 - (iv) Encourage those agencies which collect and use crop yield data to complete NRCS-SOI- 1 forms. These agencies include the State land grant university, the Cooperative Extension Service, the Agricultural Research Service, the Farm Services Agency, the Economic Research Service, and NRCS.

627.8 Documentation

(A) Definition.—Soil survey documentation is scientific data from measurements and observations of basic soil properties and qualities and of spatial arrangements that are collected in the field or remotely sensed using standardized procedures. This data is systematically recorded. Soil survey documentation is used to verify soil-landscape models, interpretations, and projections for use. The dominant type of documentation varies by soil order (section 627.17). The percentages of delineations that use any one type of documentation vary by the size and number of delineations of a map unit in a physiographic area. The information is presented as geographical descriptions of landscapes and boundaries, soil profiles, soil layers, chemical and physical properties, or temporal condition. It has spatial, temporal, physical, and chemical aspects. Documentation ensures proper soil classification, uniform and consistent mapping, and supports inferences for application of the information to similar landscapes.

- (1) Documentation is collected over time and permanently archived. The information is cumulative. It is organized by major land resource area. Documentation progressively refines and improves soil-landscape models.
- (2) The SSO organizes and analyzes support data and adds it to the National Soil Information System. Field notes, including soil pedon descriptions, map unit descriptions, transects, laboratory data, and notes of an interpretive nature supplement soil maps. Soil maps and this descriptive information in the database become the primary records of a soil survey. Chapter 7 of the *Soil Survey Manual* gives helpful information about field notes and soil descriptions.

(B) Purpose of Documentation.—Documentation is collected for specific outcomes within each survey area. The main outcomes are to—

- (1) Be able to develop science-based soil-landscape models so we can delineate polygons of like soils.
- (2) Be able to build and store property data in a permanent database accessible to users.
- (3) Quantify soil spatial variability in order to make logical breaks in soil landscapes.
- (4) Better communicate with soil scientists and related professions (nomenclature, taxonomy, etc.).
- (5) Correlate ecological sites with soils.
- (6) Be able to classify and correlate soils consistently.
- (7) Be able to develop and test interpretations.
- (8) Be able to test and report the reliability of soil survey information.

(C) Specifying Documentation.—The memorandum of understanding and the project plan specify the kind and amount of support data required. The requirements for documentation written into the memorandum are based on the evaluation of the deficiencies in the map units of the previous soil survey. Refer to part 610 of this handbook for guidance on evaluations. For previously unmapped areas the requirements for documentation are based on the evaluation of the landscapes and map units of the surveys adjacent to the area. Generally map units that are not revised do not need further documentation other than that provided in the evaluation. Map units revised or redesigned need full documentation within the major land resource area.

Because of the variable nature of parent material, landscape patterns, uniformity, land use, user needs, scale, access, and past documentation, flexibility is needed for requirements in the type and amount of field documentation for map units within each survey area.

Agreements on documentation requirements that differ from standard field description standards should be spelled out in the memorandum of understanding for each survey area

before field work starts. The soil survey regional office (SSR) takes the lead, as part of quality assurance, in assuring these standards are reasonable and adequate for correlation and interpretation and are addressed in the memorandum of understanding and project work plans.

D. Kinds of Documentation

(1) Field Notes

(i) Field notes are essential for the preparation of the descriptive legend and soil survey manuscript because—

- Many of the facts obtained in the field cannot be recorded on the map or in standard soil descriptions.
- The soil scientist cannot remember the details of all field observations, or the soil scientist may retire or transfer before completing the survey.
- They help office staff to achieve consistent work among the project members.
- They provide the data necessary for describing, classifying, and interpreting soils.
- They provide data for long-term records.
- They aid in developing and recording the map unit concept and criteria.
- Soil scientists take field notes as they progressively map the soils. They—
 - Record them on location at the time of the observation.
 - Emphasize documenting the ordinary, the prevalent, and the commonplace.
 - If not a direct observation, clearly identify location, date, author, soil component, and source.
 - Use standard terminology and standard database programs.
 - Clearly separate observations from conclusions and speculations.
 - Summarize at regular intervals to determine the status of the documentation effort.
 - Add to the site observation table in NASIS.
 - File in a logical manner, preferably by map unit component and map unit, for easy reference.

(ii) Interpretive field notes are important in documenting soil behavior in the survey area. Interpretive notes result from direct observation or from information provided by resource specialists, farmers, extension personnel, agricultural teachers, fertilizer and farm equipment dealers, soil consultants, environmental scientists, county sanitarians, engineers, and other persons with experience or knowledge of soil relationships.

(2) *Pedon descriptions* are the primary records for soil identification, classification, and interpretation. Chapters 7 and 11 of the Soil Survey Manual provide helpful information, guidance, and standard terminology for describing soils. Typical pedons characterize each named component in a map unit. The SSO maintains a map that locates soil description sites, especially the typical pedons. Describe soils as they occur in order to represent each map unit component. All soil descriptions are to be taken in metric units of centimeters to avoid errors of conversion. One pedon description represents each component. *It is permissible to use pedons from surveys sharing the data mapunit from within the same major land resource area and MLRA legend.* Tentatively classify all pedons at the time when they are described. After sufficient descriptions have been taken, establish a central concept and range for a kind of soil. Consult the official soil series descriptions to determine proper series placement. If the soil differs significantly from all recognized soil series in the same taxonomic family, classify the soil in the lowest possible category of soil taxonomy.

Pedons that have all soil characteristics representative of a given kind of soil often are difficult to locate or do not exist in an individual survey area. Soil scientists must

objectively locate and describe pedons that are representative of the kind of soil in the area. Soil descriptions must be complete and legible. It is important to give the exact geographic location of pedons to allow for spatial analysis and revisitation of the sites.

- (3) *Map unit descriptions* are based from the collection of field notes, transects, and soil descriptions. The notes and descriptions—
 - (i) Characterize the soils within the map unit.
 - (ii) Determine the patterns of occurrence of different kinds of soils within the map unit, their proportionate extent, and their position on the landform.
 - (iii) Determine the relationships of one map unit to another and the distinction between similar map units to support the descriptive legend.
- (4) *Images*, including slides, black and white photos, color photos, and digital images taken during the soil survey illustrate and document field conditions for soil survey reports, information activities, and training sessions. Soil profiles, landscapes, vegetation patterns, typical landforms, rock exposure, and the results of management practices applied to particular soils are needed.
- (5) *Soil survey investigations* may take the form of laboratory data obtained by collecting samples for chemical, physical, or engineering analysis. Other investigations may result in documentation of soil temperature, moisture, or other soil property or quality. Refer to part 631 of this handbook for information on soil survey investigations.

E. Field Description Standards

- (1) The MLRA leader ensures the systematic collection of documentation by providing each staff member with a list of specific instructions about the kind of information needed for each map unit and soil map unit component.
- (2) The memorandum of understanding for the survey area, or project plan, provides guidance for the type and amount of documentation. Documentation needs and standards may vary by map unit within the same survey area. Flexibility of guidance allows for sufficient data collection for each map yet avoids the excess time and expense of redundant or superfluous data.
 - (i) *Proposed series* require complete descriptions of at least 5 pedons for new series with an extent of less than 2,000 acres. New series with an extent of over 20,000 acres require 10 complete pedon descriptions. The number and distribution of pedon descriptions must be adequate to classify, differentiate, and develop a valid range of characteristics. Larger acreage units require more pedons descriptions to assure reasonable spatial representation across its extent.
Laboratory data and field notes supplement these requirements. Part 614, Section 614.6, of this handbook provides helpful information on proposing a soil series.
 - (ii) *Map unit soil components* each have a unique description. This representative pedon description exhibits typical properties and horizonation of the map unit component as it exists within the major land resource area. Each major soil component named within a map unit of the major land resource area legend requires one pedon description from the map unit. Minor components that are not named in a map unit of the legend but that occur in the component list of the database need a minimum of one pedon description. Provisional map units are exempted. This documentation is adequate for map units where the extent of the map unit is up to 3,000 acres. Where the extent is over 3,000 acres, the amount of additional descriptions are agreed upon and recorded in the memorandum of understanding. Factors that need to be considered are uniformity of material, scale, land use, and access.

To ensure that documentation is adequate for the correlation of soil component

names to established soil series or higher taxonomic categories, at least three pedon descriptions are required for each taxon used in the legend. Descriptions gathered to typify the map unit component as mentioned above and descriptions within adjacent surveys within the major land resource area are included in this total.

- (iii) *Map units* require a minimum of 30 recorded points for each map unit to document the composition. The points need to be distributed throughout the full extent of the map unit to account for spatial variability. Depending upon the nature of the map unit, the points can come from a fixed interval transect, a line transect (points selected to represent line segments related to vegetation, hillslope position, photo tone, etc.) or other techniques to ensure composition. This documentation is adequate where the extent of the map units are less than 2,000 acres. Where the extent is over 2,000 acres, add an additional 10 recorded points for each 4,000 acres. Sufficient documentation typically exists when the number of recorded points reach 60, given adequate spatial distribution. Due to unique situations and variability, the memorandum of understanding state specific requirements as needed based on uniformity of material, scale, land use, or access. Where applicable, the use of statistics can be helpful in determining the adequacy of recorded points.
- (iv) *Exceptions* to the minimum standards for documentation of map units and map unit components apply when adding small acreage map units along the boundary of an ongoing soil survey or modern published soil survey. Section 627.3 provides more details on map units of small extent. In these cases use the documentation from the joining soil survey area that has the larger acreage for correlation.

The SSO regularly review and summarize all documentation. Where applicable, a statistical analysis of data is done to objectively evaluate soil properties and map unit composition. The descriptive legend, manuscript, and database are updated periodically based on progressively gathered documentation. Documentation undergoes a quality assurance review at regular intervals by the SSRO.

Determinations are made about the documentation in regard to—

- Attaining the outcomes as stated above.
- Meeting the Field Description Standards (or standards modified in the MOU).
- Identifying the need for additional documentation.

F. Descriptive Legend.—A descriptive legend is required for all soil surveys. It may be unique for an initial soil survey area, but in most cases should be an MLRA regional legend. Prepare the first draft of the descriptive legend during the preliminary study of the soils. It is available for inspection at the initial field review. At a minimum update and review the legend during annual progress reviews.

- (1) The descriptive legend has four parts:
 - (i) The identification legend
 - (ii) The feature and symbol legend
 - (iii) The descriptions of map units, descriptions and classification of the soils
 - (iv) The general soil map and legend
- (2) Chapter 4 of the Soil Survey Manual also gives helpful information about the descriptive legend and survey area soil handbook.
 - (i) Identification Legend.—The identification legend consists of a list of map unit symbols and map unit names. Prepare the identification legend from map units and map unit components proposed and described. Only list those map units whose occurrence and justification were established during mapping. The SSO or staff maintains records of all symbols and proposed changes to the identification legend.

Field reviews record legend changes that are approved by the SSR. The field review reports must account for all the map units and symbols used at any time during the survey. All field review reports include an updated identification legend. The National Soil Information System is the official depository of legends, correlation notes, and legend text. Chapter 4 of the Soil Survey Manual describes the identification legend.

- The legend is sorted numerically or alphabetically by map unit symbol. Numerically sort and publish the legend, map units, and tables where map unit symbols (or labels) are numeric or alpha-numeric. Alphabetically sort and publish the legend, map units, and tables where map unit symbols (or labels) are alphabetical.
- Symbols.—Map unit symbols are descriptive labels on soil maps. They are designed in a manner that avoids confusion with other symbols shown on soil maps representing specific features, such as those in the “Feature and Symbol Legend for Soil Survey” (section 627.14). Soil survey map unit symbols combine alpha, alphanumeric, or numeric characters. Section 627.13 gives several examples. Symbols should be as short as possible, but may contain up to six characters, including special characters like hyphens. Avoid the use of the lowercase letters “i,” “j,” “q,” and “l” because when handwritten these letters are easily confused with other letters or the number 1.
- Slope Phases.—Identification of a slope phase with a symbol is optional. However, a capital letter (A through G) commonly identifies a map unit slope phase. Examples are AoB for Alpha loam, 3 to 6 percent slopes, and 123B for Alpha sandy loam, 3 to 6 percent slopes. If two or more slope groups, such as 3 and 6 percent and 6 to 9 percent, combine during correlation into a map unit, such as 3 to 9 percent slopes, only use one letter to identify slope. Use the symbol for the most restrictive slope from the named components if you combine slope groups. Consider using separate components, each with their own slope group, if these components would be dissimilar.

(ii) Feature and Symbol Legend for Soil Survey

- Each soil survey area requires a Feature and Symbol Legend for Soil Survey (NRCS- SOI-37A). See section 627.14. The legend identifies all approved map features that may be published in soil surveys including—
 - Area, line, and point soil features including soil boundary lines and soil symbols.
 - Ad hoc features and standard landform and miscellaneous surface features that are too small to be delineated as areas on soil map sheets at either 1:12,000 (<1.4 acres) or 1:24,000 (<5.7 acres) scale.
 - Cultural features, such as structures, political boundaries, road emblems, and airports.
 - Hydrographic features, such as streams, springs, and wells.
- The descriptions of the standard landform and miscellaneous surface features are on the back of the Form NRCS-SOI-37A. If the legend includes ad hoc features, write the description on the back of the NRCS-SOI-37A.
- Use standard landform and miscellaneous surface features or ad hoc features to show local areas of significantly contrasting soils or features too small to delineate at the publication scale. The need for these features depends on their significance to present or projected use of the soils and the soil map. These features are primarily for location purposes and only surface determined properties or responses define them. These features are not used to indicate soils

Title 430 – National Soil Survey Handbook
or features that are identified in the name or description of the map unit delineated. Nor are these features used as identifying symbols in small delineations.

- Define ad hoc features on the 37A in the section entitled “Descriptions for Ad Hoc Features.” Define the specific kind and size of the area represented.
- All symbols must correspond exactly to those listed on Form NRCS-SOI-37A.
- The SSO prepares the first draft of the feature and symbol legend before the initial field review of the survey area using the NRCS-SOI-37A. The review report includes the NRCS-SOI-37A. The back of the form includes the rules of application. All subsequent progress field reviews update and approve changes to this legend. Underline or otherwise highlight those features that are selected. Only compile those features that are highlighted.

(iii) Descriptions and Classification of the Soils

- Throughout the course of the survey, the SSO describes all map units and map unit components. The SSR approves these units before they are added to the identification legend. The SSO makes minor revisions, such as adding minor components to map units, broadening the range for the taxonomic unit, or improving descriptions of the shape of delineations of the map unit.
- The SSR approves major changes, such as the addition or deletion of a map unit or the change in concept of a taxonomic unit. The SSR prescribes the manner for submitting proposals for additions or deletions, and the supporting information. Make approved changes in all copies of the descriptive legend, including those used by the SSO and the SSR or lead agency. Keep a complete record of all major revisions and record these revisions and the reasons for them in the report of the first field review that is made after the revisions are proposed. The National Soil Information System is the official depository of legends, correlation notes, and legend text.
- The SSR or the appropriate supervisor of the lead agency arranges procedures with cooperating agencies to obtain their concurrence to revisions of the legend.

(iv) General Soil Map and Legend.—The general soil map shows the geographic distribution of general soil areas within the survey area.

G. Survey Area Soil Handbook

- (1) Each soil survey area in which acres of initial field mapping are being reported includes a survey area soil handbook. The preparation of a survey area soil handbook starts at the beginning of the soil survey with the inclusion of the descriptive legend. The SSO prepares and keeps current a survey area soil handbook through the life of the survey. The SSO prepares an outline of the survey area soil handbook during the first year of the soil survey to meet the requirements of the survey area. The SSO similarly prepares a schedule that lists target dates for completion of all major parts of the survey area soil handbook. Part 608 of this handbook provides more information. The arrangement and format of material in the survey area soil handbook is similar to that in published soil surveys. In addition to the descriptive legend, the handbook includes the soil survey manuscript prewritten material, original material that is prepared by the SSO and guest authors, block diagrams, references, and pictures. The handbook is usually maintained in loose-leaf binders with dividers that separate major parts. Part 644, Subpart B, Section 644.8, “Sections of a Soil Survey Publication,” gives information on the format and arrangement of a published soil survey. Chapter 4 of the Soil Survey Manual provides additional information about the soil survey area soil handbook.

- (2) The survey area soil handbook receives additions and revisions as the survey progresses to reflect the knowledge gained during fieldwork. Persons who need soil data before the survey is published often use this handbook. The handbook is available in the soil survey office and in the office of the district conservationists for use and testing by other disciplines.
- (3) At the time field activities conclude, the handbook encompasses the information needed to complete the manuscript for the survey area. The soil survey manuscript is essentially complete before the final field review.

627.9 Ecological Site and Soil Correlation Procedures

A. Definition and Purpose

- (1) Ecological site and soil correlation procedures are actions to consistently relate ecological sites and soil components. The soil is an integral part of the ecological site.
- (2) Soil survey is often a component of an ecosystem inventory. Ecosystem inventories include not only soil and vegetation but also include the associated topography, climate, water, animals, and other living organisms. Fire and air are sometimes included. These components are interrelated. Human actions and disturbance are considered. Any disturbance exerted on one component affects other components.
- (3) Ecological site correlation relates ecosystem components within and between areas perceived as having the same historic climax plant community. Ecological site correlation procedures support consistent descriptions, documentation of the ecosystem components, and interpretations associated within the site.
- (4) Correlation is a continuous process that is initiated at the beginning of any soil or vegetation survey and progresses through a final correlation.
- (5) Soil-ecological site correlation can take place in conjunction with progressive soil correlation. However, ecological site correlation may also be necessary because of updates or revisions of ecological site descriptions.
- (6) Title 190, National Ecological Site Handbook, Part 630; Title 190, National Range and Pasture Handbook (NRPH), Part 600, Chapter 3, Section 1; and Title 190, National Forestry Manual (NFM), Part 537, Subpart D, define and describe ecological site correlation procedures.

B. Records of Site Descriptions

The Ecological Site Information System (ESIS).—Ecological Site Description database is the official repository for all data associated with ecological site descriptions. The State office is responsible for entry and maintenance of site descriptions in this database.

C. Updating or Revising Site Descriptions

Update site descriptions according to procedures established by NRCS in the NRPH and NFM.

D. Interstate Correlation of Soils and Ecological Sites.—The following steps serve as a guideline for interstate correlation of soils and ecological sites. It is recommended to allow a minimum of 6 months to complete this process.

- (1) Evaluate resource data and summaries for adequacy of use for site comparison. Include data on soils, vegetation, climate, landform, animals, and other living organisms.
- (2) Exchange proposed and established site descriptions for the area.
- (3) Jointly visit the sites.
- (4) Document which sites can be correlated and those that cannot be correlated at this time.

Title 430 – National Soil Survey Handbook

- (5) Make an initial grouping or separation of sites based on the criteria for comparison between sites (see sections 627.9F and G of the correlation guidelines).
- (6) Submit a proposal to other states for correlating comparable sites and resolving the remaining issues.
- (7) Coordinate with field staff to jointly select locations to be correlated. It is not necessary to visit every site if there are no disagreements.
- (8) Provide all necessary documentation (see section 627.9H correlation guidelines), including soil pits at the review sites.

Part 627 – Legend Development and Data Collection

Subpart B – Exhibits

627.10 Miscellaneous Areas

Miscellaneous areas have essentially no soil or are bodies of soil that are heavily disturbed. They can result from active erosion and deposition, flooding and ponding, unfavorable edaphic conditions, or human activities. Some miscellaneous areas can be made productive, but only after major reclamation efforts. The paragraphs below discuss the 20 miscellaneous areas that are approved for use as component names. No other miscellaneous area names are used. See section 627.4F(2) for the process to revise the list of areas. Phase terms are not populated in the component name column of the database. Map unit names can consist of the concatenated miscellaneous area name and the local phase term (e.g., “Water, saline”). Local phase terms are developed as needed and have no finite limit or national approval process.

Badland is moderately steep to very steep barren land that is dissected by many intermittent drainage channels. Ordinarily, the areas are not stony. Badland is most common in semiarid and arid regions where streams and surface runoff have cut into soft bedrock such as shale. Local relief generally ranges from 10 to 200 meters in height. Potential runoff is very high and erosion is active.

Beaches are sandy, gravelly, or cobbly shores that are washed and rewashed by waves. The areas may be partly covered with water during high tides or storms.

Chutes are elongated areas on steep mountain slopes. The vegetation has been removed by avalanche or mass movement processes. Chutes consist of exposed bedrock, rock fragments, and large woody debris. Their slopes are parallel to the slope of the mountain and their lengths are at least ten times their widths.

Cinder land is composed of loose cinders and other scoriaceous tephra. The water-holding capacity of the tephra is very low and the trafficability is poor. Cinder land is commonly associated with cinder cone volcanoes, but not all cinder land occurs on the flanks of volcanic hills or mountains.

Dams are artificial structures, oriented across a watercourse or natural drainage area, for the purpose of impounding or diverting water.

Dumps are areas of smoothed or uneven accumulations or piles of waste rock and general refuse. Some dumps that are closely associated with pits are mapped as a complex map unit of dumps and pits.

Dune land consists of sand in ridges and intervening troughs that shift with the wind.

Glaciers are large masses of ice that formed, at least in part, on land by the compaction and recrystallization of snow. They may be moving slowly downslope or outward in all directions because of the stress of their own weight, they may be retreating, or they may be stagnant. Rocks and some earthy material may be on the surface of or imbedded within the ice. Permanent snowfields are associated with glaciers in some regions.

Gullied land consists of areas where erosion has cut a network of V-shaped or U-shaped channels. The areas resemble miniature badlands. Generally, gullies are so deep that extensive reshaping is necessary

for most uses. Small areas can be shown by spot symbols. Phases that indicate the kind of material remaining may be useful for some areas.

Lava flows are areas covered with barren lava. In most humid regions, the flows are of Holocene age, but in arid and very cold regions they may be older. Some flows have sharp, jagged surfaces, crevices, and angular blocks that are characteristic of slow-moving viscous lava. The Hawaiian term for a basaltic lava flow with these features is named “aa.” Other lava flows are relatively smooth and have a ropy, glazed surface due to hotter eruption temperatures, lower viscosity, and rapid flow rates. The Hawaiian term for this form of lava flow is “pahoehoe.” A little earthy material, ash, cinders, or accumulations of fresh organic material may be in a few fractures and sheltered pockets, but the flows are virtually devoid of soil. Lava flows have no vegetation other than lichens or other plant life growing in small pockets.

Mined land is areas which are significantly altered by mining activities. Soil material and rock has been moved into, out of, or within the areas designated. Because access to mined land may be limited by permissions or hazardous materials, identification of soil components can be difficult or impossible. Mined land may also have associated small excavations which could be correlated and delineated as pits if needed.

Oil-waste land consists of areas where liquid oily wastes, principally of salt water and oil, have accumulated. It includes slush pits and adjacent areas that are affected by the liquid wastes. The land is barren, although some of it can be reclaimed at high cost.

Pits are open excavations from which soil and commonly underlying material have been removed, exposing either rock or other material. Common kinds of pits are those that result from mining, gravel operations, and quarries. Pits are often closely associated with dumps.

Playas are barren flats in closed basins in arid regions. The largest playas occupy the dry beds of ancient, pluvial lakes. The sediments in playas are mainly fine-grained lacustrine deposits that accumulate from silt and clay particles settling in still water. Many playas are subject to removal of sediments by wind action and are a local source of fine particulate matter. Many playas are saline, sodic, or both and may have mineral crusts of soluble salts. Some nearly level playas are subject to intermittent ponding following periods of heavy precipitation, snowmelt, or both. The water table may be near the surface at times, or it may remain at depth.

Riverwash is unstabilized sandy, silty, clayey, or gravelly sediment that is flooded, washed, and reworked frequently by rivers or streams that little or no vegetation can become established. The recent deposition of fresh alluvium precludes soil development.

Rock outcrop consists of exposures of barren bedrock, other than lava flows, chutes, and rock-lined pits. Some areas are large and are only broken by small areas of soil. Most rock outcrops are hard rock, but some are soft rock such as thin beds of weakly cemented shale interbedded with thick beds of strongly cemented sandstone.

Rubble land consists of areas of cobbles, flagstones, stones, and boulders in unstable deposits of sufficient thickness to significantly limit the establishment of vegetation. Rubble land is commonly at the base of mountains but in some areas consists of deposits of large rock fragments left on mountain slopes by glaciation or by periglacial processes.

Slickens are accumulations of fine textured material, such as that separated in placer mine and ore mill operations. Slickens from ore mills consist largely of freshly ground rock that commonly has undergone

chemical treatment during the milling process. Slickens are usually confined in specially constructed basins and are often contaminated by metallic compounds.

Urban land is land covered by pavement, buildings, storage tanks, bridges, and other impervious, human-manufactured surfaces and structures. Pavement is a hard-layered surface of concrete or asphalt that forms a walkway, road, street, highway lane, runway, parking lot, or similar paved area. Urban land can occur in urban areas such as large cities and industrial centers as well as in suburban neighborhoods and rural towns. If correlated properly, urban land consists of 100-percent manufactured surface. Older soil surveys correlating urban land with a less strict concept may consist of as little as 75-percent manufactured surface. Some modern soil surveys require identification of the materials below urban land. Urban land is an anthropogenic type of miscellaneous area that does not necessarily represent a permanent condition.

Water includes streams, lakes, ponds, and estuaries more than about 2.5 meters deep or less than 2.5 meters deep and lacks either distinguishable horizons or rooted vegetation in the bottom sediment. These areas are covered with water in most years, at least during the period that is warm enough for plants to grow. Many areas are covered throughout the year. Pits and playas that contain water most of the time are mapped as water.

627.11 Example of Form NRCS-SOI-1, “Soil-Crop Yield Data”

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE										SOIL-CROP YIELD DATA										NRCS-SOI-1 1-88										
1	SAMPLE NUMBER CO ID			PLOT KIND	SIZE OF PLOT WIDTH LENGTH		LATITUDE DEG MIN SEC		LONGITUDE DEG MIN SEC		LOCATION OTHER DESCRIPTION						AGENCY	DATE MO DY YR												
	ST.																													
2	SOIL MAP SYMBOL				SOIL MAP UNIT NAME														SOIL IDENT. AT SITE? Y/N											
																			Y											
3	SOIL INTERP. RECORD NUMBER			USDA TEXTURE		SLOPE (PCT)		FLOODING		OTHER PHASE CRITERIA																				
	ST.																													
4	EROSION	A HORIZON		THICKNESS (IN)	ORGANIC MATTER (PCT)	pH	ROOT DEPTH (IN)	SLOPE LENGTH THRU SITE (FT)		SLOPE ABOVE SITE (FT)		K FACTOR	SURFACE AGGREGATES >84 mm	ROUGHNESS FACTOR																
		COLOR												KIND	SHAPE	ASPECT	HEIGHT (IN)	SPACING (IN)												
5	MOISTURE RESERVE PLANTING		GROWING DEGREE DAYS		WEATHER Qual. Source		PRECIPITATION BY MONTH												DAMAGE		FACTORS									
							1	2	3	4	5	6	7	8	9	10	11	12	DRGHT	WATER	R	C %								
6	MULTI-CROP Y/N	CURRENT CROP				CURRENT CULTIVAR (VARIETY)				CROP HISTORY DATA FIRST				PREVIOUS CROPS SECOND				THIRD												
7	DATE MO DY YR		TIMING		PLANTING INFORMATION RATE		UNITS OF MEASURE		ROW SPACING		COVER AFTER PLTG (PCT)		DATE MO DY YR		TIMING		STAND DENSITY		HARVEST INFORMATION CROP YIELD		UNITS OF MEASURE		T/AC		RESIDUE ORIENTATION					
8	SOIL TEST		N		COMMERCIAL FERTILIZER LBS/AC		OTHER KIND		LBS/AC		ORGANIC MATERIALS T/AC		KIND		TILLAGE AGE		WEED CONTROL CHEM Y/N		NUM CULT		CROP DAM.		CHEM Y/N		INSPECT/DISEASE CONTROL KIND TREAT		NUM APPLIC		CROP DAMAGE	
9	OTHER DAMAGE		CONS. PRAC.		IRRIGATION Y/N		ADEQ. TYPE		UACY		DRAINAGE Y/N		CROP DAMAGE		FACTORS C		P		CONSERVATION PRACTICE CODES				RECORDER NAME							
																			1	2	3									

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[Clear Form](#)

627.12 Instructions for Completing Form NRCS-SOI-1, “Soil-Crop Yield Data”

(a) Line 1

- (1) Sample number.
 - (i) State code. Use the two-character alphabetic Federal Information Processing Standards (FIPS) code, for example, VA.
 - (ii) County code. Use the three-character numerical FIPS code.
 - (iii) Site identification number within county. Set up a sequence of two-digit numbers for each field and another sequence of two-digit numbers for each site within the field. Keep a log of these numbers as a record for testing at the same sites in subsequent years.
- (2) Kind of plot.

Enter one of the following codes:

1 = Yield measurements in commercial farm fields.

2 = Yield measurements in field trials of special treatment practices (fertilizer field trials, variety trials, conservation tillage trials).

3 = Yield measurements of small research plots at experiment stations (variety tests, fertilizer tests).

4 = Yield estimates.
- (3) Size of plot.

Enter width x length in feet, for example, 4 x 10.9
- (4) Location.

Use a map such as a 7½° quad, aerial photograph or soil survey to record the location.

 - (i) X coordinate. Enter latitude north. Separate degrees, minutes, and seconds by a hyphen, for example, 25-05-03.
 - (ii) Y coordinate. Enter longitude west, for example 108-25-49.
 - (iii) Other location description, for example NE¼ sec. 12, T. 31 N., R. 11 W.
- (5) Agency.

Enter the abbreviation of the agency entering the data.
- (6) Date.

Enter the date the form is filled out, for example, 8/14/81.

(b) Line 2

- (1) Soil symbol.

Enter the soil symbol of the area at the sample site (if known).
- (2) Soil name.

Enter the name of the soil identified at the sample site or through reference to the soil survey, for example, NORFOLK FINE SANDY LOAM, 3-5 PERCENT SLOPE.
- (3) Soil identified at site?

Indicate whether soil scientists identified the site. Enter Y for yes or N or no.

(c) Line 3

- (1) XX
- (2) USDA texture.

Enter the codes for texture class and texture modifier of the surface layer, for example, GR-L for gravelly loam. Use only the approved codes shown in the Part 618, Subpart B, Section 618.94, “Texture Class, Texture Modifier, and Terms Used in Lieu of Texture.”
- (3) Slope.

Enter the percent slope gradient to the nearest whole number on slopes of 1 percent or more; enter to the nearest 0.1 percent for slopes less than 1 percent.
- (4) Flooding.

Enter the flooding frequency (see part 618 of this handbook) that most nearly represents sample site. Use NONE, VERY RARE, RARE, OCCASIONAL, FREQUENT, or VERY FREQUENT.

- (5) Other phase criteria.
Enter phases used to name soil map unit components (see section 627.6), other than surface texture, slope, or flooding, that are needed to select the correct capability and yield interpretations for the component, for example, SEVERELY ERODED.
- (d) Line 4
- (1) Erosion.
Enter the code that most nearly represents the estimate of erosion:
1 = Slight
2 = Moderate
3 = Severe
- (2) Color of A horizon.
Enter the color (Munsell notation) of the A horizon.
- (3) Thickness of A horizon (inches).
Enter the thickness of the A horizon.
- (4) Organic matter.
Enter an estimate or measurement of the percent of organic matter (organic carbon x 1.72) in the A horizon.
- (5) pH.
Enter the pH of the surface 4 inches at the time of harvest, for example, 6.7.
- (6) Rooting depth (inches).
Measure the depth to fragipan, bedrock, gravel, or other root-impeding layer. If greater than 60 inches, enter >60.
- (7) Slope length.
(i) Through site (ft.). Enter the length of slope through the sample site, in feet. On terraced land enter the distance between terraces. Slope length is the distance from the point of origin of overland flow to either (a) the point where the slope decreases to the extent that deposition begins or (b) the point where runoff enters an area of concentrated flow or channel.
(ii) Above site (ft.). Enter the length of slope from point or origin of overland flow to the sample point in feet.
- (8) Slope.
(i) Kind.
Enter the code that most nearly represents kind of slope at the sample site:
1 = Summit
2 = Shoulder
3 = Back slope
4 = Foot slope
(ii) Shape.
Enter the code that most nearly represents the slope shape:
1 = Convex
2 = Plane
3 = Concave
4 = Undulating
5 = Complex
- (9) Aspect.
On slopes where aspect is important, enter one of the 8 points of the compass that the slope faces, for example, NE.
- (10) K factor.
Enter the soil erodibility (Kf) factor.
- (e) Line 5
- (1) Moisture reserve at planting time.
Enter one of the following codes:

- 1 = Above normal
- 2 = Normal
- 3 = Below normal
- (2) Moisture reserve at beginning of spring growing season following fall planting (winter wheat, and rye).
Enter one of the following codes:
 - 1 = Above normal
 - 2 = Normal
 - 3 = Below normal
- (3) Precipitation during the growing season.
 - (i) Qualitative. Enter the code that represents qualitative judgment:
 - 1 = Above normal
 - 2 = Normal
 - 3 = Below normal
 - (ii) By month. If monthly records are available, enter to the nearest inch the precipitation for each month.
- (4) Drought damage.
Enter the code that represents the judgment of the amount of crop damage caused by drought:
 - 1 = None
 - 2 = Slight
 - 3 = Moderate
 - 4 = Severe
- (5) Water damage.
Enter the code that describes the amount of crop damage caused by excessive wetness:
 - 1 = None
 - 2 = Slight
 - 3 = Moderate
 - 4 = Severe
- (6) R factor.
Enter the R (rainfall) factor.
- (f) Line 6
 - (1) Multiple-cropped.
Is the site double or triple cropped? Enter Y for yes, or N for no.
 - (2) Current crop.
Enter the crop name or code from the crop name and units of measure list in the NASIS-related metadata at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/tools/?cid=nrcs142p2_053548 <http://soils.usda.gov/technical/nasis/documents/metadata/>. Then follow the link to the “NASIS Version 76.x” index webpage. On the NASIS Version index webpage see the file named “Domains.pdf” for the most current list of crop names and crop yield units.
 - (3) Cultivar (variety).
Enter the name or identification of the crop variety.
 - (4) Previous crops.
Enter the names or codes of the crops grown in first, second, and third previous crop seasons.
- (g) Line 7
 - (1) Planting information.
 - (i) Date.
Enter the date of planting (month/day/year) if known, for example 5/15/86.
 - (ii) Timing.
Enter the code that describes timeliness of planting:
 - 1 = Early

2 = Normal

3 = Late

(iii) Crop yield.

Enter the amount of harvested crop per acre, for example, 110. Use standard procedures for measuring yield.

(iv) Unit of measure.

Enter the unit of measure (see part 618 of this handbook) for the crop, for example, bu/acre.

(v) Residue yield (t/acre).

Enter the air-dry tons per acre of crop residue (estimate if necessary).

(h) Line 8

(1) Commercial fertilizer.

(i) NPK

Enter the pounds of elemental nitrogen, phosphorus, and potassium applied per acre.

(ii) Other fertilizer materials (excluding lime).

(A) Specify kind, for example, ZINC.

(B) Enter the pounds per acre applied.

(2) Organic materials

(i) Enter tons of manure applied per acre.

(ii) Enter the code representing the kind of manure:

1 = Cattle

2 = Poultry

3 = Hog

4 = Horse

5 = Sludge (human)

6 = Other

(3) Crop residues returned.

Enter Y for yes, or N for no.

(4) Tillage.

Enter the code that represents the kind of tillage practice at the sample site:

1 = No till (slot tillage)

2 = Strip till

3 = Other conservation tillage

4 = Nonconservation tillage (moldboard, disk plow, lister)

(5) Weed control.

(i) Were herbicides used for this crop?

Enter Y for yes, or N for no.

(ii) Enter the number of cultivations used primarily or partly for weed control.

(iii) Enter the code that represents the extent of weed damage on this crop:

0 = None

1 = Slight

2 = Moderate

3 = Severe

(6) Insect and disease control.

(i) Were chemicals used to control insects or disease?

Enter Y for yes, or N for no.

(ii) If chemical control was used, enter the code that represents the kind of treatment:

1 = Foliage

2 = Seed

3 = Soil

4 = Two or more of the above treatments

(iii) If foliage treatment, enter the number of chemical applications.

(iv) Enter the code that represents the extent of insect or disease damage on this crop:

0 = None

1 = Slight

2 = Moderate

3 = Severe

(i) Line 9

(1) Other damage.

Enter the code that represents the extent of damage from other causes such as hail, wind, lodging, and freezing:

0 = None

1 = Slight

2 = Moderate

3 = Severe

(2) Conservation practices, other than tillage and cropping sequence.

Enter one of the following conservation practices codes. If more than one used, enter the code listed first:

0 = None

1 = Terraces

2 = Stripcropping, contour

3 = Stripcropping, field

4 = Stripcropping, wind

5 = Contour farming

(3) Irrigation.

(i) Was irrigation water applied to this crop?

Enter Y for yes, or N for no.

(ii) Type:

1 = Furrow

2 = Sprinkle

3 = Drip

4 = Flood

(iii) Enter the code that represents the adequacy of the irrigation in meeting crop moisture requirements:

1 = Good

2 = Fair

3 = Poor

(4) Drainage.

(i) Is this soil artificially drained?

Enter Y for yes, or N for no.

(ii) Enter the code that represents the damage to the crop caused by inadequate drainage system:

0 = None

1 = Slight

2 = Moderate

3 = Severe

(5) Factors.

(i) C factor. Enter the C factor (cover-management factor used in the Revised Universal Soil Loss Equation) applicable to the site.

(ii) P factor. Enter the P factor (support practices factor used in the Revised Universal Soil Loss Equation) applicable to the site.

(6) Conservation Practice Codes

Enter the practice code applicable to the site.

(7) Recorder Name. The name of the individual recording the data.

627.13 Identification Legend of Map Unit Symbols and Names

Example of an alphabetic map unit legend for Alpha County, Any State:

Map Unit Symbol	Map Unit Name
AaA	Alpha silt loam, 0 to 3 percent slopes
AaB	Alpha silty clay loam, 3 to 6 percent slopes
AAE	Alpha association, moderately steep
AAG	Alpha association, very steep
Ab	Alpha-Beta complex
AbA	Alpha, rarely flooded-Beta, occasionally flooded complex
ABG	Alpha-Beta association, very steep
BTF	Beta-Gamma association, steep
GE	Gamma and Beta soils
ROF	Rock outcrop
STC	Sigma and Gamma soils, rolling
W	Water
ZAB	Zeta association, rolling

Example of an alphanumeric map unit legend for Beta County, Any State:

Map Unit Symbol	Map Unit Name
12A	Alpha silt loam, 0 to 2 percent slopes
12B	Alpha silt loam, 2 to 4 percent slopes
12B2	Alpha silt loam, 2 to 4 percent slopes, eroded
13	Beta silty clay loam
14	Beta silty clay loam, stony
17	Water, fresh
20	Water, saline
21	Gamma muck
23	Rock outcrop
27A	Sigma sandy loam, 0 to 2 percent slopes
29A	Sigma sandy loam, saline, 0 to 2 percent slopes
51D2	Zeta loamy sand, 8 to 15 percent slopes, eroded
52B	Zeta fine sandy loam, 2 to 5 percent slopes
52C	Zeta fine sandy loam, 5 to 8 percent slopes

Example of a numeric map unit legend for Gamma County, Any State:

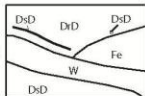
Map Unit Symbol	Map Unit Name
----------------------------	----------------------

Title 430 – National Soil Survey Handbook

10	Alpha silt loam, 0 to 2 percent slopes
11	Alpha silt loam, 2 to 4 percent slopes
12	Alpha silt loam, 2 to 4 percent slopes, eroded
14	Zeta fine sandy loam, 2 to 5 percent slopes
15	Zeta fine sandy loam, 5 to 8 percent slopes
16	Zeta loamy fine sand, 8 to 15 percent slopes
17	Rock outcrop
20	Beta silty clay loam
21	Beta silty clay loam, stony
60	Sigma sandy loam, 0 to 2 percent slopes
62	Sigma sandy loam, saline, 0 to 2 percent slopes
99	Water
145	Gamma muck

627.14 Form NRCS-SOI-37A, “Feature and Symbol Legend for Soil Survey”**Electronic version:** https://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_050696.jpgNRCS-SOI-37A
REVISED June 2013Soil Survey Area: _____
State: _____**FEATURE AND SYMBOL LEGEND
FOR SOIL SURVEY**U.S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

Date: _____

DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL
SOIL SURVEY FEATURES		CULTURAL FEATURES (Optional)		HYDROGRAPHIC FEATURES (Optional)	
SOIL DELINEATIONS AND LABELS 		BOUNDARIES National, state or province County or parish Minor civil division Reservation (national or state forest or park) Limit of soil survey (label) and/or denied access areas Field sheet matchline and neckline Public Land Survey System Section Boundary Public Land Survey System Section Corner Ticks		Perennial stream Intermittent stream Unclassified stream Perennial drainage or irrigation ditch Intermittent drainage or irrigation ditch Unclassified drainage or irrigation ditch Flood pool line Spring Well, artesian Well, irrigation	
STANDARD LANDFORM AND MISCELLANEOUS SURFACE FEATURES Bedrock escarpment Non-bedrock escarpment Gully Levee Short steep slope Blowout Borrow pit Clay spot Closed depression Gravel pit Gravelly spot Landfill Lava flow Marsh or swamp Mine or quarry Miscellaneous water Perennial water Rock outcrop Saline spot Sandy spot Severely eroded spot Sinkhole Slide or slip Sodic spot Spoil area Stony spot Very stony spot Wet spot		ROAD EMBLEMS Interstate Federal State County, farm or ranch LOCATED OBJECTS Airport, airfield Cemetery Church Lighthouse Located object (label) Lookout tower Other Religion (label) School Soil sample site (compiled only not published) Windmill			
AD HOC FEATURES (Describe on back)					
LABEL	SYMBOL ID	SYMBOL	LABEL	SYMBOL ID	SYMBOL
_____	1		_____	23	
_____	2		_____	24	
_____	3		_____	25	
_____	4		_____	26	
_____	5		_____	27	
_____	6		_____	28	
_____	7		_____	29	
_____	8		_____	30	
_____	9		_____	31	
_____	10		_____	32	
_____	11		_____	33	
_____	12		_____	34	
_____	13		_____	35	
_____	14		_____	36	
_____	15		_____	37	
_____	16		_____	38	
_____	17		_____	39	
_____	18		_____	40	
_____	19		_____	41	
_____	20		_____	42	
_____	21		_____	43	
_____	22		_____	44	

Title 430 – National Soil Survey Handbook

DESCRIPTIONS FOR STANDARD LANDFORM AND MISCELLANEOUS SURFACE FEATURES

LABEL NAME	DESCRIPTION
BLO Blowout	A saucer-, cup-, or trough-shaped depression formed by wind erosion on a pre-existing dune or other sand deposit, especially in an area of shifting sand or loose soil or where protective vegetation is disturbed or destroyed. The adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Blowouts are commonly small. Typically ____ to ____ acres.
BPI Borrow pit	An open excavation from which soil and underlying material have been removed, usually for construction purposes. Typically ____ to ____ acres.
CLA Clay spot	A spot where the surface texture is silty clay or clay in areas where the surface layer of the soils in the surrounding map unit is sandy loam, loam, silt loam, or coarser. Typically ____ to ____ acres.
DEP Depression, closed	A shallow, saucer-shaped area that is slightly lower on the landscape than the surrounding area and that does not have a natural outlet for surface drainage. Typically ____ to ____ acres.
ESB Escarpment, bedrock	A relatively continuous and steep slope or cliff, produced by erosion or faulting, that breaks the general continuity of more gently sloping land surfaces. Exposed material is hard or soft bedrock.
ESO Escarpment, nonbedrock	A relatively continuous and steep slope or cliff, which generally is produced by erosion but can be produced by faulting, that breaks the continuity of more gently sloping land surfaces. Exposed earthy material is nonsoil or very shallow soil.
GPI Gravel pit	An open excavation from which soil and underlying material have been removed and used, without crushing, as a source of sand or gravel. Typically ____ to ____ acres.
GRA Gravelly spot	A spot where the surface layer has more than 35 percent, by volume, rock fragments that are mostly less than 3 inches in diameter in an area that has less than 15 percent rock fragments. Typically ____ to ____ acres.
GUL Gully	A small, steep-sided channel caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage whereas a rill is of lesser depth and can be smoothed over by ordinary tillage.
LDF Landfill	An area of accumulated waste products of human habitation, either above or below natural ground level. Typically ____ to ____ acres.
LAV Lava flow	A solidified, commonly lobate body of rock formed through lateral, surface outpouring of molten lava from a vent or fissure. Typically ____ to ____ acres.
LVS Levee	An embankment that confines or controls water, especially one built along the banks of a river to prevent overflow onto lowlands.
MAR Marsh or swamp	A water saturated, very poorly drained area that is intermittently or permanently covered by water. Sedges, cattails, and rushes are the dominate vegetation in marshes, and trees or shrubs are the dominant vegetation in swamps. Not used in map units where the named soils are poorly drained or very poorly drained. Typically ____ to ____ acres.
MPI Mine or quarry	An open excavation from which soil and underlying material have been removed and in which bedrock is exposed. Also denotes surface openings to underground mines. Typically ____ to ____ acres.
MIS Miscellaneous water	Small, constructed bodies of water that are used for industrial, sanitary, or mining applications and that contain water most of the year. Typically ____ to ____ acres.
WAT Perennial water	Small, natural or constructed lakes, ponds, or pits that contain water most of the year. Typically ____ to ____ acres.
ROC Rock outcrop	An exposure of bedrock at the surface of the earth. Not used where the named soils of the surrounding map unit are shallow over bedrock or where "Rock outcrop" is a named component of the map unit. Typically ____ to ____ acres.
SAL Saline spot	An area where the surface layer has an electrical conductivity of 8 mmhos/cm more than the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has an electrical conductivity of 2 mmhos/cm or less. Typically ____ to ____ acres.
SAN Sandy spot	A spot where the surface layer is loamy fine sand or coarser in areas where the surface layer of the named soils in the surrounding map unit is very fine sandy loam or finer. Typically ____ to ____ acres.
ERO Severely eroded spot	An area where, on the average, 75 percent or more of the original surface layer has been lost because of accelerated erosion. Not used in map units in which "severely eroded", "very severely eroded", or "gullied" is part of the map unit name. Typically ____ to ____ acres.
SLP Short, steep slope	A narrow area of soil having slopes that are at least two slope classes steeper than the slope class of the surrounding map unit.
SNK Sinkhole	A closed, circular or elliptical depression, commonly funnel shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, or salt) or by collapse of underlying caves within bedrock. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography. Typically ____ to ____ acres.
SLI Slide or slip	A prominent landform scar or ridge caused by fairly recent mass movement or descent of earthy material resulting from failure of earth or rock under shear stress along one or several surfaces. Typically ____ to ____ acres.
SOD Sodic spot	An area where the surface layer has a sodium adsorption ratio that is at least 10 more than that of the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has a sodium adsorption ratio of 5 or less. Typically ____ to ____ acres.
SPO Spoil area	A pile of earthy materials, either smoothed or uneven, resulting from human activity. Typically ____ to ____ acres.
STN Stony spot	A spot where 0.01 to 0.1 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surrounding soil has no surface stones. Typically ____ to ____ acres.
STV Very stony spot	A spot where 0.1 to 3.0 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surface of the surrounding soil is covered by less than 0.01 percent stones. Typically ____ to ____ acres.
WET Wet spot	A somewhat poorly drained to very poorly drained area that is at least two drainage classes wetter than the named soils in the surrounding map unit. Typically ____ to ____ acres.

DESCRIPTION FOR AD HOC FEATURES

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

627.15 Ecological Site and Soil Correlation Checklist

(Use to Supplement Soil Survey Quality Assurance Worksheet)

1. Name of area (including county, State and MLRA(s)) _____

2. Level of detail for vegetative data (indicate rangeland ecological site, forestland ecological site, rangeland similarity index, or other special studies)
3. Has soil survey memo of understanding been reviewed in regard to vegetative (rangeland, forestland, etc. (management needs)? Yes ____, No ____.
4. Do soil survey project members and field office staff have copies of site descriptions being used? Yes ____, No ____.
5. Is a site assigned to each soil component in the identification legend? Yes ____, No ____.
6. Are all sections of the ecological site descriptions written? Yes ____, No ____.
7. Does documentation for each site support all soils correlated to the site? Yes ____, No ____.
8. Field notes (how kept, by whom). _____
9. Are soil-plant relationships adequately described and documented? Yes ____, No ____.
10. Is the range of characteristics of the site description adequate? (Note kinds of deficiencies)
 - a. Site Characteristics:
 1. Physiographic features
 2. Climatic features
 3. Influencing water features
 4. Representative soil features
 - b. Plant Communities
 1. Description of the vegetation dynamics of the site
 2. State and transition model diagram
 3. Description of the common states that occur on the site and the transitions between the states. If needed, describe the plant communities and community pathways within the state.
 4. Plant community composition
 5. Ground cover and structure
 6. Annual production
 7. Growth curves
 8. Photos of each state or community
11. Are interpretations for the ecological site description adequate? (Note kinds of deficiencies)

Site Interpretations:

1. Animal community
2. Hydrology functions
3. Recreation uses
4. Wood products
5. Other products
6. Other information

12. Is the supporting information for the site description adequate? (Note kinds of deficiencies)

Supporting Information:

1. Associate sites
2. Similar sites
3. Inventory data references
4. State correlation
5. Type locality
6. Relationship to other established classification systems

13. Is the supporting information for the site description adequate to separate this site from other sites?

Yes ____, No ____.

14. List of sites reviewed and status. (Indicate soils correlated to each site during this review.)

15. Have sites been correlated with existing site descriptions? Yes____No____

16. Have sites been correlated to adjoining soil survey areas? Yes____No____

17. Have sites been named and numbered correctly? Yes____No____

18. Have appropriate Federal and State agencies reviewed or assisted in writing site descriptions?
Yes____No____

19. Have field office staff provided input or reviewed site descriptions? Yes____No____

20. Deficiencies noted and recommended actions. (Be specific and provide dates for completion)

21. Scheduled dates for completion of the vegetation inventory are compatible with the scheduled dates of the soil survey? Yes ____, No ____.

Date: _____

Signature _____

627.16 Ecological Site Checklist

1. Name of Area(s) _____
(County(s) State(s) MLRA(s))
2. Type of Survey(s) _____
(Level of detail - soil and vegetation)
3. Participants _____

4. Site Content (Number reviewed _____)
 - a. Field sheets, maps, etc.
 - b. Range of characteristics for physiographic features:
 - c. Climatic features:
 - d. Water features:
 - e. Soil features and official soil series descriptions:
Range of soil properties for the site:
 - f. Vegetation data (417s, etc., and plant association tables)
 - g. Animal data:
 - h. General (field notes, photographs, etc.)
5. Sites with deficiencies:
6. Recommended actions:
7. Site description completed _____(date)

Date: __

Signature(s) _____

627.17 Matrix of Investigation Intensity of Soil Surveys and Documentation

The table below is a generalized matrix showing investigation intensity of soil survey (order) by the dominant type of documentation.

Within physiographic areas, percentages for the number of delineations can be assigned to the entries to specify required documentation. (i.e., 25% would indicate 25 of 100 delineations)

Key type of documentation to verify or identify map units in soil delineations				
	Order 1	Order 2	Order 3	Order 4
Traversing	Primary	Primary	Secondary	Secondary
Observation	-----	Secondary	Primary	Secondary
Remotely sensed/ancillary data	-----	Secondary	Primary	Primary
Key type of documentation to determine composition of a map unit				
Transecting	-----	Primary	Primary	Primary

Identification or verification of soil map units with a delineation is made by one of three methods. These methods provide documentation to the survey when the method is either recorded in the database or on the map as to type. These methods are—

-Traversing – Describing the soil and conditions at stops selected to reference vegetation, position on the landform, photo tone, etc. This is an onsite identification of the soil and verification of the projected assignment of the map unit.

-Observation – Visual notation of items as geologic features, vegetation, surface conditions, disturbed areas, etc. without borings. This drive by or other sighted observation does not involve a soil examination, and instead relies on surface characteristics observed by the surveyor.

-Remotely sensed/ancillary data – includes photo tone on aerial photographs, three-dimensional digital elevation models, topographic maps, geology maps, vegetative maps, etc.

-Primary – the principal way polygons and properties are verified.

-Secondary – additional methods in support of primary methods.

-No entry – This category is generally not used in the specified order.

-Transecting – Describing the soils and conditions at points (or continuously as with GPR) along a fixed length at regular intervals or by selecting points to represent measured line segments of various patterns. Transecting is used to identify the composition of a delineation and to design a map unit. A very small percentage of the total number of delineations of any one map unit have transects unless there are very few delineations of the map unit. As soil order increases the length and intervals of the transect would generally increase. A transect is different from grid or line mapping used for determining line placement.

Part 629 – Glossary of Landform and Geologic Terms

Subpart A – General Information

629.0 Definition and Purpose

This glossary provides the NCSS soil survey program, soil scientists, and natural resource specialists with landform, geologic, and related terms and their definitions to—

- (1) Improve soil landscape description with a standard, single source landform and geologic glossary.
- (2) Enhance geomorphic content and clarity of soil map unit descriptions by use of accurate, defined terms.
- (3) Establish consistent geomorphic term usage in soil science and the National Cooperative Soil Survey (NCSS).
- (4) Provide standard geomorphic definitions for databases and soil survey technical publications.
- (5) Train soil scientists and related professionals in soils as landscape and geomorphic entities.

629.1 Responsibilities

This glossary serves as the official NCSS reference for landform, geologic, and related terms. The staff of the National Soil Survey Center, located in Lincoln, NE, is responsible for maintaining and updating this glossary. Soil Science Division staff and NCSS participants are encouraged to propose additions and changes to the glossary for use in pedon descriptions, soil map unit descriptions, and soil survey publications. The Glossary of Geology (GG, 2005) serves as a major source for many glossary terms. The American Geologic Institute (AGI) granted the USDA Natural Resources Conservation Service (formerly the Soil Conservation Service) permission (in letters dated September 11, 1985, and September 22, 1993) to use existing definitions. Sources of, and modifications to, original definitions are explained immediately below.

629.2 Definitions

A. Reference Codes

Sources from which definitions were taken, whole or in part, are identified by a code (e.g., GG) following each definition. Underlined codes (e.g., GG) signify a definition modification of the original source. The reference codes are:

- (i) BHM.—Buol, S.W., Hole, F.D., McCracken, R.J., and Southard, R.J. 1997. Soil genesis and classification, 4th edition. Iowa State University Press, Ames, IA.
- (ii) CC.—Cowardin, L.M., Carter, V., Golet, F.C., and Laroe, E.T. 1979. Classification of wetlands and deepwater habitats of the United States. US Dept. Interior, US Fish and Wildlife Service, US Government Printing Office, Washington, DC.
- (iii) CF.—Clayton, L. and Freers, T.F. (eds.) 1967. Glacial geology of the Missouri Coteau and adjacent areas. Guidebook 18th annual field conference Midwest Friends of the Pleistocene. North Dakota Geological Survey Miscellaneous Series #30, 170 p.

- (iv) CV.—Cruden, D.M., and Varnes, D.J. 1996. Landslide types and processes. In: Turner, A.K., and Schuster, R.L., (eds). 1996. Landslides: investigations and mitigation. National Research Council, Transportation Research Board Special Report No. 247; National Academy Press, Washington, DC; 673 p.
- (v) DV.—Varnes, D. 1978. Slope movement types and processes. In: Schuster, R.L., and R.J. Krizek. (eds). 1978. Landslides: analysis and control. National Academy Sciences, Transportation Research Board Special Report No. 176; 234 p.
- (vi) FC.—Freeze, A.L. and Cherry, J.A. 1979. Groundwater. Prentice-Hall, Inc., Englewood Cliffs, NJ. 604 p.
- (vii) FFP.—Peterson, F.F. 1981. Landforms of the Basin and Range Province defined for soil survey. Nevada Agricultural Experiment Station Technical Bulletin No. 28, Reno, NV. 52 p.
- (viii) GG.—Neuendorf, K.K.E., Mehl Jr., J.P., and Jackson, J.A. (ed.) 2005. Glossary of geology, 5th Ed. American Geological Institute, Alexandria, VA. 779 p.
- (ix) GG87.—Bates, R.L., and Jackson, J.A. (ed) 1987. Glossary of geology, 3rd Ed. American Geological Institute, Alexandria, VA. 788 p.
- (x) GHG.—Gile, L.H., Hawley, J.W., and Grossman, R.B. 1981. Soils and geomorphology in the Basin and Range area of southern New Mexico – Guidebook to the Desert Project. Memoir 39. New Mexico Bureau of Mines & Mineral Resources, Socorro, NM; 222 p.
- (xi) GM.—Goldthwaite, R.P. and Matsch, C.L. (eds.) 1988. Genetic classification of glaciogenic deposits: final report of the commission on genesis and lithology of glacial Quaternary deposits of the International Union for Quaternary Research (INQUA). A.A. Balkema, Rotterdam; 294 p.
- (xii) GS.—Green, J., and Short, N.M. 1971. Volcanic landforms and surface features: A photographic atlas and glossary. Springer – Verlag, New York, NY. 519 p.
- (xiii) GSST.—Soil Science Society of America. 2008. Glossary of Soil Science terms. Soil Science Society of America, Madison, WI. 92 p. Also:
<https://www.soils.org/publications/soils-glossary>
- (xiv) HD.—Holdorf, H. and Donahue, J. 1990. Landforms for soil surveys in the Northern Rockies. Montana Forest and Conservation Experiment Station, School of Forestry, University of Montana, Misc. Publ. No. 51. 26 p.
- (xv) HF.—Fisk, H.N. 1959. Padre Island and the Laguna Madre flats, coastal south Texas. Louisiana State University, 2nd Coastal Geography Conference; pp. 103-151.
- (xvi) HP.—Hawley, J.W., and Parsons, R.B. 1980. Glossary of selected geomorphic and geologic terms. Mimeo. USDA Soil Conservation Service, West National Technical Center, Portland, OR. 30 p.
- (xvii) HS.—Sigurdsson, H., (ed). 2000. Encyclopedia of volcanoes. Academic Press, Inc., San Diego, USA. ISBN# 0-12-643140-X
- (xviii) ICOMANTH.—International Committee for Anthropogenic Soils. 2012. Circular Letter 7, Proposed Revisions to NSSH Part 629 (working draft), 13 p.
- (xix) KST.—Soil Survey Staff. 2014. Keys to Soil Taxonomy, Twelfth edition. USDA - Soil Conservation Service.
- (xx) MA.—MacDonald, G.A. and A.T. Abbott. 1970. Volcanoes in the sea, the geology of Hawaii. University of Hawaii Press, 441 p.
- (xxi) NL.—Lancaster, N. 1995. Geomorphology of desert dunes. Routledge, New York, NY. 209 p.
- (xxii) NRC.—National Research Council of Canada. 1988. Glossary of permafrost and related ground ice terms. Associate Committee Geotechnical Research, Technical Memorandum 142; 156 p.
- (xxiii) RD.—Daniels, Dr. Raymond B. (personal communication).

- (xxiv) RF.—Fairbridge, R.W. (ed.). Encyclopedia of geomorphology. 1968. Encyclopedia of Earth Sciences Series, vol. 3. Reinhold Book Corporation, New York, NY.
- (xxv) RR.—Ruhe, R.V. 1975. Geomorphology: Geomorphic processes and surficial geology. Houghton-Mifflin, Boston, MA, 246 p.
- (xxvi) SJ.—Sugden, D.E. and John, B.S. 1976. Glaciers and landscape, a geomorphological approach. Halsted Press, John Wiley and Sons, Inc., New York, NY, 376 p.
- (xxvii) SS.—Summer, M.E., and Stewart, B.A. (eds). 1992. Soil crusting in Australia. In: Soil crusting: chemical and physical process. Advances in Soil Science, Lewis Publishing, Boca Raton, FL.
- (xxviii) SSM.—Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service, U.S. Department of Agriculture Handbook No. 18, U.S. Gov. Print. Office, Washington, DC.
- (xxix) SSS.—Subaqueous Soils Subcommittee. 2005. Glossary of terms for subaqueous soils, landscapes, landforms, and parent materials of estuaries and lagoons. National Cooperative Soil Survey Conference, USDA-NRCS, National Soil Survey Center, Lincoln, NE.
- (xxx) ST.—Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.
- (xxxi) SW.—Schoeneberger, P.J. and Wysocki, D.A. 1991-2017. (personal communication), National Soil Survey Center, NRCS, Lincoln, NE.
- (xxxii) WA.—Way, D.S. 1973. Terrain analysis. Harvard University, Dowden, Hutchinson & Ross, Inc., Stroudsburg, PA. 392 p.
- (xxxiii) WT.—Thornbury, W.D. 1969. Principles of geomorphology; 2nd Ed. John Wiley and Sons, Inc., New York, NY; 594 p.
- (xxxiv) WW.—White, W.B. 1988. Geomorphology and hydrology of karst terrains. Oxford Univ. Press, New York, NY; 478 p.

B. Clarifying Comments Included With Glossary Definitions

- (1) **(not recommended) Use.**—Denotes an unacceptable term (obsolete, poorly defined, or erroneous) that **should not be used**. The glossary provides alternative terms.
- (2) **(not preferred) Refer to.**—Denotes a technically acceptable, but poorly defined or outdated term that **should be avoided** to prevent confusion and redundancy. Preferred alternatives are provided.
- (3) **(colloquial:).**—Denotes a regionally derived or applied term and identifies the region where it has been used. A colloquial term is either not widely accepted or unknown outside the geographic area where it originates. A colloquial term **should be avoided** if a more widely recognized alternative exists.
- (4) **Compare.**—Follows a term definition and indicates additional glossary entries that are similar or related to that term.

C. Glossary

- (1) **aa lava.**—A type of basaltic lava (material) having a rough, jagged, clinkery surface and a vesicular interior. Compare – block lava, pahoehoe lava, pillow lava. GG & MA
- (2) **aa lava flow.**—A type of basaltic lava flow dominated by aa lava and a characteristically rough, jagged, clinkery surface. Compare – block lava flow, pahoehoe lava flow, pillow lava flow. GG & MA
- (3) **ablation till.**—(not preferred) Refer to supraglacial till.
- (4) **accretion.**—[sedimentology] The gradual increase or extension of land by natural forces acting over a long period of time, as on a beach by the washing up of sand from the sea or on

- a flood plain by the accumulation of sediment deposited by a stream. Synonym: aggradation. GG
- (5) **active layer**.—The top layer of ground subject to annual thawing and freezing in areas underlain by permafrost. NRC
 - (6) **active slope**.—(not recommended: obsolete)
 - (7) **aeolian**.—(not recommended: obsolete) Use eolian.
 - (8) **aggradation**.—The building-up of the earth's surface by deposition; specifically, the accumulation of material by any process in order to establish or maintain uniformity of grade or slope; also called accretion. Compare – degradation. GG
 - (9) **agricultural anthroscape**.—A human-modified “landscape” dominated by permanent, extensive alterations to the physical shape or internal stratigraphy of the land due to agricultural management for food, fiber or forage production, that have substantively altered water flow and sediment transport across and within the regolith (e.g., leveled land). Commonly excludes areas of minor alterations (e.g. shallow plowing) that are easily obscured or obliterated by natural bio-, pedo-, or cryoturbation. Compare – hillslope terrace anthroscape, urban anthroscape, suburban anthroscape. SW
 - (10) **alas**.—A type of thermokarst depression with steep sides and a flat, grass-covered floor, found in thermokarst terrain, produced by thawing of extensive areas of very thick and exceedingly ice-rich permafrost. Compare – thermokarst depression. NRC and GG
 - (11) **alluvial**.—Pertaining to material or processes associated with transportation and/or subaerial deposition by concentrated running water. Compare – colluvial. GSST
 - (12) **alluvial cone**.—A semiconical type of alluvial fan with very steep slopes; it is higher, narrower, and steeper (e.g., > 40% slopes) than a fan, and composed of coarser, and thicker layers of material deposited by a combination of alluvial episodes and to a much lesser degree, landslides (e.g., debris flow). Coarsest materials tend to concentrate at the cone apex. Compare – alluvial fan, talus cone. SW
 - (13) **alluvial fan**.—A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes, shaped like an open fan or a segment of a cone, deposited by a stream (best expressed in semiarid regions) at the place where it issues from a narrow mountain or upland valley; or where a tributary stream is near or at its junction with the main stream. It is steepest near its apex, which points upstream and slopes gently and convexly outward (downstream) with a gradual decrease in gradient. Compare – fan remnant, eroded fan remnant, eroded fan remnant sideslope. GG
 - (14) **alluvial flat**
 - (i) (colloquial: western United States) A nearly level, graded, alluvial surface in bolsons and semi-bolsons that lacks distinct channels, terraces, or flood plain levels. Compare – flood plain step, terrace, valley flat. FFP, GG, & SW.
 - (ii) (not preferred) A general term for a small flood plain bordering a river, on which alluvium is deposited during floods. GG
 - (15) **alluvial plain**
 - (i) A large assemblage of fluvial landforms (braided streams, terraces, etc.) that form low gradient, regional ramps along the flanks of mountains and extend great distances from their sources (e.g., High Plains of North America. SW
 - (ii) (not recommended, use flood plain.) A general, informal term for a broad flood plain or a low-gradient delta. Compare – alluvial flat. FFP
 - (16) **alluvial plain remnant**.—An erosional remnant of an alluvial plain that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to a present-day stream or drainage network. Compare – alluvial plain, erosional remnant, paleoterrace. SW
 - (17) **alluvial terrace**.—(not preferred) Refer to stream terrace.

- (18) **alluvium**.—Unconsolidated, clastic material subaerially deposited by running water (channel flow), including gravel, sand, silt, clay, and various mixtures of these. Compare – colluvium, slope alluvium. HP
- (19) **alpine**
- (i) [geomorphology] (adjective) Characteristic of, or resembling the European Alps, or any lofty mountain or mountain system, especially one so modified by intense glacial erosion as to contain cirques, horns, etc. (e.g., alpine lake) GG
 - (ii) (not recommended as a landform term) An ecological community term for high-elevation plant communities. SW & GG
- (20) **alpine glacier**
- (i) Any glacier in a mountain range except an ice cap or ice sheet. It usually originates in a cirque and may flow down into a valley previously carved by a stream. Compare – continental glacier. GG
 - (ii) (not preferred – refer to U-shaped valley) Relict – landforms or sediments formed, modified or deposited by a glacier in or on mountains or high hills that has since melted away. Compare – glacial-valley floor, glacial-valley wall. SW
- (21) **andesitic lahar deposit**.—A lahar dominated by andesitic volcanoclastics. SW
- (22) **angle of repose**.—The maximum angle of slope (measured from a horizontal plane) at which loose, cohesionless material will come to rest. GG
- (23) **annular drainage pattern**.—A drainage pattern in which subsequent streams follow a roughly circular or concentric path along a belt of weak rocks, resembling, in plan view, a ring-like pattern where the bedrock joints or fracturing control the parallel tributaries. It is best displayed in streams draining a maturely dissected granitic or sedimentary structural dome or basin where erosion has exposed rimming sedimentary strata of greatly varying degrees of hardness, as in the Red Valley, which nearly encircles the domal structure of the Black Hills, SD. SW, GG, & WA
- (24) **anthropogenic feature**
- (i) An enduring, human-made (or extensively modified), surface or subsurface feature (e.g., fire pit), mark (e.g., shovel mark), structure (e.g., building pad) or other physical evidence of human manipulation (after Hester et al., 1975). Note: Phenomena that do not leave permanent evidence of human activity (e.g., features of accelerated erosion, amendments of inorganic fertilizers or lime, shallow plowing or in-situ mixing) are not included. Artifacts (specific objects, pieces) are not included (use – human artifacts). SW, & ICOMANTH
 - (ii) (obsolete – use Anthroscapes, Anthropogenic Landform, or Anthropogenic Microfeature) An artificial feature on the earth's surface (including those in shallow water), having a characteristic shape and range in composition, composed of unconsolidated earthy, organic materials, artificial materials, or rock, that is the direct result of human manipulation or activities; can be either constructional (e.g., artificial levee) or destructional (e.g., quarry).
 - (iii) Formerly a category in NASIS and the Geomorphic Description System, subsequently subdivided into and replaced by anthroscapes, anthropogenic landforms, and anthropogenic microfeatures. SW, ICOMANTH
- (25) **anthroscapes**
- (i) A human-modified “landscape” of substantial and permanent alterations (removal, additions, or reorganization) of the physical shape and/or internal stratigraphy of the land, associated with management for habitation, commerce, food or fiber production, recreation, or other human activities that have substantively altered water flow and sediment transport across or within the regolith. SW

- (ii) A category in NASIS and the Geomorphic Description System for large, human-modified areas. Compare – anthropogenic landform, anthropogenic microfeature. SW
- (26) **anthropogenic landform**
 - (i) A discrete, human-made “landform” on the earth’s surface or in shallow water, with a characteristic shape and range in composition (unconsolidated earthy, organic, human-transported materials, or rock) that is the direct result of human manipulation or activities and is mappable at common soil survey scales (e.g., Order 2: > 1: 10,000 and < 1:24,000). Anthropogenic landforms can be either constructional (accumulations; e.g., artificial levee) or destructional (voids; e.g., quarry) in origin.
 - (ii) A category in NASIS and the Geomorphic Description System for human-derived or modified “landforms.” Compare – anthropogenic microfeature, anthroscape. SW
- (27) **anthropogenic microfeature**
 - (i) A small, human-made “microfeature” on the earth’s surface or in shallow water, with a characteristic shape and range in composition of unconsolidated earthy, organic, human-transported materials, or rock and that is typically too small to delineate at common soil survey scales (e.g., Order 2: > 1: 10,000 and < 1:24,000). Anthropogenic microfeatures can be either constructional accumulations (e.g. railroad bed) or destructional voids (e.g. ditch) in origin.
 - (ii) A category in NASIS and the Geomorphic Description System for human-derived or modified “landforms.” Compare – anthropogenic landform, anthroscape. SW
- (28) **anticline**
 - (i) [landform] A unit of folded strata that is convex upward and whose core contains the stratigraphically oldest rocks, and occurs at the earth’s surface. In a single anticline, beds forming the opposing limbs of the fold dip away from its axial plane. Compare – monocline, syncline, fold. SW & HP
 - (ii) [structural geology] A fold, at any depth, generally convex upward whose core contains the stratigraphically older rocks. GG
- (29) **aquiclude**.—A layer of soil, sediment, or rock that may or may not be saturated, that is incapable of transmitting significant quantities of water under ordinary hydraulic gradients. Compare – aquitard. FC
- (30) **aquifer**.—A saturated, permeable geologic unit of sediment or rock that can transmit significant quantities of water under hydraulic gradients. FC
- (31) **aquitard**.—A body of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs but may serve as a storage unit for groundwater. GG
- (32) **arete**.—A narrow, jagged mountain crest, often above the snowline, sculptured by alpine glaciers and formed by backward erosion of adjoining cirque walls. HP
- (33) **arroyo**.—(colloquial: southwestern United States) The channel of a flat-floored, ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material; sometimes called a wash. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed. Where arroyos intersect zones of ground-water discharge, they are more properly classed as intermittent stream channels. HP
- (34) **artifact**.—An artificial (human-derived) object or material (e.g., brick, concrete, metal, plastic, or treated wood), commonly larger than 2 mm in diameter, made and deposited in association with habitation, manufacturing, excavation, or construction activities. SW
- (35) **artificial collapsed depression**.—A collapse basin, commonly a closed depression, which is the direct result of surficial subsidence associated with subsurface mining (e.g., long-wall mining). SW

- (36) **artificial drainage pattern**.—Human-made networks of drainage structures (ditches, canals, etc.) built primarily to lower or control the local water table in low lying, flat topography such as glacial lakebeds, broad flood plains, low coastal plains, or marshes most commonly in humid climates. Irrigation ditches found in arid and semiarid climates, which bring water into the fields, should not be confused with drainage structures. SW & WA
- (37) **artificial levee**.—An artificial embankment constructed along the bank of a watercourse or an arm of the sea, to protect land from inundation or to confine streamflow to its channel. GG
- (38) **ash**.—[volcanic] Unconsolidated, pyroclastic material less than 2 mm in all dimensions. Commonly called volcanic ash. Compare – cinders, lapilli, tephra, volcanic block. SW & KST
- (39) **ash field**.—A land area covered by a relatively thick or distinctive, surficial deposit of volcanic ash (air fall) that can be traced to a specific source and has well defined boundaries. An ash field can be distinguished from adjacent landforms or land areas based on ash thickness, mineral composition, and physical characteristics. Soils within an ash field form solely or predominantly within the ash deposit. SW and GG
- (40) **ash flow**.—(not preferred – see pyroclastic flow, pyroclastic surge) A highly heated mixture of volcanic gases and ash, traveling down the flank of a volcano or along the surface of the ground; produced by the explosive disintegration of viscous lava in a volcanic crater, or by the explosive emission of gas-charged ash from a fissure or group of fissures. The solid materials contained in a typical ash flow are generally unsorted and ordinarily include volcanic dust, pumice, scoria, and blocks in addition to ash. (Also called a *pyroclastic* flow.) Compare – nuée ardente, lahar, pyroclastic. GG
- (41) **aspect**.—The direction toward which a slope faces with respect to the compass or to the rays of the Sun; also called *slope* aspect. GSST
- (42) **atoll**.—A coral reef appearing in plan view as roughly circular, and surmounted by a chain of closely spaced, low coral islets that encircle or nearly encircle a shallow lagoon in which there is no land or islands of non-coral origin; the reef is surrounded by open sea. GG
- (43) **avalanche**.—A large mass of snow, ice, soil, or rock, or mixtures of these materials, falling, sliding, or flowing very rapidly under the force of gravity. Velocities may sometimes exceed 500 km/hr. GG
- (44) **avalanche chute**.—The central, channel-like corridor, scar, or depression along which an avalanche has moved. An eroded surface marked by pits, scratches, and grooves. GG
- (45) **avalanche track**.—(not recommended as a landform term – use avalanche chute) The path formed by an avalanche. It may take the form of an open path in a forest, with bent and broken trees, or an eroded surface marked by pits, scratches, and grooves. Compare – avalanche chute. GG
- (46) **avulsion**.—A sudden cutting off or separation of land by a flood or by abrupt change in the course of a stream, as by a stream breaking through a meander or by a sudden change in current whereby the stream deserts its old channel for a new one. Compare – crevasse, flood-plain splay. GG
- (47) **axial stream**
- (i) The main stream of an intermontane valley, flowing in the deepest part of the valley and parallel to its longest dimension.
 - (ii) A stream that follows the axis of a syncline or anticline. GG
- (48) **back-barrier beach**.—A narrow, elongate, intertidal, sloping landform that is generally parallel with the shoreline located on the lagoon or estuary side of the barrier island, or spit. Compare – barrier island. SSS

- (49) **back-barrier flat**.—A subaerial, gently sloping landform on the lagoon side of the barrier beach ridge composed predominantly of sand washed over or through the beach ridge during tidal surges; a portion of a barrier flat. Compare – washover-fan flat. SSS
- (50) **backshore**.—The upper or inner, usually dry, zone of the shore or beach, lying between the high-water line of mean spring tides and the upper limit of shore-zone processes; it is acted upon by waves or covered by water only during exceptionally severe storms or unusually high tides. It is essentially horizontal or slopes gently landward, and is divided from the foreshore by the crest of the most seaward berm. Compare – washover fan. GG
- (51) **backshore terrace**.—(not preferred) Refer to berm.
- (52) **backslope**.—The hillslope profile position that forms the steepest and generally linear, middle portion of the slope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below. They may or may not include cliff segments (i.e., free faces). Backslopes are commonly erosional forms produced by mass movement, colluvial action, and running water. Compare – summit, shoulder, footslope, toeslope. GSST and HP
- (53) **backswamp**.—A flood-plain landform. Extensive, marshy or swampy, depressed areas of flood plains between natural levees and valley sides or terraces. Compare – valley flat. HP
- (54) **backswamp deposit**.—Lamina of silt and clay deposited in the flood basin between valley sides or terraces and the natural levees of a river. Compare – slackwater. GG
- (55) **backwearing**.—Slope erosion that causes the parallel retreat of an escarpment or the slope of a hill or mountain or the sideways recession of a slope without changing its general slope; a process contributing to the development of a pediment. GG
- (56) **badlands**.—A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes with narrow interfluves. Badlands develop on surfaces with little or no vegetative cover, overlying unconsolidated or poorly cemented materials (clays, silts, or in some cases sandstones) sometimes with soluble minerals such as gypsum or halite. GG
- (57) **bajada**.—(colloquial: southwestern United States) A broad, gently inclined, alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins. Synonym – coalescent fan piedmont. Compare – fan apron. HP and SW
- (58) **bold**.—(not preferred; colloquial: southeastern United States; use summit, mountaintop, etc.) An ecological term for the grass or shrub covered (naturally treeless) summit of a high elevation hill or mountain, flanked by forested slopes; not above the local tree line. Compare – glade. SW and GG
- (59) **ballena**.—(colloquial: western United States) A fan remnant having a distinctively-rounded surface of fan alluvium. The ballena's broadly rounded shoulders meet from either side to form a narrow summit and merge smoothly with concave side slopes and then concave, short pediments that form smoothly rounded drainageways between adjacent ballenas. A partial ballena is a fan remnant large enough to retain some relict fan surface on a remnant summit. Compare – fan remnant. SW and FFP
- (60) **ballon**.—(colloquial: western United States) A rounded, dome-shaped hill, formed either by erosion or uplift. GG
- (61) **bar**
 - (i) [streams] A general landform term for a ridge-like accumulation of sand, gravel, or other alluvial material formed in the channel, along the banks, or at the mouth of a stream where a decrease in velocity induces deposition (e.g., a channel bar or a meander bar).

- (ii) [coast] A generic landform term for any of various elongate offshore ridges, banks, or mounds of sand, gravel, or other unconsolidated material submerged at least at high tide, and built up by the action of waves or currents, especially at the mouth of a river or estuary, or at a slight distance offshore from the beach. Compare – longshore bar. GG and GSST
- (iii) [microfeature term] A small, sinuous or arcuate, ridge-like lineation on a flood plain and separated from others by small channels or troughs; caused by fluvial processes and common to flood plains and young alluvial terraces; a constituent part of *bar and channel topography*. Compare – meander scroll. SW
- (62) **bar and channel topography**.—A local-scale topographic pattern of recurring, small, sinuous or arcuate ridges separated by shallow troughs irregularly spaced across low-relief flood plains (slopes generally 2 to 6%); the effect is one of a subdued, sinuously undulating surface that is common on active, meandering flood plains. Microelevational differences between bars and channels generally range from <0.5 to 2 m and are largely controlled by the competency of the stream. The ridge-like bars often consist of somewhat coarser sediments compared to the finer textured sediments of the microlow troughs. Compare – meander scroll, meander belt. SW
- (63) **barchan dune**.—A crescent-shaped dune with tips extending leeward (downwind), making this side concave and the windward (upwind) side convex. Barchan dunes tend to be arranged in chains extending in the dominant wind direction. Compare – parabolic dune. HP
- (64) **barrier bar**.—(not recommended) Use longshore bar.
- (65) **barrier beach**.—A narrow, elongate, coarse-textured, intertidal, sloping landform that is generally parallel with the beach ridge component of a barrier island or spit and adjacent to the ocean. Compare – barrier island. SSS
- (66) **barrier beach [relict]**.—(colloquial: western United States) A wide, gently sloping portion of a bolson floor comprising numerous, parallel, closely spaced, relict longshore bars and lagoons built by a receding pluvial lake. Synonym, offshore barrier, offshore beach, bar beach. Compare – bar – [coast], barrier island. GG and FFP
- (67) **barrier cove**.—A subaqueous area adjacent to a barrier island or submerged barrier beach that forms a minor embayment or cove within the larger basin. Compare – cove, mainland cove. SSS
- (68) **barrier flat**.—A relatively flat, low-lying area, commonly including pools of water, separating the exposed or seaward edge of a barrier beach or barrier island from the lagoon behind it. An assemblage of both deflation flats left behind migrating dunes and/or storm washover sediments; may be either barren or vegetated. Compare – barrier beach, back-barrier flat. SSS
- (69) **barrier island**.—A long, narrow, sandy island, that is above high tide and parallel to the shore that commonly has dunes, vegetated zones, and swampy or marshy terrains extending lagoonward from the beach. Compare – barrier beach. GG
- (70) **barrow pit**.—(not preferred) Refer to borrow pit.
- (71) **basal till**.—(not preferred) Refer to subglacial till.
- (72) **base level**.—The theoretical limit or lowest level toward which erosion of the earth's surface constantly progresses but seldom, if ever, reaches; especially the level below which a stream cannot erode its bed. The general or ultimate base level for the land surface is sea level, but temporary base levels commonly exist locally. GG
- (73) **base slope**.—[geomorphology] A geomorphic component of hills consisting of the concave to linear slope (perpendicular to the contour) that, regardless of the lateral shape, is an area that forms an apron or wedge at the bottom of a hillside dominated by colluvial and slope wash processes and sediments (e.g., colluvium and slope alluvium). Distal base slope sediments commonly grade to, or interfinger with, alluvial fills, or gradually thin to form

- pedis sediment over residuum. Compare – head slope, side slope, nose slope, interfluvium, free face. SW
- (74) **basin**
- (i) Drainage basin.
 - (ii) A low area in the earth's crust, of tectonic origin, in which sediments have accumulated. GG.
 - (iii) (colloquial: western United States) A general term for the nearly level to gently sloping, bottom surface of an intermontane basin (bolson). Landforms include playas, broad alluvial flats containing ephemeral drainageways, and relict alluvial and lacustrine surfaces that rarely, if ever, are subject to flooding. Where through-drainage systems are well developed, flood plains are dominant and lake plains are absent or of limited extent. Basin floors grade mountainward to distal parts of piedmont slopes. FFP
- (75) **basin floor**.—A general term for the nearly level, lower-most part of intermontane basins (i.e., bolsons, semibolsons). The floor includes all of the alluvial, eolian, and erosional landforms below the piedmont slope. Compare – basin, piedmont slope. FFP
- (76) **basin-floor remnant**.—(colloquial: western United States) A relatively flat, erosional remnant of any former landform of a basin floor that has been dissected following the incision of an axial stream. FFP
- (77) **batholith**.—A large, generally discordant plutonic rock body exposed at the land surface, with an aerial extent > 40 sq. mi. (100 km²) and no known bottom (e.g., Idaho batholith). Compare – stock. SW and GG
- (78) **bauxite**.—An off-white to dark red brown weathered detritus or rock composed of aluminum oxides (mainly gibbsite with some boehmite and diaspore), iron hydroxides, silica, silt, and especially clay minerals. Bauxite originates in tropical and subtropical environments as highly weathered residue from carbonate or silicate rocks and can occur in concretionary, earthy, pisolitic, or oolitic forms. SW and GG
- (79) **bay [coast]**
- (i) A wide, curving open indentation, recess, or arm of a sea (e.g., Chesapeake Bay) or lake (e.g., Green Bay, WI) into the land or between two capes or headlands, larger than a cove [coast], and usually smaller than, but of the same general character as, a gulf.
 - (ii) A large tract of water that penetrates into the land and around which the land forms a broad curve. By international agreement a bay is a water body having a baymouth that is less than 24 nautical miles wide and an area that is equal to or greater than the area of a semicircle whose diameter is equal to the width of the bay mouth. Compare – gulf. GG
- (80) **bay [geom.]**
- (i) Any terrestrial formation resembling a bay of the sea, as a recess or extension of lowland along a river valley or within a curve in a range of hills.
 - (ii) A Carolina Bay. GG and GSST
- (81) **bay bottom**.—The nearly level or slightly undulating central portion of a submerged, low-energy, depositional estuarine embayment characterized by relatively deep water (1.0 to >2.5 m). Compare – lagoon bottom. SSS
- (82) **bayou**.—A term applied to many local water features in the lower Mississippi River basin and in the Gulf Coast region of the United States. Its general meaning is a creek or secondary watercourse that is tributary to another body of water; especially a sluggish and stagnant stream that follows a winding course through alluvial lowlands, coastal swamps or river deltas. Compare – oxbow, slough. GG
- (83) **beach**
- (i) A gently sloping zone of unconsolidated material, typically with a slightly concave profile, extending landward from the low-water line to the place where there is a definite change in material or physiographic form (such as a cliff) or to the line of permanent

- vegetation (usually the effective limit of the highest storm waves); a shore of a body of water, formed and washed by waves or tides, usually covered by sand or gravel.
- (ii) The relatively thick and temporary accumulation of loose water-borne material (usually well-sorted sand and pebbles) accompanied by mud, cobbles, boulders, and smoothed rock and shell fragments, that is in active transit along, or deposited on, the shore zone between the limits of low water and high water. GG
- (84) **beach plain**.—A continuous and level or undulating area formed by closely spaced successive embankments of wave-deposited beach material added more or less uniformly to a prograding shoreline, such as to a growing compound spit or to a cusped foreland. Compare – wave-built terrace, chenier plain. GG
- (85) **beach ridge**.—A low, essentially continuous mound of beach or beach-and-dune material heaped up by the action of waves and currents on the backshore of a beach, beyond the present limit of storm waves or the reach of ordinary tides, and occurring singly or as one of a series of approximately parallel deposits. The ridges are roughly parallel to the shoreline and represent successive positions of an advancing shoreline. GG
- (86) **beach sands**.—[soil survey] Well sorted, sand-sized, clastic material transported and deposited primarily by wave action and deposited in a shore environment. Compare – eolian sands. SW
- (87) **beach terrace**
- (i) A landform that consists of a wave-cut scarp and wave-built terrace of well-sorted sand and gravel of marine and lacustrine origin.
- (ii) (colloquial: western United States) Relict shorelines from pluvial lakes, generally restricted to valley sides. Compare – strandline, shoreline. FFP
- (88) **beaded drainage pattern**.—(not recommended) Use beaded stream pattern.
- (89) **beaded stream pattern**.—A characteristic pattern of small streams in areas underlain by ice wedges. The course of the stream channel is controlled by the pattern of the wedges, with beads (pools) occurring at the junctions of the wedges. NRC
- (90) **bed**.—[stratigraphy] The layer of sediments or sedimentary rocks bounded above and below by more or less well-defined bedding surfaces. The smallest, formal lithostratigraphic unit of sedimentary rocks. The designation of a bed or a unit of beds as a formally named lithostratigraphic unit generally should be limited to certain distinctive beds whose recognition is particularly useful. Coal beds, oil sands, and other layers of economic importance commonly are named, but such units and their names usually are not a part of formal stratigraphic nomenclature. Compare – formation. GG
- (91) **bedded**.—Formed, arranged, or deposited in layers or beds, or made up of or occurring in the form of beds; especially said of a layered sedimentary rock, deposit, or formation. GG
- (92) **bedding plane**.—A planar or nearly planar bedding surface that visibly separates each successive layer of stratified sediment or rock (of the same or different lithology) from the preceding or following layer; a plane of deposition. It often marks a change in the circumstances of deposition, and may show a parting, a color difference, a change in particle size, or various combinations. A term commonly applied to any bedding surface even when conspicuously bent or deformed by folding. SW and GG
- (93) **bedrock**.—A general term for the solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface. Compare – regolith, residuum. GG
- (94) **bench**.—(not preferred) Refer to structural bench.
- (95) **berm**.—[beach] A low, impermanent, nearly horizontal or landward-sloping shelf, ledge, or narrow terrace on the backshore of a beach, formed of material thrown up and deposited by storm waves; it is generally bounded on one side or the other by a beach ridge or beach scarp. Some beaches have no berms, others have one or several. GG

- (96) **beveled base**.—The lower portion of a canyon wall or escarpment marked by a sharp reduction in slope gradient from the precipitous cliff above, and characteristically composed of thinly mantled colluvium (i.e., < 1 m) and/or carapaced with a thin surficial mantle of large rock fragments from above, which overly residuum of less resistant rock (e.g., shale) whose thin strata intermittently outcrop at the surface; a zone of erosion and transport common in the canyonlands of the semiarid, southwestern United States. Compare – talus slope. SW
- (97) **beveled cut**.—A bank or slope portion of a cut excavated into unconsolidated material (regolith) or bedrock as in a roadcut, whose slope gradient has been mechanically reduced to a subdued angle (e.g., to < 33%) to increase slope stability, reduce erosion, or to facilitate revegetation. Compare – cut, cutbank, roadcut. SW
- (98) **bioswale**.—An artificially constructed or modified closed basin or semiopen basin or drainageway designed to capture storm water runoff primarily from impervious surfaces (e.g., parking lots, roofs) and to maximize onsite infiltration in order to reduce runoff, to improve water quality by soil filtration, and to recharge local ground water. SW
- (99) **blind valley**.—A valley, commonly in karst, that ends abruptly downstream at the point at which its stream disappears underground. GG
- (100) **block** [volcanic].—(not preferred) Refer to volcanic block.
- (101) **block field**.—A thin accumulation of stone blocks, typically angular, with only rock fragments in the upper part, over solid or weathered bedrock, colluvium, or alluvium, without a cliff or ledge above as an apparent source. Block fields occur on high mountain slopes above the tree line or in polar or paleo-periglacial regions, they are most extensive along slopes parallel to the contour, and they generally occur on slopes of less than 5 percent. Synonym – felsenmeer. Compare – block stream, talus slope, scree slope. GG
- (102) **block glide**.—The mass movement process, associated sediments (block glide deposit), or resultant landform characterized by a slow type of slide, in which largely intact units (blocks) of rock or soil slide downslope along a relatively planar surface, such as a bedding plane, without any significant distortion of the original mass; a type of translational rock slide. Compare – rotational landslide, debris slide, lateral spread, landslide. SW and DV
- (103) **block lava**.—Lava having a surface of angular blocks; it is similar to aa lava but the fragments are larger and more regular in shape, somewhat smoother, and less vesicular. Compare – aa lava, pahoehoe lava, pillow lava. GG
- (104) **block lava flow**.—A lava flow dominated by block lava. Compare – aa lava flow, pahoehoe lava flow, pillow lava flow. SW
- (105) **block stream**.—An accumulation of boulders or angular blocks, with no fine sizes in the upper part, overlying solid or weathered bedrock, colluvium, or alluvium, and lying below a cliff or ledge from which rock fragments originate. Block streams usually occur at the heads of ravines as narrow bodies that are more extensive downslope than along the slope. They may exist on any slope angle, but ordinarily not steeper than 90 percent slope (approx. 40 degrees). Compare – block field. GG
- (106) **blowout**.—A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand, loose soil, or where protective vegetation is disturbed or destroyed; the adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Commonly small, some blowouts may be large (kilometers in diameter). Compare – deflation basin. GG
- (107) **blue rock**.—[volcanic] (colloquial: Hawaii) The very dense (e.g., 2.75 g/cm³), extremely hard and massive, nominally vesicular lava that commonly forms the inner core of an aa lava flow. SW
- (108) **bluff**

- (i) A high bank or bold headland, with a broad, precipitous, sometimes rounded cliff face overlooking a plain or body of water, especially on the outside of a stream meander (e.g., a river bluff).
- (ii) (not preferred) Use cliff. Any cliff with a steep, broad face. GG
- (109) **bog**.—Waterlogged, spongy ground, consisting primarily of mosses, containing acidic, decaying vegetation such as sphagnum, sedges, and heaths that may develop into peat. Compare – fen, marsh, swamp. GG
- (110) **bolson**.—(colloquial: western United States) A term applied to an internally drained (closed) intermontane basin in arid regions where drainages from adjacent mountains converge toward a central depression. Bolsons are often tectonically formed depressions. According to Peterson, a bolson can include alluvial flat, alluvial plain, beach plain, barrier beach, lake plain, sand sheet, dune, and playa landforms. The piedmont slope above a bolson includes erosional (pediments) and older depositional surfaces (fans) that adjoin the mountain front. A semibolson is an externally drained (open) bolson. Synonym – intermontane basin. GG and FFP
- (111) **bomb** [volcanic].—(not preferred) Refer to volcanic bomb.
- (112) **borrow pit**.—An excavated area from which earthy material has been removed typically for construction purposes offsite; also called barrow pit. GG
- (113) **bottomland**.—(not recommended) Use flood plain. An obsolete, informal term loosely applied to varying portions of a flood plain. SW
- (114) **boulder field**.—(not recommended) Use block stream. Compare – block field.
- (115) **bowl**.—[gilgai] A cup- or trough-shaped subsurface morphology centered under and surrounding the microlow of a gilgai, commonly 3 to 5 m across and 1.5 to 3 m thick, containing numerous slickensides (oblique slip/shear faces) within it, and bounded at its base by master slickensides. A bowl contains turbated material produced in soils with substantial amounts of smectite clay minerals (e.g., Vertisols). Bowl morphology is distinct from that in adjacent microslopes (intermediate position) and microhighs (chimney). Substratum morphology is not preserved within the bowl. Compare – chimney, intermediate position, gilgai. SW
- (116) **box canyon**
 - (i) A narrow gorge or canyon containing an intermittent stream following a zigzag course, characterized by high, steep rock walls and typically closed upstream by a similar wall, giving the impression, as viewed from its bottom, of being surrounded or “boxed in” by almost vertical walls.
 - (ii) A steep-walled canyon heading against a cliff a dead-end canyon. GG
- (117) **braided channel**.—(not recommended) Use braided stream.
- (118) **braided stream**.—A channel or stream with multiple channels that interweave as a result of repeated bifurcation and convergence of flow around interchannel bars, resembling (in plan view) the strands of a complex braid. Braiding is generally confined to broad, shallow streams of low sinuosity, high bed load, noncohesive bank material, and a steep gradient. At a given bank-full discharge, braided streams have steeper slopes and shallower, broader, and less stable channel cross sections than meandering streams. Compare – meandering channel, flood plain landforms. HP
- (119) **breached anticline**.—A structurally controlled landscape or landform typically underlain by sedimentary rocks in which an anticline crest has been eroded such that the former crest has become a canyon or valley flanked by inward-facing erosional scarp slopes or cliffs and outward-facing dip slopes. When used as a landscape term, the associated landforms include cuestas and strike valleys. SW and GG
- (120) **break**

- (i) [slopes] An abrupt change or inflection in a slope or profile (as in “a break in slope”). Compare – knickpoint, shoulder, escarpment.
- (ii) [geomorphology] A marked variation of topography, or a tract of land distinct from adjacent land, or an irregular or rough piece of ground. Compare – breaks. GG
- (121) **breaks**.—(colloquial: western United States) A landscape or large tract of steep, rough or broken land dissected by ravines and gullies and marks a sudden change in topography as from an elevated plain to lower hilly terrain, or a line of irregular cliffs at the edge of a mesa or a river (e.g., the Missouri River breaks). SW and GG
- (122) **breaklands**.—An assemblage of very steep (e.g., 60-90%), high relief slopes flanking major rivers and streams in mountainous terrain that form the walls of a v-shaped river valley. Breaklands are characterized by colluviated slopes of which the majority of the ground surface drains directly to a large axial stream at the base, and the remainder consists of shallowly incised, parallel drainageways. Breaklands have shallow to very deep soils, substantial rock outcrop, and more frequent fires than lower-gradient mountain slopes above; extensive along the rivers and streams of the Idaho Batholith. Compare – dissected breaklands. SW and HD
- (123) **breccia**.—A coarse-grained, clastic rock composed of angular rock fragments (larger than 2 mm) commonly bonded by a mineral cement in a finer-grained matrix of varying composition and origin. The consolidated equivalent of rubble. Compare – conglomerate. GSST
- (124) **broad interstream divide**.—(colloquial: southeastern United States) A type of very wide, low gradient (level to nearly level) interfluvium that lacks a well developed drainage network such that large portions of the local upland lack stream channels or other drainageways; extensive in lower coastal plains and some lake plains, till plains and alluvial plain remnants. Compare – interfluvium. SW and RD
- (125) **brook**.—[streams] (not preferred: refer to ephemeral stream) Generally a very small, ephemeral stream, especially one that issues from a spring or seep and conducts less water volume and over shorter distances than a creek. Compare – intermittent stream. GG
- (126) **burial mound**.—A pile, hillock, or human-made hill, composed of debris or earth heaped up to mark a burial site. ICOMANTH and GG
- (127) **buried**.—(adjective) Landforms, geomorphic surfaces, or paleosols covered by younger sediments (e.g., eolian, glacial, and alluvial). Compare – exhumed, relict. HP
- (128) **buried soil**.—Soil covered by an surface mantle of new soil material, typically to depths exceeding 50 cm; recent surface deposits < 50 cm thick are generally considered as part of the ground soil. Compare – ground soil, exhumed, relict. GSST and ST
- (129) **butte**.—An isolated, generally flat-topped hill or mountain with relatively steep slopes and talus or precipitous cliffs and characterized by summit width that is less than the height of bounding escarpments, commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks. Compare – mesa, plateau, cuesta. HP and GG
- (130) **caldera**.—A large, more or less circular depression, formed by explosion and/or collapse, which surrounds a volcanic vent or vents, and whose diameter is many times greater than that of the included vent, or vents. Compare – volcanic crater. GG
- (131) **caliche**.—A general term for a prominent zone of secondary carbonate accumulation in surficial materials in warm, subhumid to arid areas. Caliche is formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in non-indurated forms to very strong in types that are indurated. Other minerals (carbonates, silicates, sulfates) may be present as accessory cements. Most petrocalcic and some calcic horizons are caliche. HP

- (132) **canyon**.—A long, deep, narrow, very steep-sided valley cut primarily in bedrock with high and precipitous walls in an area of high local relief (e.g., mountain or high plateau terrain), often with a perennial stream at the bottom; similar to but larger than a gorge. Compare – gorge, box canyon, slot canyon. SW, HP, and GG
- (133) **canyon bench**.—One of a series of relatively narrow, flat landforms occurring along a canyon wall and caused by differential erosion of alternating strong and weak horizontal strata; a type of structural bench. SW and GG
- (134) **canyon wall**.—The steep to near-vertical slope between a canyon bottom and higher, adjacent hillslopes, mountain slopes, or summits. Canyon walls are generally dominated by rock outcrop and/or bedrock within the soil profile. Canyon walls commonly include cliffs or ledges, and may include a beveled base cut into less resistant rocks (e.g., shale). In large canyons (e.g., Grand Canyon), canyon walls may be vertically interrupted by nearly level or gentle slopes of canyon benches. SW
- (135) **canyonlands**.—A deeply and extensively dissected landscape composed predominantly of relatively narrow, steep-walled valleys with small flood plains or valley floors; commonly with considerable outcrops of hard bedrock on steep slopes, ledges, or cliffs, and with broader summits or interfluvies than found in badlands. Side slopes exhibit extensive erosion, active back-wearing, and relatively sparse vegetation. SW
- (136) **caprock**
- (i) A hard rock layer, usually sandstone, lava, or in arid environments, limestone, that lies above shale or other less resistant bedrock or sediments; specifically a rock layer that forms relatively level, resistant topmost strata that holds up hills, ridges, mesas, etc., and commonly forms cliffs or escarpments. Also spelled “cap rock.” SW and GG.
 - (ii) A hard rock layer, usually sandstone, overlying the shale above a coal bed. Also spelled “cap rock.” GG
- (137) **captured stream**.—A stream whose course has been diverted into the channel of another stream by natural processes. GG
- (138) **Carolina Bay**.—Any of various shallow, often oval or elliptical, generally marshy, closed depressions in the Atlantic coastal plain (from southern New Jersey to northeastern Florida, especially developed in the Carolinas) that share an approximately parallel orientation of their long axes. They range from about 100 meters to many kilometers in length, are rich in humus, and under native conditions contain trees and shrubs different from those of the surrounding areas. Also called Grady ponds (colloquial: Georgia and Alabama) and Delmarva Bays (colloquial: Maryland). Compare – pocosin. GG
- (139) **cat clay**.—(not recommended: obsolete) Wet, clay-dominated soils containing ferrous sulfide that become highly acidic when drained. GSST
- (140) **catena**.—(as used in United States) A sequence of soils across a landscape, of about the same age, derived from similar parent material, and occurring under similar climatic conditions, but have different characteristics due to variations in relief and in drainage. GSST
- (141) **catsteps**.—(not preferred: refer to terracettes) A terracette; especially one produced by slumping of loess deposits as in western Iowa. GG
- (142) **centripetal drainage pattern**.—A drainage pattern in which the streams converge inward toward a central depression; generally indicative of a structural basin, volcanic crater, caldera, breached dome, bolson, or the end of an eroded anticline or syncline. SW, GG, and WA
- (143) **channel**
- (i) [streams] The hollow bed where a natural body of surface water flows or may flow. The deepest or central part of the bed of a stream, containing the main current and occupied more or less continuously by water.

- (ii) (colloquial: western United States) The bed of a single or braided watercourse that commonly is barren of vegetation and is formed of modern alluvium. Channels may be enclosed by banks or splayed across and slightly mounded above a fan surface and include bars and mounds of cobbles and stones.
- (iii) [microfeature term] Small, trough-like, arcuate or sinuous channels separated by small bars or ridges, caused by fluvial processes; common to flood plains and young alluvial terraces; a constituent part of *bar and channel* topography. GG, FFP, and SW
- (144) **chenier**.—A long, narrow, vegetated marine beach ridge or sandy hummock, 1 to 6 m high, forming roughly parallel to a prograding shoreline seaward of marsh and mud-flat deposits, enclosed on the seaward side by fine-grained sediments, and resting on foreshore or mud-flat deposits. It is well drained, often supporting trees on higher areas. Widths range from 45 to 450 m, and lengths may exceed several tens of kilometers. GG
- (145) **chenier plain**.—A mud-rich strand plain, occupied by cheniers and intervening mud flats with marsh and swamp vegetation. Compare – chenier, strand plain. GG
- (146) **chert**.—A hard, extremely dense or compact, dull to semivitreous, cryptocrystalline sedimentary rock, consisting dominantly of interlocking crystals of quartz less than about 30 mm in diameter; it may contain amorphous silica (opal). It sometimes contains impurities such as calcite, iron oxide, or the remains of siliceous and other organisms. It has a tough, splintery to conchoidal fracture and may be white or variously colored gray, green, blue, pink, red, yellow, brown, and black. Chert occurs principally as nodular or concretionary segregations in limestones and dolomites. GG
- (147) **chimney**.—[gilgai] A subsurface morphology that forms a crude cone or wave-crest structure centered under a microhigh (e.g., a low mound or rim) and extends at least part-way under adjacent intermediate positions; composed of substratum material that appears to upwell and reaches close to the surface. A chimney is commonly bounded by master slickensides in the subsoil with maximum angles of dip reaching 60 to 75 degrees under the microhigh. Its morphology is distinct from the solum of the adjacent microslopes and microlows (e.g., lighter colored, more alkaline, and contains carbonate or gypsum concretions absent under microslopes and microlows). Compare – puff, bowl, intermediate position, gilgai. SW
- (148) **chimney and bowl topography**.—(not recommended) Use gilgai.
- (149) **cinder cone**.—A conical hill formed by the accumulation of cinders and other pyroclastics, normally of basaltic or andesitic composition. Slopes generally exceed 20 percent. GG
- (150) **cinders**.—Unconsolidated, juvenile, vitric, vesicular pyroclastic material; individual fragments are 2.0 mm or more in at least one dimension with an apparent specific gravity (including vesicles) of more than 1.0 and less than 2.0 g/cm³. Compare – ash, lapilli, scoria, tephra, volcanic block, volcanic bomb. KST
- (151) **circle**.—A form of patterned ground whose horizontal mesh is dominantly circular. Compare – nonsorted circle, patterned ground. GG
- (152) **circular gilgai**.—A type of gilgai dominated by circular closed depressions (microlows) separated by low mounds (microhighs); the prevailing type of gilgai on relatively level terrain (slopes < 3%). Distance from microhigh to the center of an adjacent microlow is generally 4 to 8 m. Compare – elliptical gilgai, linear gilgai, gilgai. SW
- (153) **cirque**.—A steep-walled, half bowl-like recess or hollow, crescent-shaped or semicircular in plan, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain, and produced by the erosive activity of a mountain glacier. It often contains a small round lake (tarn). Compare – cirque floor, cirque platform, cirque wall. SW and GG
- (154) **cirque floor**.—The comparatively level bottom of a cirque, thinly mantled with till and consisting of glacially scoured knolls and hillocks separated by depressions, flat areas and

- small lakes (tarn); commonly it is bounded by a slightly elevated rock lip at its exit. SW and HD
- (155) **cirque headwall**.—The glacially scoured, steep and arcuate side or wall of a cirque, dominated by rock outcrop, rubble, and colluvium. Compare – headwall. SW and HD
- (156) **cirque platform**.—A relatively level or bench-like surface formed by the coalescence of several cirques. GG and SW
- (157) **cirque wall**.—(not preferred) Refer to cirque headwall.
- (158) **clast**.—An individual constituent, grain, or fragment of sediment or rock, produced by the mechanical weathering (disintegration) of a larger rock mass. HP
- (159) **clastic**.—(adjective) Pertaining to rock or sediment composed mainly of fragments derived from preexisting rocks or minerals and moved from their place of origin. The term indicates sediment sources that are both within and outside the depositional basin. Compare – detritus, epiclastic, pyroclastic, volcanoclastic. GG
- (160) **claypan**.—A dense, compact, slowly permeable layer in the subsoil, with a much higher clay content than overlying materials from which it is separated by a sharply defined boundary. Claypans are usually hard when dry, and plastic and sticky when wet. GSST
- (161) **cliff**.—Any high, very steep to perpendicular or overhanging face of rock or earth; a precipice. Compare – bluff, beveled base. GG
- (162) **climbing dune**.—A dune formed by the piling-up of sand by wind against a cliff or mountain slope; very common in arid regions with substantial local relief and strong, prevailing winds. Compare – sand ramp. GG and SW
- (163) **closed depression**.—A generic name for any enclosed area that has no surface drainage outlet and from which water escapes only by evaporation or subsurface drainage; an area of lower ground indicated on a topographic map by a hachured contour line forming a closed loop. Compare – open basin. SW and GG
- (164) **coalescent fan piedmont**.—(not preferred) Refer to fan piedmont. HP
- (165) **coastal plain**.—A low, generally broad plain that has as its margin an oceanic shore and its strata horizontal or gently sloping toward the water and generally represents a strip of recently prograded or emerged sea floor (e.g., the coastal plain of the southeastern United States that extends for 3000 km from New Jersey to Texas). GG87
- (166) **coastal marl**.—An earthy, unconsolidated deposit of gray to buff-colored mud of low bulk density (dry) composed primarily of very fine, almost pure calcium carbonate formed in subaqueous settings that span freshwater lacustrine conditions (e.g., Florida Everglades) to saline intertidal settings (e.g., Florida Keys) formed by the chemical action of algal mats and organic detritus (i.e., periphyton); other marl varieties associated with different environments (e.g., freshwater marl, glauconitic marl) also occur. Coastal marl can be quite pure or it can be finely disseminated throughout living root mats (e.g., mangrove roots), organic soil layers, or both. Compare – marl, freshwater marl. SW
- (167) **cockpit**.—A crudely star-shaped, closed depression (i.e., large sinkhole) in tropical karst having an inverted conical or slightly concave floor, with an irregular or serrate perimeter formed by subsidiary solution channels and corridors into adjacent hills, and surrounded by residual hills with steep, concave side slopes; the dominant type of closed depression in cockpit karst. Compare – sinkhole, kegel karst. SW, WW, and GG
- (168) **cockpit karst**.—A karst landscape dominated by subsurface drainage and serrate or star-shaped depressions (cockpits) that range widely in size and density but typically are considerably larger than sinkholes (dolines), and are separated by intermediate residual hills with concave side slopes; a common type of tropical karst (e.g., Jamaica). Compare – kegel karst, karst. SW and WW

- (169) **col.**—A high, narrow, sharp-edged pass or saddle through a divide or between two adjacent peaks in a mountain range; especially a deep pass formed by the headward erosion and intersection of two cirques. Compare – gap, pass, saddle. GG
- (170) **collapse sinkhole.**—A type of sinkhole that is formed by collapse of a cave within the underlying soluble bedrock (e.g., limestone, gypsum, salt). Compare – solution sinkhole. SW, WW, and GG
- (171) **collapsed ice-floored lakebed.**—A lakebed formed in a lake on glacial ice and subsequently “let down” or collapsed by the melting of underlying ice, resulting in contortion or folding of the lacustrine sediment and sedimentary structures. These modified or distorted lacustrine sediments cap present-day topographic highs and generally lie at elevations higher than the surrounding disintegration moraine. Compare – collapsed lake plain, collapsed ice-walled lakebed. SW and CF
- (172) **collapsed ice-walled lakebed.**—A lakebed that formed in a lake bounded by stagnant ice, but floored by solid ground, usually till. Collapse features are limited to the lakebed margins. Presently, these materials and sedimentary structures generally occur as roughly circular-shaped hills of till capped by lacustrine sediments, generally at elevations higher than surrounding disintegration moraine. Compare – collapsed ice-floored lakebed, collapsed lake plain. SW and CF
- (173) **collapsed lake plain.**—A lake plain formed on, and bounded by, glacial ice and subsequently “let down” or collapsed by the melting of underlying ice resulting in contortion or folding of the sediments and sedimentary structures. Lacustrine sediments cap present topography. Compare – lake plain. SW and CF
- (174) **collapsed outwash plain.**—An outwash plain that forms on glacial ice (inside the glacial margin) and is subsequently let down or collapsed when the underlying ice melts, resulting in contortion or folding of the sediments and sedimentary structures to the extent that little of the original plain or its gradient remain. Outwash sediments commonly cap present-day topography. Compare – collapsed lake plain, pitted outwash plain. SW and CF
- (175) **colluvial.**—(adjective) Pertaining to material or processes associated with transportation and/or deposition by mass movement (direct gravitational action) and local, unconcentrated runoff (overland flow) on side slopes, at the base of slopes, or both. Compare – alluvial, fluvial. HP
- (176) **colluvial apron.**—A landform with a concave to planar surface composed of a thick wedge-shaped deposit of colluvium, slope alluvium, or both that forms the base (footslope) of a bluff, escarpment or steep slope. Compare – beveled base. SW
- (177) **colluvium.**—Unconsolidated, unsorted earth material being transported or deposited on side slopes, at the base of slopes, or both by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff. Compare – alluvium, slope alluvium, scree, talus, mass movement. HP
- (178) **competence.**—The ability of a current of water or wind to transport sediment, in terms of particle size rather than amount, measured as the diameter of the largest particle transported. It depends upon velocity: a small but swift current for example, may have greater competence than a larger but slower moving current. GG
- (179) **complex landslide.**—A category of mass movement processes, associated sediments (complex landslide deposit), or resultant landforms characterized by a composite of several mass movement processes none of which dominates or leaves a prevailing landform. Numerous types of complex landslides can be specified by naming the constituent processes evident (e.g., a *complex earth spread* – *earthflow* landslide). Compare – fall, topple, slide, lateral spread, flow, landslide. SW and DV
- (180) **composite cone.**—(not preferred) See stratovolcano.
- (181) **compound sinkhole.**—(not preferred) Refer to karst valley.

- (182) **cone karst**.—A variety of kegel karst topography, common in the tropics (e.g., Puerto Rico and some Pacific islands) characterized by steep-sided, cone-shaped residual hills and ridges separated by star-shaped depressions, broader valleys, or lagoons. These hills and ridges have steep, convex side slopes and rounded tops that are dissected into secondary karst surfaces with shafts and various forms of karren microfeatures. Compare – karst cone, cockpit karst, fluviokarst, sinkhole karst, tower karst. SW, GG, and WW
- (183) **conformity**.—The mutual and undisturbed relationship between adjacent sedimentary strata that have been deposited in orderly sequence with little or no evidence of time lapses; true stratigraphic continuity in the sequence of beds without evidence that the lower beds were folded, tilted, or eroded before the higher beds were deposited. Compare – unconformity. GG
- (184) **congelifraction**.—(not preferred) Refer to frost shattering.
- (185) **congeliturbate**.—(not recommended) Use cryoturbate.
- (186) **congeliturbation**.—(not recommended) Use cryoturbation.
- (187) **conglomerate**.—A coarse-grained, clastic sedimentary rock composed of rounded to subangular rock fragments larger than 2 mm, commonly with a matrix of sand and finer material; cements include silica, calcium carbonate, and iron oxides. The consolidated equivalent of gravel. Compare – breccia. HP
- (188) **conservation terrace**.—An earthen embankment constructed across a slope for conducting water from above at a regulated flow to prevent accelerated erosion and to conserve water. Compare – hillslope terrace. SW and GSST
- (189) **constructional**.—[geomorphology] (adjective) Said of a landform that owes its origin, form, position, or general character to depositional (aggradational) processes, such as the accumulation of sediment (e.g., alluvial fan, volcanic cone). Compare – aggradation, destructional, erosional. GG
- (190) **continuous permafrost**.—Permafrost occurring everywhere beneath the exposed land surface throughout a geographic region. Compare – discontinuous permafrost, sporadic permafrost. NRC
- (191) **continental glacier**.—A glacier of considerable thickness completely covering a large part of a continent or an area of at least 50,000 square km, obscuring the underlying surface, such as the ice sheets covering Antarctica or Greenland. Continental glaciers occupied northern portions of the conterminous United States and Alaska in the past (e.g., Pleistocene) and usage commonly implies former continental glacier conditions. Compare – alpine glacier. SW and GG
- (192) **coppice dune field**.—An extensive area dominated by small, streamlined shrub-coppice dunes that form around brush and other clump vegetation; a type of dune field. Shrub-coppice dunes are commonly 50-300 cm high and 1-7 m wide. SW
- (193) **coppice mound**.—(also called coppice dune) (not recommended: obsolete) Use shrub-coppice dune.
- (194) **coprogenous earth**.—[Soil Taxonomy] A type of sedimentary peat that is a limnic layer composed predominantly of fecal material derived from aquatic animals. ST
- (195) **coprogenic material**.—[soil survey] The remains of fish excreta and similar materials that occur in some organic soils. GSST
- (196) **coral island**
- (i) A relict coral reef that stands above sea level and surrounded by water (e.g., Florida Keys). Carbonate sands rich in coral and shell fragments generally mantle the underlying flat coral platform.
 - (ii) An oceanic island formed from coral accumulations lying atop or fringing volcanic peaks or platforms. SW and GG

- (197) **coral limestone**.—An informal term for massive limestone composed primarily of coral and coral fragments commonly associated with marine islands or coral reefs in tropical or subtropical waters. Compare – coral island. SW
- (198) **corda**.—Small, tightly bunched, parallel ridges or corrugations of lava, commonly < 1 m in amplitude (high) and < 3 m in period (wide) on the surface of corded pahoehoe lava (ropy lava). SW and GS
- (199) **corrosion**.—[geomorphology] A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation. GG
- (200) **coulee**.—(colloquial: northwestern United States and ND) A dry or intermittent stream valley or wash with an underfit stream, especially a long, steep-walled gorge representing a Pleistocene overflow channel that carried meltwater from an ice sheet (e.g., the Grand Coulee in Washington State). HP
- (201) **country rock**.—A general term for the nonigneous rock surrounding an igneous intrusion. GG
- (202) **cove** [geomorphology]
- (i) A walled and rounded or cirque-like opening at the head of a small steep valley.
 - (ii) (colloquial: southern Appalachians, United States) A smooth-floored, somewhat oval-shaped “valley” sheltered by hills or mountains; e.g., Cades Cove in eastern Tennessee. GG
- (203) **cove** [water]
- (i) A small, narrow sheltered bay, inlet, creek or recess in an estuary, often inside a larger embayment. Compare – lagoon bottom. SSS and GG
 - (ii) A small, often circular, wave-cut indentation in a cliff; it usually has a restricted or narrow entrance.
 - (iii) A fairly broad, looped embayment in a lake shoreline.
 - (iv) A shallow tidal river, or the backwater near the mouth of a tidal river. Compare – estuary. GG
- (203) **cradle and knoll topography**.—(not recommended) Use tree-tip pit and mound topography.
- (204) **crag and tail**.—An elongate hill or ridge of subglacially streamlined drift, having at the stoss end (up-ice) a steep, often precipitous face or knob of ice-smoothed, resistant bedrock (the “crag”) obstructing the movement of the glacier, and at the lee end (down-ice) a tapering, streamlined, gentle slope (the “tail”) of intact, weaker rock and / or drift protected by the crag; also called lee-side cone. Compare – drumlin, drumlinoid ridge, flute, stoss and lee. GG, SW, and GM
- (205) **crater** [volcanic].—See volcanic crater.
- (206) **craton**.—A part of the earth’s crust that has attained stability, and has been minimally deformed for a prolonged period. The term is now restricted to continental areas of largely Precambrian rocks. GG
- (207) **creek**.—[streams] (not preferred: refer to intermittent stream) A general term used throughout the United States (except New England), Canada, and Australia for a small, intermittent stream that is larger than a brook but smaller than a river. GG
- (208) **creep**.—The mass movement process, surficial sediments (creep deposit), or landform that results from very slow downslope mass wasting of unconsolidated earthy material driven primarily by gravity, but facilitated by water saturation and by and freeze-thaw. Sometimes redundantly called soil creep. Compare – mudflow, flow, landslide, solifluction. SW
- (209) **crest**

- (i) The commonly linear, narrow top of a ridge, hill, or mountain. It is appropriately applied to elevated areas where retreating backslopes are converging such that these high areas are almost exclusively composed of convex shoulders.
- (ii) (not preferred) Sometimes used as an alternative for the hillslope component *summit*.
Compare – summit (*part b*), saddle. FFP and SW
- (210) **crest**.—[geomorphology] A geomorphic component of hills consisting of the convex slopes (perpendicular to the contour) that form the narrow, roughly linear top area of a hill, ridge, or other upland where shoulders have converged to the extent that little or no summit remains; dominated by erosion, slope wash and mass movement processes and sediments (e.g., slope alluvium, creep). Commonly, soils on crests are more similar to those on side slopes than to soils on adjacent interfluvies. Compare – interfluve, head slope, side slope, nose slope. SW
- (211) **crevasse** [geomorphology]
 - (i) A wide breach or crack in the bank of a river or canal; especially one in a natural levee or an artificial bank of the lower Mississippi River. Compare – avulsion, flood-plain splay.
 - (ii) A wide, deep break or fissure in the earth after an earthquake. [glaciology] A deep, nearly vertical fissure, crack, or rift in a glacier or other mass of land ice. GG
- (212) **crevasse filling**.—A short, straight ridge of stratified sand and gravel believed to have been deposited in a crevasse of a wasting glacier and left standing after the ice melted; a variety of kame. May also occur as long, sinuous ridges and linear complexes of till or drift. GG
- (213) **crevasse splay**.—(not recommended) Use flood-plain splay. Compare – crevasse.
- (214) **cross-bedding**
 - (i) Cross-stratification in which the cross-beds are more than 1 cm in thickness.
 - (ii) A cross-bedded structure; a cross-bed. Compare – cross-lamination. GG
- (215) **cross-lamination**
 - (i) Cross-stratification characterized by cross-beds that are less than 1 cm in thickness.
 - (ii) A cross-laminated structure; a cross-lamina. Compare – cross-bedding. GG
- (216) **cross-stratification**.—Arrangement of strata inclined at an angle to the main stratification. This is a general term having two subdivisions; cross-bedding, in which the cross-strata are thicker than 1 cm, and cross-lamination, in which they are thinner than 1 cm. A single group of related cross-strata is a set and a group of similar, related sets is a coset. GG
- (217) **cryoplanation**.—The reduction and modification of a land surface by processes associated with intensive frost action, such as solifluction, supplemented by the erosive and transport actions of running water, moving ice, and other agents. GG
- (218) **cryoturbate**.—A mass of soil or other unconsolidated earthy material moved or disturbed by frost action, and usually coarser than the underlying material; especially a rubbly deposit formed by solifluction. GG
- (219) **cryoturbation**.—A collective term used to describe all soil movements due to frost action, characterized by folded, broken and dislocated beds and lenses of unconsolidated deposits. Compare – pedoturbation. NRC
- (220) **cryptogamic crust**.—A type of microbiotic crust consisting of a thin, biotic layer at the ground surface composed predominantly of cryptogams (i.e., algae, lichen, mosses, lichens and liverworts), most commonly found in semiarid or arid environments. Compare – microbiotic crust. SW and SS
- (221) **cuesta**.—An asymmetric ridge capped by resistant rock layers of slight to moderate dip, commonly less than 10° (approximately < 15 percent); a homocline type produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope), that roughly parallels the inclined beds, and on the opposite side has a

- relatively short, steep or cliff-like slope (scarp slope) that cuts the tilted rocks. Compare – hogback, homoclinal ridge, mesa, dipslope, scarp slope, cuesta valley. SW and HP
- (222) **cuesta valley**.—An asymmetric depression adjacent to a cuesta that lies parallel to the strike of the underlying strata; a type of strike valley. It's formed by differential erosion of weaker strata interbedded with, or stratigraphically adjacent to more resistant rocks. It may or may not contain a local drainage network but commonly lies above and is unconnected to the regional drainage system. Compare – cuesta, strike valley. SW
- (223) **cut**.—A passage, incision, or space from which material has been excavated, such as a road cut or a railroad cut. GG
- (224) **cut and fill**.—A *process* of leveling, whereby material eroded from one place by waves, currents, streams, or winds is deposited nearby until the surfaces of erosion and deposition are continuous and uniformly graded; especially lateral erosion on the concave banks of a meandering stream accompanied by deposition within its loops. Compare – flood plain step, stream terrace, terrace. GG
- (225) **cutbank**
- (i) A slope or wall portion of a cut excavated into unconsolidated material (regolith) or bedrock, as in a borrow pit. It may stand nearly vertical resulting from collapse as the base is undercut during excavation or by erosion, or it may be reduced by subsequent erosion to a more subdued angle by slope wash. Compare – cut, beveled cut, roadcut. SW.
 - (ii) (not preferred – refer to escarpment, meander scar, bluff; colloquial: western United States) A steep, bare slope formed by lateral migration of a stream. GG
- (226) **cutoff**.—[streams] The new and relatively short channel formed when a stream cuts through a narrow strip of land and thereby shortens the length of its channel. GG
- (227) **cutter**.—[karst] A dissolution groove or trench formed along vertical bedrock fractures beneath soil and usually buried beneath regolith with little or no ground surface expression, commonly wider than a solution fissure (widths commonly range from 0.5 to 3 meters) and tapering down to a crack or a bedrock floored trench; also called grike (not preferred) or subsurface karren. Compare – karren, solution fissure, solution corridor. SW and WW
- (228) **cyclothem**.—A series of beds deposited during a single sedimentary cycle of the type that prevailed during the Pennsylvanian Period. It is an informal, lithostratigraphic unit equivalent to “formation.” Cyclothems are typically associated with unstable shelf or interior basin conditions in which alternate marine transgression and regressions occur. The term has also been applied to rocks of different ages and of different lithologies from the Pennsylvanian cyclothems. Compare – rhythmite. GG
- (229) **dead-ice**.—(not recommended) Use stagnant ice.
- (230) **dead-ice moraine**.—(not recommended) Use disintegration moraine.
- (231) **debris**.—Any surficial accumulation of loose material detached from rock masses by chemical and mechanical means, as by decay and disintegration. It consists of rock clastic material of any size and sometimes organic matter. GG
- (232) **debris avalanche**.—The mass movement process, associated sediments (debris avalanche deposit), or resultant landform characterized by a very rapid to extremely rapid type of *flow* dominated by the sudden downslope movement of incoherent, unsorted mixtures of soil and weathered bedrock that, although comparatively dry, behave much as a viscous fluid when moving. Compare – debris flow, earthflow, landslide, rockfall avalanche. SW and GG
- (233) **debris fall**.—The mass movement process, associated sediments (debris fall deposit), or resultant landform characterized by a rapid type of *fall* involving the relatively free, downslope movement or collapse of detached, unconsolidated material that falls freely through the air (lacks an underlying slip face); sediments have substantial proportions of both

- fine earth and rock fragments; common along undercut stream banks. Compare – rockfall, soil fall, landslide. SW
- (234) **debris flow**—The mass movement process, associated sediments (debris flow deposit), or resultant landform characterized by a very rapid type of *flow* dominated by a sudden downslope movement of a mass of rock, soil, and mud (more than 50% of the particles are > 2mm), and whether saturated or comparatively dry, behaves much as a viscous fluid when moving. Compare – lahar, mudflow, landslide. SW
- (235) **debris slide**.—The mass movement process, associated sediments (debris slide deposit), or resultant landform characterized by a rapid type of *slide*, composed of comparatively dry and largely unconsolidated earthy material that slides or rolls downslope (does not exhibit backward rotation) and resulting in an irregular, hummocky deposit somewhat resembling a moraine. Compare – rotational landslide, block glide, lateral spread, landslide. SW and GG
- (236) **debris spread**.—The mass movement process, associated sediments (debris spread deposit), or resultant landform characterized by a very rapid type of *spread* dominated by lateral movement in a soil and rock mass resulting from liquefaction or plastic flow of underlying materials that may be extruded out between intact units; sediments have substantial proportions of both fine earth and rock fragments. Compare – earth spread, rock spread, landslide. SW and DV
- (237) **debris topple**.—The mass movement process, associated sediments (debris topple deposit), or resultant landform characterized by a localized, very rapid type of *topple* in which large blocks of soil and rock material literally fall over, rotating outward over a low pivot point; sediments have substantial proportions of both fine earth and rock fragments. Portions of the original material may remain intact, although reoriented, within the resulting debris pile. Compare – earth topple, rock topple, landslide. SW
- (238) **deflation**.—The sorting out, lifting and removal of loose, dry, fine-grained soil particles (clays, silts, and fine sands) by the turbulent eddy action of the wind; a form of wind erosion. GG and GSST
- (239) **deflation basin**.—A topographic basin excavated and maintained by wind erosion that removes unconsolidated material and commonly leaves a rim of resistant material surrounding the depression. Unlike a blowout, a deflation basin does not include adjacent deposits derived from the basin. Compare – blowout. GG
- (240) **deflation flat**.—(colloquial: US Gulf Coast) A series of low ridges and troughs on an essentially flat surface on barrier islands formed by dune field migration during alternating wet and dry periods; a type of interdune. Troughs are eroded down to the wet sand level during drought periods (dune slack), while the ridges are stabilized by vegetation that invades the edge of dune fields during wet periods. Compare – blowout, deflation basin. HF
- (241) **degradation**.—[geomorphology] The wearing down or away, and the general lowering of the land surface by natural processes of weathering and erosion (e.g., the deepening by a stream of its channel); it may infer the process of transportation of sediment. Compare – destructional. GG
- (242) **Delmarva Bay**.—See Carolina Bay.
- (243) **delta**.—A body of alluvium, nearly flat and fan-shaped, deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, usually a sea or lake. HP
- (244) **delta plain**.—The level or nearly level surface composing the land-ward part of a large delta; strictly, a flood plain characterized by repeated channel bifurcation and divergence, multiple distributary channels, and interdistributary flood basins. GG
- (245) **dendritic drainage pattern**.—A common drainage pattern in which the tributaries join the gently curving mainstream at acute angles, resembling in plan view the branching habit of an oak or chestnut tree; it is produced where a consequent stream receives several tributaries that in turn are fed by smaller tributaries. It indicates streams flowing across horizontal rock

- strata and homogenous soil typified by the landforms of soft sedimentary rocks, volcanic tuff, old dissected coastal plains, or complex crystalline rocks offering uniform resistance to erosion. SW, WA, GG
- (246) **deposit**.—Either consolidated or unconsolidated material of any type that has accumulated by natural processes or by human activity. SW
- (247) **deposition**.—The laying down of any material by any agent such as wind, water, ice or by other natural processes. HP
- (248) **depression**.—Any relatively sunken part of the earth's surface; especially a low-lying area surrounded by higher ground. A closed depression has no natural outlet for surface drainage (e.g., a sinkhole). An open depression has a natural outlet for surface drainage. Compare – closed depression, open depression. GG
- (249) **deranged drainage pattern**.—A distinctively disordered drainage pattern of nonintegrated streams that indicates a complete lack of underlying structural and bedrock control, resulting from a relatively young landscape having a flat or undulating topographic surface and a high water table. It is characterized by relatively few, irregular streams with few, short tributaries, that flow into and out of depressions containing swamps, bogs, marshes, ponds, or lakes; interstream areas are swampy. Regional streams may meander through the area but do not influence its drainage. These drainage patterns commonly occur on young, thick till plains, end moraines, flood plains, and coastal plains. SW and WA
- (250) **desert pavement**.—A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments, mantling a desert surface. It is formed where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It usually protects the underlying, finer-grained material from further deflation. Compare – erosion pavement, stone line. SW, GSST, and GG
- (251) **desert varnish**.—(not preferred) Refer to rock varnish.
- (252) **destructional**.—[geomorphology] (adjective) Said of a landform that owes its origin, form, position, or general character to the removal of material by erosion and weathering (degradation) processes resulting from the wearing-down or away of the land surface. Compare – constructional. GG
- (253) **detritus**.—[geology] A collective term for rock and mineral fragments occurring in sediments, that are detached or removed by mechanical means (e.g., disintegration, abrasion) and derived from preexisting rocks and moved from their place of origin. Compare – clastic, epiclastic, pyroclastic. GG
- (254) **diamict**.—(not preferred; refer to diamicton) A general term that includes both diamictite (coherent rock) and diamicton (unconsolidated sediments). GG
- (255) **diamictite**.—A general term for any nonsorted or poorly sorted, noncalcareous, terrigenous sedimentary *rock* (e.g., pebbly mudstone) containing a wide range of particle sizes. Compare – diamicton. GG
- (256) **diamicton**.—A generic term for any nonlithified, nonsorted or poorly sorted *sediment* that contains a wide range of particle sizes, such as rock fragments contained within a fine earth matrix (e.g., till) and used when the genetic context of the sediment is uncertain. Compare – diamictite. SW and GG
- (257) **diapir**.—A dome or anticlinal fold in which the overlying rocks or sediments have been ruptured by the squeezing-out of plastic core material. Diapirs in sedimentary strata usually contain cores of salt or shale; igneous intrusions may also show diapiric structure. GG
- (258) **diatomaceous earth**.—[geology] A lacustrine or marine geologic deposit of fine, grayish, siliceous material composed chiefly or wholly of the remains of diatoms. It may occur as a powder or a rigid material (i.e., *diatomite*). GSST

- (259) **diatomaceous earth**.—[Soil Taxonomy] A layer of soil material (limnic materials) that is composed of diatoms. Diatomaceous earth is identified by several diagnostic criteria such as moist color value that changes on drying as a result of the irreversible shrinkage of organic-matter coats on diatoms and either a moist color value of 8 or more and a chroma of 2 or less from a saturated sodium-pyrophosphate extract on white chromatographic or filter paper, or a cation-exchange capacity of less than 240 cmol⁽⁺⁾ per kg organic matter (measured by loss on ignition). KST and ST
- (260) **diatomite**.—A light-colored, soft, siliceous sedimentary rock consisting chiefly of opaline diatom frustules deposited in a lacustrine or marine environment. Diatomite has a number of uses owing to its high surface area, absorptive capacity, and relative chemical stability but the term is generally reserved for deposits of actual or potential commercial value. Compare – diatomaceous earth – (geology). GG
- (261) **diatrema**.—A breccia-filled volcanic pipe that was formed by a gaseous explosion (e.g., hydrovolcanic eruption); commonly, but not exclusively associated with exposed throat or neck of maar, as in the Hopi Buttes area of northeastern Arizona. Compare – volcanic neck. SW and GG
- (262) **dike**.—[intrusive rocks] A tabular igneous intrusion that cuts across the bedding or foliation of the country rock. Compare – sill. GG
- (263) **dip**.—[soil survey] A geomorphic component (characteristic piece) of flat plains (e.g., lake plain, low coastal plain, low-relief till plain) consisting of a shallow and typically closed depression that tends to be an area of focused groundwater recharge but not a permanent water body and that lies slightly lower and is wetter than the adjacent talf, and favors the accumulation of fine sediments and organic materials. SW
- (264) **dip**.—[structural geology] The maximum angle that a structural surface, (e.g., a bedding or fault plane) makes with the horizontal, measured perpendicular to the strike of the structure and in the vertical plane; used in combination with “dip” to describe the orientation of bedrock strata. SW and GG
- (265) **dip slope**.—A slope of the land surface, roughly determined by and approximately conforming to the dip of underlying bedded rocks; (i.e., the long, gently inclined surface of a cuesta). Compare – scarp slope. HP
- (266) **discontinuity**.—[stratigraphy] Any interruption in sedimentation, whatever its cause or length, usually a manifestation of nondeposition and accompanying erosion; an unconformity. GG
- (267) **discontinuous permafrost**.—Permafrost occurring in some areas beneath the exposed land surface throughout a geographic region where other areas are free of permafrost. Compare – continuous permafrost, sporadic permafrost. NRC
- (268) **disintegration moraine**.—A drift topography characterized by chaotic mounds and pits, generally randomly oriented, developed in supraglacial drift by collapse and flow as the underlying stagnant ice melted. Slopes may be steep and unstable and there will be used and unused stream courses and lake depressions interspersed with the morainic ridges. Characteristically, there are numerous abrupt lateral and vertical changes between unconsolidated materials of differing lithology. SJ and SW
- (269) **dissected breaklands**.—Very steep slopes flanking major rivers and streams in mountainous terrain and dominated by deeply incised, subparallel to dendritic, chute-like drainageways that occupy > 50 percent of the ground surface. Dissected breakland slopes are dominated by hillslope elements that grade to secondary drainageways, rather than directly to the axial stream; a type of breakland. SW and HD
- (270) **dissected plateau**.—A land area (landscape) produced by significant stream erosion and incision of a plateau such that only a small part of the plateau surface is at or near the original

- summit level. Much of the area occurs as hillslopes, or if incision is sufficient and relief is > 1000 feet, as mountain slopes. Compare – plateau. SW
- (271) **distal**.—(sedimentology; adjective) Said of a sedimentary deposit consisting of fine clastics and deposited farthest from the source area. Compare – proximal. GG
- (272) **distributary** [streams]
- (i) A divergent stream flowing away from the main stream and not returning to it, as in a delta or on a flood plain. It may be produced by stream deposition choking the original channel.
 - (ii) One of the channels of a braided stream; a channel carrying the water of a stream distributary. GG
- (273) **ditch**.—An open and usually unpaved (unlined), channel or trench excavated to convey water for drainage (removal) or irrigation (addition) to or from a landscape; smaller than a canal; some ditches are modified natural waterways. GG
- (274) **divide**.—A summit area or tract of high ground, which can vary from broad to narrow, or a line of separation that constitutes a watershed boundary between adjacent drainage basins; a divide separates surface waters that flow naturally in one direction from those that flow in a different or opposite direction. Compare – interfluvium. GG
- (275) **doline**.—(not preferred) Refer to synonym “sinkhole.”
- (276) **doline karst**.—(not preferred) Refer to sinkhole karst.
- (277) **dolomite**
- (i) [mineral] A common rock-forming rhombohedral carbonate mineral: $\text{CaMg}(\text{CO}_3)_2$. GG
 - (ii) [rock] A carbonate sedimentary rock consisting chiefly (more than 50 percent by weight or by areal percentages under the microscope) of the mineral dolomite. GG
- (278) **dolostone**.—(not recommended – use dolomite) An obsolete term proposed for the sedimentary rock called dolomite, in order to avoid confusion with the mineral of the same name. Compare – dolomite. GG
- (279) **dome**
- (i) [structural geology] An uplift or anticlinal structure, either circular or elliptical in outline, in which the rocks dip gently away in all directions. A dome may be small (e.g., a salt dome) or many kilometers in diameter.
 - (ii) (geomorphology) A landform that is a smoothly rounded rock mass such as a rock-capped mountain summit that roughly resembles a building dome. (e.g., the rounded granite peaks of Yosemite National Park, CA). GG
- (280) **double-bedding mound**.—Raised, linear mounds with subdued, convex slope cross-sections constructed by mounding and shaping spoil material dredged from adjacent drainage ditches and placed over natural soil. The mounds serve as preferred, better-drained bedding areas for managed timber plantations; common in the lower coastal plains of the Atlantic and Gulf coasts, United States. SW
- (281) **drainage basin**.—A general term for a region or area bounded by a drainage divide and occupied by a drainage system. GG
- (282) **drainage network**.—(not preferred) Refer to drainage pattern.
- (283) **drainage pattern**.—The configuration or arrangement, in plan view, of stream courses in an area, including gullies or first-order channelized flow areas, higher order tributaries, and main streams. Drainage pattern is related to local geologic materials and structure, geomorphologic features, and geomorphic history of an area. Major drainage pattern types include dendritic, trellis, artificial, etc. Also called drainage network. SW, GG, and WA
- (284) **drainageway**
- (i) A general term for a course or channel along which water moves in draining an area. GG

- (ii) [soil survey] a term restricted to relatively small, roughly linear or arcuate depressions that move concentrated water at some time, and either lack a defined channel (e.g., head slope, swale) or have a small, defined channel (e.g., low order streams). SW
- (285) **drainhead complex**.—An irregular series of low, broad depressions that form the uppermost reaches of surface drainage networks in low-relief and low-gradient terrain, such as coastal plains, and separated by slightly higher and drier areas (e.g., flatwoods). They characteristically lack defined stream channels but contribute surface water to the drainage system further downstream through a network of subtle topographic lows. SW
- (286) **draw**.—A small, natural watercourse cut in unconsolidated materials, generally more open with a broader floor and more gently sloping sides than an arroyo, ravine or gulch, and whose present stream channel may appear inadequate to have cut the drainageway that it occupies. SW
- (287) **dredged channel**.—A roughly linear, deep water area formed by a dredging operation for navigation purposes (after Wells et al., 1994; dredged hole). Compare – dredge-deposit shoal. SSS
- (288) **dredge-deposit shoal**.—A subaqueous area, substantially shallower than the surrounding area that resulted from the deposition of materials from dredging and dumping (modified from Demas 1998). Compare – dredged channel, shoal. SSS
- (289) **dredge spoils**.—Unconsolidated, randomly mixed sediments composed of rock, soil, and/or shell materials extracted and deposited during dredging and dumping activities. Dredge spoils lie unconformably upon natural, undisturbed soil or regolith and can form anthropogenic landforms (e.g., dredge spoil bank). SW
- (290) **dredge spoil bank**.—A subaerial mound or ridge that permanently stands above the water composed of dredge spoils; randomly mixed sediments deposited during dredging and dumping. Compare – dredged channel, dredge-deposit shoal, filled marshland. SW
- (291) **drift**.—[glacial geology] A general term applied to all mineral material (clay, silt, sand, gravel, boulders) transported by a glacier and deposited directly by or from the ice, or by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines, and stratified deposits that form outwash plains, eskers, kames, varves, and glaciofluvial sediments. The term is generally applied to Pleistocene glacial deposits in areas that no longer contain glaciers. GG
- (292) **dropstone**.—An oversized stone (compared to the matrix sediments) in laminated sediment that depresses the underlying laminae and can be covered by “draped laminae.” Most dropstones originate through ice-rafting; another source is floating tree roots. Compare – erratic, ice-rafting. GG
- (293) **drumlin**.—A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It usually has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longest axis is parallel to the general direction of glacier flow. Drumlins are products of streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition. Compare – drumlinoid ridge. SW, HP, and GG
- (294) **drumlin field**.—Groups or clusters of closely spaced drumlins or drumlinoid ridges, distributed more or less en echelon, and commonly separated by small, marshy tracts or depressions (interdrumlins). SW
- (295) **drumlinoid ridge**.—A rock drumlin or drift deposit whose form approaches but does not fully attain that of a classic drumlin, even though it seemingly results from similar processes of moving ice. Compare – drumlin, interdrumlin. SW and GG
- (296) **dry wash**.—(not preferred – refer to wash). A dry, ephemeral stream channel, especially in semiarid regions that only moves water in response to intense, infrequent precipitation. Compare – arroyo. SW

- (297) **dump**.—An area of smooth or uneven accumulations or piles of waste rock, earthy material, or general refuse that without major reclamation are incapable of supporting plants. Compare – fill, sanitary landfill. GSST
- (298) **dune**.—A low mound, ridge, bank or hill of loose, windblown, subaerially deposited granular material (generally sand), either barren and capable of movement from place to place, or covered and stabilized with vegetation, but retaining its characteristic shape. (See barchan dune, parabolic dune, parna dune, shrub-coppice dune, seif dune, transverse dune). SW and GG
- (299) **dune field**.—An assemblage of moving dunes, stabilized dunes, or both, together with sand plains, interdune areas, and the ponds, lakes, or swamps produced by the blocking of waterways by migrating dunes. See dune lake. Compare – coppice dune field. SW and SSS
- (300) **dune lake**
- (i) A lake occupying a deflation basin as in a blowout on a dune.
 - (ii) A lake occupying a basin formed by the blocking of a stream by sand dunes migrating along a shore (e.g., Moses Lake, WA). GG
- (301) **dune slack**.—A damp depression or trough between dunes in a dune field or dune ridges on a shore, caused by intersecting the capillary fringe of the local water table; a moist type of interdune. Compare – interdune, dune lake. SW and GG
- (302) **dune traces**.—A series of linear to semi-concentric micro-ridges and intervening troughs, on the floor of a dune slack or interdune that were exposed by deflation or dune migration. The ridges are remnant bases of slip face lamina held together by soil moisture, cemented by evaporates, or both. SW
- (303) **earth dike**.—(not preferred) Refer to levee.
- (304) **earth fall**.—see soil fall.
- (305) **earth hummock**.—A type of hummock consisting predominantly of a core of silty and clayey mineral soil and showing evidence of cryoturbation. Earth hummocks are a type of nonsorted circle. Compare – turf hummock, hummock [patterned ground], nonsorted circle, patterned ground. NRC
- (306) **earth pillar**.—A tall, conical column of unconsolidated to semi-consolidated earth materials (e.g., clay till, or landslide debris) produced by differential erosion and usually capped by a flat, hard rock fragment that shields the underlying, softer material from erosion. It can measure up to 6-20 m in height, and its diameter is a function of the width of the protective boulder. Compare – hoodoo. GG
- (307) **earth spread**.—The mass movement process, associated sediments (earth spread deposit), or resultant landform characterized by a very rapid type of *spread* dominated by lateral movement in a soil mass resulting from liquefaction or plastic flow of underlying materials that may be extruded out between intact units. Compare – debris spread, rock spread, landslide. SW and DV
- (308) **earth topple**.—The mass movement process, associated sediments (earth topple deposit), or resultant landform characterized by a localized, very rapid type of *topple* in which large blocks of soil material literally fall over, rotating outward over a low pivot point; sediments < 2 mm predominate. Portions of the original material may remain intact, although reoriented, within the resulting deposit. Compare – debris topple, rock topple, landslide. SW
- (309) **earthflow**.—The mass movement process, associated sediments (earthflow deposit), or resultant landform characterized by slow to rapid flow dominated by downslope movement of soil, rock, and mud (more than 50% of the particles are < 2 mm), and whether saturated or comparatively dry, behaves as a viscous fluid when moving. Compare – debris flow (coarser, less fluid), mudflow (finer, more fluid). SW
- (310) **elevation**.—[survey] The height of a point on the earth's surface relative to mean sea level (msl). Compare – relief. SW

- (311) **elevated lake plain**.—(not preferred) Refer to collapsed lake plain, collapsed ice-floored lakebed.
- (312) **elliptical gilgai**.—A type of gilgai dominated by elliptical, closed and semiclosed depressions (microlows) separated by low mounds or ridges (microhighs); the prevailing type of gilgai on mildly sloping terrain (slopes 3-8%); as slope increases, basins become more eccentric and the occurrence of interconnected micro-lows increases. Compare – circular gilgai, linear gilgai, gilgai. SW
- (313) **end moraine**.—A ridge-like accumulation that is being or was produced at the outer margin of an actively flowing glacier at any given time; a moraine that has been deposited at the outer or lower end of a valley glacier. Compare – terminal moraine, recessional moraine, ground moraine. GG
- (314) **Eocene**.—An epoch (from 35.4 to 56.5 million years ago) of the Tertiary Period of geologic time that follows the Paleocene and precedes the Oligocene epoch; also the corresponding (time-stratigraphic) “series” of earth materials. SW
- (315) **eolian**.—Pertaining to material transported and deposited (eolian deposit) by the wind. Includes clastic materials such as dune sands, sand sheets, loess deposits, and clay (e.g., parna). HP
- (316) **eolian deposit**.—[soil survey] Sand, silt or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess. Conventionally, primary volcanic deposits (e.g., tephra) are handled separately. Compare – loess, parna, beach sands. SW
- (317) **eolian sands**.—[soil survey] Sand-sized, clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sand sheet. Compare – beach sands. SW
- (318) **ephemeral lake**.—(not preferred) Compare – pluvial lake, pluvial lake [relict], playa lake, glacial lake, proglacial lake.
- (319) **ephemeral stream**.—Generally a small stream, or upper reach of a stream, that flows only in direct response to precipitation. It receives no protracted water supply from melting snow or other sources and its channel is above the water table at all times. Compare – arroyo, intermittent stream, perennial stream. HP
- (320) **epiclastic**.—(adjective) Pertaining to any clastic rock or sediment other than pyroclastic. Constituent fragments are derived by weathering and erosion rather than by direct volcanic processes. Compare – pyroclastic, volcanoclastic, clastic, detritus. HP
- (321) **eroded fan remnant**.—All, or a portion of an alluvial fan that is much more extensively eroded and dissected than a fan remnant; sometimes called an *erosional fan remnant* (FFP). It consists primarily of eroded and highly dissected sides (*eroded fan-remnant sideslopes*) dominated by hillslope positions (shoulder, backslope, etc.), and to a lesser extent an intact, relatively planar, relict alluvial fan “summit” area best described as a tread (e.g., < 50% of the original fan surface remains). SW and FFP
- (322) **eroded fan-remnant sideslope**.—A rough or broken margin of an *eroded fan remnant* highly dissected by ravines and gullies that can be just a fringe or make up a large part of an eroded alluvial fan; its bounding escarpments (risers), originally formed by inset channels, have become highly dissected and irregular such that terrace components (tread and riser) have been consumed or modified and replaced by hillslope positions and components (shoulder, backslope, footslope, etc.); sometimes referred to as *fan remnant sideslopes* (FFP). Compare – eroded fan remnant. SW and FFP
- (323) **erosion**.—The wearing away of the land surface by running water, waves, or moving ice and wind, or by such processes as mass wasting and corrosion (solution and other chemical processes). The term “geologic erosion” refers to natural erosion processes occurring over long (geologic) time spans. “Accelerated erosion” generically refers to erosion in excess of

- what is presumed or estimated to be naturally occurring levels, and which is a direct result of human activities (e.g., cultivation, logging, etc.). SW and HP
- (324) **erosional**.—[geomorphology] (adjective) Owing its origin, form, position or general character to degradational processes by water, wind, ice or gravity. Compare – constructional. HP
- (325) **erosional outlier**.—(not preferred) Refer to erosion remnant.
- (326) **erosional pavement**.—see erosion pavement.
- (327) **erosion pavement**.—A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion. Compare – desert pavement, stone line. SW, GSST, and GG
- (328) **erosion remnant**.—A topographic feature that remains or is left standing above the general land surface after erosion has reduced the surrounding area; e.g., a monadnock, a butte, or a stack. GG
- (329) **erosion surface**.—A land surface shaped by the action of erosion, especially by running water. GG
- (330) **erratic**.—A rock fragment carried by glacial ice, or by floating ice (ice-rafting), and subsequently deposited at some distance from the outcrop from which it was derived, and generally, though not necessarily, resting on bedrock or sediments of different lithology. Fragments range in size from a pebble to a house-size block. GG
- (331) **escarpment**.—A relatively continuous and steep slope or cliff produced by erosion or faulting and that topographically interrupts or breaks the general continuity of more gently sloping land surfaces. The term is most commonly applied to cliffs produced by differential erosion. Synonym: “scarp.” SW and HP
- (332) **esker**.—A long, narrow, sinuous and steep-sided ridge composed of irregularly stratified sand and gravel deposited as the bed of a stream flowing in an ice tunnel within or below the ice (subglacial) or between ice walls on top of the ice of a wasting glacier, and left behind as high ground when the ice melted. Eskers range in length from less than a kilometer to more than 160 kilometers, and in height from 3 to 30 meters. Compare – kame, crevasse filling, glaciofluvial deposits, outwash. SW
- (333) **estuarine deposit**.—Fine-grained sediments (very fine sand, silt and clay) of marine and fluvial origin commonly containing decomposed organic matter, laid down in the brackish waters of an estuary; characteristically finer sediments than deltaic deposits. Compare – fluviomarine deposit, lacustrine deposit, lagoonal deposit, marine deposit, overbank deposit. GG
- (334) **estuarine subaqueous soils**.—Soils that form in sediment found in shallow-subtidal environments in protected estuarine coves, bays, inlets, and lagoons. Excluded from the definition of these soils are any areas “permanently covered by water too deep (typically greater than 2.5 m) for the growth of rooted plants.” SSS
- (335) **estuarine tidal stream**.—A subaqueous, depositional landform composed of a clearly defined channel, creek, stream, river, or basin entering into “mainland coves” and surrounded on three sides by the mainland associated with the larger estuary. These areas are influenced by the ebb and flow of the tide, where freshwater from the upstream mainland areas flows seaward and contests with the saltwater flows that move landward. Sediments commonly contain sequestered woody swamp materials (e.g. stumps, etc.). PK, SW
- (336) **estuary**
- (i) A seaward end or the widened funnel-shaped tidal mouth of a river valley where fresh water comes into contact with seawater and where tidal effects are evident (e.g., a tidal river, or a partially enclosed coastal body of water where the tide meets the current of a stream).

- (ii) A portion of an ocean or an arm of the sea affected by fresh water.
- (iii) A drowned river mouth formed by the subsidence of land near the coast or by the drowning of the lower portion of a non-glacial valley due to the rise of sea level.
Compare – lagoon. GG
- (337) **everglades**.—(colloquial: southern United States) A large expanse of marshy land, covered mostly by grasses, e.g., the Florida Everglades. GG
- (338) **exfoliation**.—The process by which concentric scales, plates, or shells of rock, from less than a centimeter to several meters in thickness, are successively spalled or stripped from the bare surface of a large rock mass. It often results in a rounded rock mass or dome-shaped hill. GG
- (339) **exhumed**.—(adjective) Formerly buried landforms, geomorphic surfaces, or paleosols that have been reexposed by erosion of the covering mantle. Compare – relict, buried, ground soil. HP
- (340) **extramorainic**.—(not preferred) Refer to extramorainal.
- (341) **extramorainal**.—(adjective) Said of deposits and phenomena occurring outside the area occupied by a glacier and its lateral and end moraines. Compare – intramorainal. GG
- (342) **extrusive**.—(adjective) Said of igneous rocks and sediments derived from deep-seated, molten matter (magma), deposited and cooled on the earth's surface (e.g., including lava flows and tephra deposits). Compare – intrusive, volcanic. HP
- (343) **faceted spur**.—The inverted V-shaped end of a ridge that has been truncated or steeply beveled by stream erosion (e.g., meander scar or bluff), glacial truncation, or fault scarp displacement. Compare – spur. SW
- (344) **facies**.—[stratigraphy] A distinctive group of characteristics that distinguish one group from another within a stratigraphic unit; the sum of all primary lithologic and paleontological characteristics of sediments or sedimentary rock that are used to infer its origin and environment; the general nature of appearance of sediments or sedimentary rock produced under a given set of conditions; e.g., contrasting river-channel facies and overbank-flood plain facies in alluvial valley fills. HP
- (345) **fall**
 - (i) A category of mass movement processes, associated sediments (fall deposit), or resultant landforms (e.g., rockfall, debris fall, soil fall) characterized by very rapid movement of a mass of rock or earth that travels mostly through the air by free fall, leaping, bounding, or rolling, with little or no interaction between one moving unit and another. Compare – topple, slide, lateral spread, flow, complex landslide, landslide. SW and DV
 - (ii) The mass of material moved by a fall. GG
- (346) **falling dune**.—An accumulation of sand that is formed as sand is blown off a mesa top or over a cliff face or steep slope, forming a solid wall, sloping at the angle of repose of dry sand, or a fan extending downward from a reentrant in the mesa wall. Compare – climbing dune, sand ramp. GG
- (347) **Fall Line**.—(not recommended: obsolete) An imaginary line or narrow zone connecting the water falls on several adjacent or near-parallel rivers, marking the points where these rivers make a sudden descent from an upland to a lowland, as at the edge of a plateau; specifically, the Fall Line marking the boundaries between the ancient, resistant crystalline rocks of the Piedmont Plateau and the younger, softer sediments of the Atlantic Coastal Plain of the Eastern United States. It also marks the limit of navigability of the rivers. Now considered an archaic term because Coastal Plain materials occur several miles west or inland of the Fall Line and current research is showing it to be a broad zone of high-angle reverse faults. GG
- (348) **fan** [geomorphology]

- (i) A gently sloping, fan-shaped mass of detritus forming a section of a low-angle cone commonly at a place where there is a notable decrease in gradient; specifically an alluvial fan (not preferred – use alluvial fan). Compare – alluvial fan, alluvial cone.
- (ii) A fan-shaped mass of congealed lava that formed on a steep slope by the continually changing direction of flow. GG
- (349) **fan apron**.—A sheet-like mantle of relatively young alluvium and soils covering part of an older fan piedmont (and occasionally alluvial fan) surface, commonly thicker and further down slope (e.g., mid-fan or mid-fan piedmont) than a fan collar. It somewhere buries an older soil that can be traced to the edge of the fan apron where the older soil emerges as the land surface, or relict soil. No buried soils should occur within a fan apron mantle itself. Compare – fan collar. FFP
- (350) **fan collar**.—A landform comprised of a thin, short, relatively young mantle of alluvium along the very upper margin (near the proximal end or apex) of a major alluvial fan. The young mantle somewhere buries an older soil that can be traced to the edge of the collar where the older soil emerges at the land surface as a relict soil. Compare – fan apron. FFP
- (351) **fan piedmont**.—The most extensive landform on piedmont slopes, formed by the lateral, downslope, coalescence of mountain-front alluvial fans into one generally smooth slope with or without the transverse undulations of the semiconical alluvial fans, and accretion of fan aprons. Also recognized and used as a landscape term. Syn.: bajada. Compare – piedmont slope. FFP
- (352) **fan remnant**.—A general term for landforms that are the remaining parts of older, nonactive, fan-landforms, such as alluvial fans, fan aprons, inset fans, and fan skirts, that either have been dissected (erosional fan-remnants) or partially buried (nonburied fan-remnants). A fan remnant must retain a relatively flat summit that is a relict fan-surface (>50% intact). A nonburied fan-remnant is a relict surface in its entirety. Compare – eroded fan remnant, eroded fan remnant sideslope, ballena. FFP
- (353) **fan remnant sideslope**.—(not preferred) Refer to eroded fan-remnant sideslope.
- (354) **fan skirt**.—The zone of smooth, laterally-coalescing, small alluvial fans that issue from gullies cut into the fan piedmont of a basin or that are coalescing extensions of the inset fans of the fan piedmont, and that merge with the basin floor at their toeslopes. These are generally younger fans that onlap older fan surfaces. FFP
- (355) **fan terrace**.—(not recommended) Use fan remnant.
- (356) **fanglomerate**.—A sedimentary rock consisting of waterworn, heterogeneous fragments of all sizes, deposited in an alluvial fan and later cemented into a firm rock. GG
- (357) **fanhead trench**.—A linear depression formed by a drainageway that is incised considerably below the surface of an alluvial fan. GG
- (358) **fault**.—A discrete surface (fracture) or zone of discrete surfaces separating two rock masses across which one mass has slid past the other. GG
- (359) **fault block**.—A displaced crustal unit, formed during block faulting, that is bounded by faults, either completely or in part, and behaves as a coherent unit during tectonic activity. SW and GG
- (360) **fault line**.—The trace of a fault plane on the ground surface or on a reference plane. Compare – fault zone, fault-line scarp. GG
- (361) **fault zone**.—A fault that is expressed as a zone of numerous small fractures or of breccia or fault gouge. A fault zone may be as wide as hundreds of meters. Compare – fault, fault-line scarp. GG
- (362) **fault-block mountains**.—Mountains that formed primarily by block faulting, and commonly exhibit asymmetrical rotation and vertical displacement from a horizontal plane by large, coherent fault-block units hinged along fault lines; common in, but not limited to, the

Basin and Range region of the western United States. The term is not applied to mountains formed by thrust-faulting. SW and GG

(363) **fault-line scarp**

- (i) A steep slope or cliff formed by differential erosion along a fault line, as by the more rapid erosion of soft rock on the side of a fault as compared to that of more resistant rock on the other side (e.g., the eastern face of the Sierra Nevada in California).
- (ii) (not recommended) A fault scarp that has been modified by erosion. This usage is not recommended because the scarp is usually not located on the fault line. GG

(364) **felsenmeer**.—refer to block field. GG

(365) **felsic rock**.—A general term for igneous rock containing abundant, light-colored minerals (granite, etc); also applied to those minerals (quartz, feldspars, feldspathoids, muscovite) as a group. Compare – mafic rock. GG

(366) **fen**.—Waterlogged, spongy ground containing alkaline decaying vegetation, characterized by reeds, that develops into peat. It sometimes occurs in sinkholes of karst regions. Compare – bog, marsh, swamp. GG

(367) **fenster**.—see window.

(368) **fill** [engineering geology]

- (i) Human-constructed deposits of natural earth materials (e.g., soil, gravel, rock) and waste materials (e.g., tailings or spoil from dredging) Used to fill a depression, to extend shore land into a body of water, or in building dams.
- (ii) Soil or loose rock used to raise the surface level of low-lying land, such as an embankment to fill a hollow or ravine in roads construction. GG

(369) **filled marshland**.—A subaerial soil area composed of fill materials (construction debris, dredged or pumped sandy or shell-rich sediments, etc.) deposited and smoothed to provide building sites and associated uses (e.g., lawns, driveways, parking lots). These fill materials are typically 0.5 to 3 m thick and have been deposited unconformably over natural soils. Compare – dredge spoil bank. SW

(370) **finger ridge**.—One in a group of small, tertiary spur ridges that form crudely palmate extensions of erosional remnants along the flanks or nose of larger ridges. Compare – ballena, rib. SW

(371) **first bottom**.—(not recommended: colloquial: Midwestern United States – use flood plain step) An obsolete, informal term loosely applied to the lowest flood-plain steps that experience regular flooding. However, the frequency of flooding is inconsistently specified. SW

(372) **fissure vent**.—An opening in earth's surface of a volcanic conduit in the form of a crack or fissure rather than a localized crater; a roughly linear crack or area along which lava, generally mafic and of low viscosity, wells up to the surface, usually without any explosive activity. The results can be an extensive lava plateau (e.g., Columbia River Plateau). Compare – volcanic crater. SW and GG

(373) **fjord**.—A long, narrow, winding, glacially eroded, U-shaped and steep-walled, generally deep inlet or arm of the sea between high rocky cliffs of slopes along a mountainous coast. Typically it has a shallow sill or threshold of solid rock or earth material submerged near its mouth and becomes deeper far inland. A fjord usually represents the seaward end of a deep, glacially excavated valley that is partially submerged by drowning after melting of the ice. GG

(374) **flat** [geomorphology]

- (i) (adjective) Said of an area characterized by a continuous surface or stretch of land that is smooth, even, or horizontal, or nearly so, and that lacks any significant curvature, slope, elevations, or depressions.

- (ii) (noun) An informal, generic term for a level or nearly level surface or small area of land marked by little or no local relief. Compare – mud flat.
- (iii) (not recommended) A nearly level region that visibly displays less relief than its surroundings. GG
- (375) **flat** [lake]
 - (i) (not preferred) Refer to lakebed. The low-lying, exposed, flat land of a lake delta or of a lake bottom. Compare – lake plain.
 - (ii) (not preferred) The flat bottom of a desiccated lake in the arid parts of western United States. Compare – playa, pluvial lake. GG
- (376) **flatwoods**.—(colloquial: southeastern United States) Broad, low gradient (generally < 1% slope but up to 2% near drainageways), low relief interstream areas and characterized by nonhydric, poorly drained soils (seasonal saturation or water table) at depths of 15 to 45 cm, and naturally forested by pines that dominate the lower coastal plain of the southeastern U.S. Regional differences occur in dominant vegetation and soil material (e.g., in south Florida, soils are dominantly sandy Spodosols and the understory is dominantly saw palmetto). Hydopedologically and elevationally this landform occurs slightly above minor depressions (which have a seasonal water table at or above the surface), drainageways, and drainhead complexes, but lies below better drained and slightly higher small rises or knolls. Generally they are most extensive toward the interiors of low, broad interstream divides and away from drainageways. SW
- (377) **flood plain**.—The nearly level plain that borders a stream and is subject to inundation under flood-stage conditions unless protected artificially. It is usually a constructional landform built of sediment deposited during overflow and lateral migration of the streams. HP
- (378) **flood-plain landforms**.—A variety of constructional and erosional features produced by stream channel migration and flooding (e.g., backswamp, braided stream, flood-plain splay, meander, meander belt, meander scroll, oxbow lake, and natural levee). HP
- (379) **flood-plain playa**.—A landform consisting of very low gradient, broad, barren, axial-stream channel segments in an intermontane basin. It floods broadly and shallowly and is veneered with barren fine-textured sediment that crusts. Commonly, a flood-plain playa is segmented by transverse, narrow bands of vegetation, and it may alternate with ordinary narrow or braided channel segments. FFP
- (380) **flood-plain splay**.—A fan-shaped deposit or other outspread deposit formed where an overloaded stream breaks through a levee (natural or artificial) and deposits its material (often coarse-grained) on the flood plain. Compare – crevasse. GG
- (381) **flood-plain step**.—An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by flood water from the present stream (e.g., below the 100-year flood level); any approximately horizontal surface still actively modified by fluvial scour and/or deposition (i.e., cut and fill and/or scour and fill processes). May occur individually or as a series of steps. Compare – stream terrace. SW and RR
- (382) **flood-tidal delta**.—A largely subaqueous (sometimes intertidal), crudely fan-shaped deposit of sand-sized sediment formed on the landward side of a tidal inlet (modified from Boothroyd et al., 1985; Davis, 1994; Ritter et al., 1995). Flood tides transport sediment through the tidal inlet and into the lagoon over a flood ramp where currents slow and dissipate (Davis, 1994). Generally, flood-tidal deltas along microtidal coasts are multi-lobate and unaffected by ebbing currents (modified from Davis, 1994). Compare – flood-tidal delta slope. SSS
- (383) **flood-tidal delta flat**.—The relatively flat, dominant component of the flood-tidal delta. At extreme low tide this landform may be exposed for a relatively short period (modified from Boothroyd et al., 1985). SSS

- (384) **flood-tidal delta slope**.—An extension of the flood-tidal delta that slopes toward deeper water in a lagoon or estuary, composed of flood channels, inactive lobes (areas of the flood-tidal delta that are not actively accumulating sand as a result of flood tides), and parts of the terminal lobe of the flood-tidal delta (modified from Boothroyd et al., 1985). SSS
- (385) **floodwall**.—(not recommended) Use levee.
- (386) **floodway**
- (i) A large-capacity channel constructed to divert floodwaters or excess streamflow from populous, flood-prone areas, such as a bypass route bounded by levees.
 - (ii) The part of the flood plain kept clear of encumbrances and reserved for emergency diversion of floodwaters. GG
- (387) **floor** [geomorphology]
- (i) A general term for the nearly level, lower part of a basin or valley; (not preferred) Refer to basin floor, valley floor.
 - (ii) The bed of any body of water (e.g., the nearly level surface beneath the water of a stream, lake, or ocean). GG
- (388) **flow**.—A category of mass movement processes, associated sediments (flow deposit) and landforms characterized by slow to very rapid downslope movement of unconsolidated material which, whether saturated or comparatively dry, behaves much as a viscous fluid as it moves. Types of flows can be specified based on the dominant particle size of sediments (i.e., debris flow (e.g., lahar), earthflow (creep, mudflow), rockfall avalanche, debris avalanche). Compare – fall, topple, slide, lateral spread, complex landslide, landslide. SW and DV
- (389) **flow till**.—A till that may be either subglacial or supraglacial in origin. Flow till displays secondary transport, sorting, and/or fabric modification by plastic mass flow. Flow till exhibits weak stratification and sorting and may contain distorted layers indicative of lateral displacement and soft sediment deformation. The secondary flow processes obliterate most of the original fabric and clast orientations in the till. Compare – subglacial till, supraglacial till, lodgment till, melt-out till. SW and GG
- (390) **flute**.—[glacial] A lineation or streamlined furrow or ridge parallel to the direction of ice movement, formed in newly deposited till or older drift. They range in height from a few centimeters to 25 m, and in length from a few meters to 20 km. Compare – glacial groove. GG
- (391) **fluve**.—(refer to drainageway) A roughly linear or elongated depression (topographic low) of any size, along which water flows, at some time. Compare – interfluve. FFP and SW
- (392) **fluvial**.—(adjective) Of or pertaining to rivers or streams; produced by stream or river action. Compare – alluvial, colluvial. HP
- (393) **fluviokarst**.—A karst landscape dominated by both karst features (deranged and subsurface drainage, blind valleys, swallow holes, large springs, closed depressions, and caves), generally limited to low-lying interfluve areas, and surface drainage by large rivers, with associated fluvial features (adjacent stream terraces) and sediments (alluvium), that commonly maintain their surface courses and are fed by underground tributaries; the dominant karst in the eastern United States. Compare – sinkhole karst, pavement karst, glaciokarst, karst. SW, WW, and GG
- (394) **fluviomarine bottom**.—The nearly level or slightly undulating, relatively low-energy, depositional environment with relatively deep water (1.0 to >2.5 m) directly adjacent to an incoming stream and composed of interfingered and mixed fluvial and marine sediments (fluviomarine deposits). SSS
- (395) **fluviomarine deposit**.—Stratified materials (clay, silt, sand, or gravel) formed by both marine and fluvial processes, resulting from non-tidal sea level fluctuations, subsidence and/or stream migration (i.e., materials originally deposited in a nearshore environment and

- subsequently reworked by fluvial processes as sea level fell). Compare – estuarine deposit, lacustrine deposit, lagoonal deposit, marine deposit, overbank deposit. SW
- (396) **fluviomarine terrace**.—A constructional coastal strip, sloping gently seaward and/or down valley, veneered or completely composed of fluviomarine deposits (typically silt, sand, fine gravel). Compare – terrace, stream terrace, marine terrace. SW
- (397) **fly ash**.—All particulate matter that is carried in a gas stream, especially in stack gases at a coal-fired plant for the generation of electric power; also name given to sediments from the same source, stock piled in settling ponds or spoil piles. SW and GG
- (398) **fold**.—[structural geology] A curve or bend of a planar structure such as rock strata, bedding planes, foliation, or cleavage. GG
- (399) **fold-thrust hills**.—A landscape along an orogenic belt margin underlain dominantly by sedimentary rocks that have undergone intensive structural deformation through a series of subparallel thrust faults and associated folds. The thrust faults typically merge along a regional, subhorizontal displacement (decollement) at the basement contact. The land area displays considerable relief, characterized by cuestas, hogbacks, strike valleys, dip slopes, scarp slopes, and structurally-controlled hills; also known as an overthrust belt (e.g., the Wyoming overthrust belt). SW and GG
- (400) **foothills**.—A steeply sloping upland composed of hills with relief of 30 up to 300 meters and fringes a mountain range or high-plateau escarpment. Compare – hill, mountain, plateau. SW and HP
- (401) **footslope**.—The hillslope profile position that forms the concave surface at the base of a hillslope. It is a transition zone between upslope sites of erosion and transport (shoulder, backslope) and downslope sites of deposition (toeslope). Compare – summit, shoulder, backslope, and toeslope. SW
- (402) **foredune**.—A coastal dune or dune ridge oriented parallel to the shoreline, occurring at the landward margin of the beach, along the shoreward face of a beach ridge, or at the landward limit of the highest tide, and more or less stabilized by vegetation. GG
- (403) **formation**.—[stratigraphy] The basic lithostratigraphic unit in the local classification of rocks. A body of rock (commonly a sedimentary stratum or strata, but also igneous and metamorphic rocks) generally characterized by some degree of internal lithologic homogeneity or distinctive lithologic features (such as chemical composition, structures, textures, or general kind of fossils), by a prevailing (but not necessarily tabular) shape, and is mappable at the earth's surface (at scales of the order of 1:25,000) or traceable in the subsurface. Formation may be combined into Groups or subdivided into members. Compare – bed. HP
- (404) **fosse**.—[glacial geology] A long, narrow depression or trough-like hollow between the edge of a retreating glacier and the wall of its valley, or between the front of a moraine and its outwash plain. GG
- (405) **free face**.—The part of a hillside or mountainside consisting of an outcrop of bare rock (scarp or cliff) that sheds colluvium to slopes below and commonly stands more steeply than the angle of repose of the colluvial slope (e.g., talus slope) immediately below. SW and GG
- (406) **free face**.—[geomorphology] A geomorphic component of hills and mountains consisting of an outcrop of bare rock that sheds rock fragments and other sediments to, and commonly stands more steeply than the angle of repose of, the colluvial slope immediately below; most commonly found on shoulder and backslope positions, and can comprise part or all of a nose slope or side slope. Compare – interfluvial, crest, nose slope, side slope, head slope, base slope. SW
- (407) **freshwater marl**.—A soft, grayish to white, earthy or powdery, usually impure calcium carbonate precipitated on the bottoms of present-day freshwater lakes and ponds largely through the chemical action of algal mats and organic detritus, or forming deposits that

- underlie marshes, swamps, and bogs that occupy the sites of former (glacial) lakes. The calcium carbonate may range from 90% to less than 30%. Freshwater marl is usually gray; it has been used as a fertilizer for acid soils deficient in lime. Syn.: *bog lime*. Compare – marl, coastal marl. SW
- (408) **fringe-tidal marsh**.—Narrow salt marsh adjacent to a relatively higher energy environment. SSS
- (409) **frost boil**.—A small mound of fresh soil material formed by frost action. A type of nonsorted circle commonly found in fine-grained sediment underlain by permafrost, or formed in areas affected by seasonal frost. Compare – patterned ground. NRC
- (410) **frost bursting**.—(not recommended) Use frost shattering.
- (411) **frost churning**.—(not recommended) Use cryoturbation.
- (412) **frost polygons**.—(not recommended) Use (periglacial) patterned ground.
- (413) **frost riving**.—(not recommended) Use frost shattering.
- (414) **frost shattering**.—The mechanical disintegration, splitting, or breakup of a rock or soil caused by the pressure exerted by freezing water in cracks or pores, or along bedding planes. Sometimes referred to as congelifraction. GG
- (415) **frost splitting**.—(not recommended) Use frost shattering.
- (416) **frost stirring**.—(not recommended) Use cryoturbation.
- (417) **frost weathering**.—(not recommended) Use frost shattering.
- (418) **frost wedging**.—(not recommended) Use frost shattering.
- (419) **furrow**.—A linear or arcuate opening left in the soil after a plow or disk has opened a shallow channel at the soil surface. A shallow channel cut in the soil surface, usually between planted rows for controlling surface water and soil loss, or for conveying irrigation water. GSST
- (420) **gap**.—A sharp break or opening in a mountain ridge, or a short pass through a mountain range (e.g., a wind gap). GG
- (421) **gelifraction**.—(not recommended) Use frost shattering.
- (422) **gelivation**.—(not recommended) Use frost shattering.
- (423) **geomorphic component**.—A fundamental, three dimensional piece or area of a geomorphic setting (i.e., hills, mountains, terraces, flat plains) that has unique and prevailing kinetic energy dynamics and sediment transport conditions that result in their characteristic form, patterns of sedimentation and soil development. SW
- (424) **geomorphic component – flat plains**.—A group of fundamental, three dimensional pieces or areas of flat plains. In descending elevational order, the geomorphic components of a simple, flat plain (e.g., lake plain, low coastal plain, etc.) are the *rise* (a broad, slightly elevated area with comparatively greater gradients (e.g., 1-3% slopes)), and the *talf* (a comparatively level (e.g., 0-1% slopes), laterally extensive, nonfluvial area), and *dip* (a slight depression that is not a permanent water body nor part of an integrated drainage network). Compare – geomorphic component – terraces. SW
- (425) **geomorphic component – hills**.—A set of fundamental, three-dimensional areas and positions that geomorphically define a hill or ridge. In descending topographic order, the geomorphic components are *interfluv* (stable summit area); *crest* (unstable summit-converged shoulders); three geometric slope areas defined by plan shape and its influence on overland flow and throughflow: the *head slope* (convergent flow), *side slope* (parallel flow), and *nose slope* (divergent flow); *free face* (rock outcrop); and *base slope* (concave accretion area (colluvium/slope alluvium) at hill bottom). SW
- (426) **geomorphic component – mountains**.—A group of fundamental, three-dimensional pieces or areas of mountains. In descending elevational order, the geomorphic components of a simple mountain are the *mountaintop* (roughly analogous to the crest or summit); *mountainflank* (the long slope along the sides of mountains that can be further subdivided

- into three portions based on the relative slope location: *upper third-*, *middle third-*, or *lower third mountainflank*); *free face* (rock outcrop); and the *mountainbase* (colluvium/slope alluvium apron at the bottom of the mountain). SW
- (427) **geomorphic component – terraces, stepped landforms**.—A group of fundamental, three dimensional pieces or areas of terraces, flood-plain steps, and other stepped landforms (e.g., stacked lava flow units). In descending elevational order, the geomorphic components are the *tread* (the level to gently sloping, laterally extensive top of a terrace, flood-plain step, or other stepped landform); and the *riser* (the comparatively short escarpment forming the more steeply sloping edge that descends to another level or a channel). SW
- (428) **geomorphic surface**.—A mappable area of the earth's surface that has a common history; the area is of similar age and is formed by a set of processes during an episode of landscape evolution. A geomorphic surface can be erosional, constructional or both. The surface shape can be planar, concave, convex, or any combination of these. Compare – constructional, erosional. RR
- (429) **geomorphology**.—The science that treats the general configuration of the earth's surface; specifically the study of the classification, description, nature, origin, and development of landforms and their relationships to underlying structures, and of the history of geologic changes as recorded by these surface features. The term is especially applied to the genetic interpretation of landforms. GG
- (430) **geyser**.—A type of hot spring that intermittently erupts jets of hot water and steam, the result of ground water coming in contact with rock or steam hot enough to create steam under conditions preventing free circulation; a type of intermittent spring. Compare – mud pot, hot spring. GG
- (431) **geyser basin**.—A valley that contains numerous springs, geysers, and steam fissures fed by the same ground-water flow. GG
- (432) **geyser cone**.—A low hill or mound built up of siliceous sinter around the orifice of a geyser. GG
- (433) **giant ripple**.—A ripple that is more than 30 m in length; e.g., the jokulhlaup derived giant ripples in Camas Prairie, MT; it usually exhibits superimposed megaripples. Compare – ripple mark. GG
- (434) **gilgai**.—A microfeature pattern of soils composed of a succession of microbasins and microknolls on level areas, or of microtroughs and microridges parallel to the slope on sloping areas, and produced by expansion-contraction and shear-thrust processes with changes in soil moisture. Found in soils containing large amounts of smectite clay minerals that swell and shrink considerably with wetting and drying. Various types of gilgai can be recognized based on the dominant shape of microhighs and microlows: circular gilgai, elliptical gilgai, and linear gilgai. Also referred to, in part or in total, as crabhole, Bay of Biscay, or hushabye in older literature. SW and GSST
- (435) **glacial** (adjective)
- (i) Of or relating to the presence and activities of ice and glaciers, as in glacial erosion.
 - (ii) Pertaining to distinctive features and materials produced by or derived from glaciers and ice sheets, as in glacial lakes.
 - (iii) Pertaining to an ice age or region of glaciation. GG
- (436) **glacial drainage channel**.—A channel formed by an ice-marginal, englacial, or subglacial stream during glaciation. GG
- (437) **glacial drift**.—(not recommended) Use drift.
- (438) **glacial groove**.—A deep, wide, usually straight furrow cut in bedrock by the abrasive action of a rock fragment embedded in the bottom of a moving glacier; it is larger and deeper than a glacial striation, ranging in size from a deep scratch to a small glacial valley. Compare – flute. GG

(439) **glacial lake**

- (i) A lake that derives much or all of its water from the melting of glacier ice, fed by meltwater, and lying outside the glacier margins (e.g., proglacial lake) or lying on a glacier (e.g., ice-walled lake, ice-floored lake) and due to differential melting.
- (ii) A lake occupying a basin produced by glacial deposition, such as one held in by a morainal dam.
- (iii) A lake occupying a basin produced in bedrock by glacial erosion (scouring, quarrying) (e.g., cirque lake, fjord).
- (iv) A lake occupying a basin produced by collapse of outwash material surrounding masses of stagnant ice.
- (v) [relict] An area formerly occupied by a glacial lake. GG

(440) **glacial-marine sedimentation**.—The accumulation of glacially eroded, terrestrially derived sediment in the marine environment. Sediment may be introduced by fluvial transport, by ice rafting, as an ice-contact deposit, or by eolian transport. Compare – glaciomarine deposits. GG

(441) **glacial outwash**.—(not recommended) Use outwash.

(442) **glacial till**.—(not recommended: use till). Till should only be used for describing glacial sediments, therefore “glacial till” is redundant. GM

(443) **glacial-valley floor**.—The comparatively flat bottom of a mountain valley predominantly mantled by till but that can grade from glacial scour (scoured rock outcrop) near its head to a thick mantle of till, and ultimately merging with alluvium or colluvium further down valley. Some glacial-valley floors descend downstream in a series of scour-derived steps that may contain sequential tarn lakes (*pater noster lakes*); (not preferred: colloquial: western United States) sometimes called a trough bottom. SW

(444) **glacial-valley wall**.—The comparatively steep, glacially scoured, concave sides of a u-shaped, mountain valley mantled by colluvium with little or no till; (not preferred: colloquial: western United States) sometimes called a trough wall. SW

(445) **glaciation**.—The formation, movement and recession of glaciers or ice sheets. A collective term for the geologic processes of glacial activity, including erosion and deposition, and the resulting effects of such action on the earth's surface. GG

(446) **glacier**

- (i) A large mass of ice formed, at least in part, on land by the compaction and recrystallization of snow, moving slowly by creep downslope or outward in all directions due to the stress of its own weight, and surviving from year to year. Included are small mountain glaciers as well as ice sheets continental in size, and ice shelves that float on the ocean but are fed in part by ice formed on land.
- (ii) A stream-like landform having the appearance of, or moving like a glacier (e.g., a rock glacier). Compare – snowfield, rock glacier. GG

(447) **glacier outburst flood**.—A sudden, often annual, release of meltwater from a glacier or glacier-dammed lake sometimes resulting in a catastrophic flood, formed by melting of a drainage channel or buoyant lifting of ice by water or by subglacial volcanic activity; also called jokulhaup. Compare – scabland, giant ripple. GG

(448) **glaciofluvial deposit**.—Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and may occur in the form of outwash plains, valley trains, deltas, kames, eskers, and kame terraces. Compare – drift and outwash. HP

(449) **glaciokarst**.—Karst in glaciated terrain developed on bedrock susceptible to dissolution (e.g., limestone), thinly mantled (e.g., < 5-30 m) with drift and characterized by surficial, closed depressions formed by postglacial, subsurface karstic collapse (e.g., sinkholes) rather

- than by glacial processes (e.g., ice-block meltout); common in IN, MI. Compare – karst. SW and GG
- (450) **glaciolacustrine deposit**.—Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes by water originating mainly from the melting of glacial ice. Many are bedded or laminated with varves or rhythmites. HP
- (451) **glaciomarine deposit**.—Glacially eroded, terrestrially derived sediments (clay, silt, sand, and gravel) that accumulated on the ocean floor. Sediments may be accumulated as an ice-contact deposit, by fluvial transport, ice-rafting, or eolian transport. GG and GM
- (452) **glade** (colloquial: Ozark uplands, United States)
- (i) A largely treeless, open, grassy area (e.g., oak savanna) on high, broad interfluves and hillsides, commonly with shallow soils. Compare – park. SW
 - (ii) (not preferred) Refer to park: An ecological term for a grassy, open depression or small valley as in a high meadow; sometimes marshy and forming the headwaters of a stream, or a low, grassy marsh that is periodically inundated. GG and SW
- (453) **glauconite pellets**.—Silt to sand-sized, nodular aggregates with a characteristic greenish color, dominantly composed of the clay mineral glauconite; formed in near-shore marine sediments and subsequently exposed by a drop in sea level or rise of a land mass, as on a coastal plain. Glauconite pellets have a high potassium content and higher CEC and moisture retention compared to other mineral sands. Compare – greensands. SW
- (454) **gorge**
- (i) A narrow, deep valley with nearly vertical, rocky walls, smaller than a canyon, and more steep-sided than a ravine; especially a restricted, steep-walled part of a canyon.
 - (ii) A narrow defile or passage between hills or mountains. GG
- (456) **graben**.—An elongate trough or basin bounded on both sides by high-angle, normal faults that dip towards the interior of the trough. It is a structural form that may or may not be geomorphically expressed as a rift valley. Compare – horst, half graben. GG
- (457) **granitoid**
- (i) In the IUGS (International Union of Geological Sciences) classification, a preliminary term (for field use) for a plutonic rock with Q (quartz) between 20 and 60 (%).
 - (ii) A general term for all phaneritic igneous rocks (*mineral crystals visible unaided and all about the same size*) dominated by quartz and feldspars. SW and GG
- (458) **Grady pond**.—see Carolina Bay.
- (459) **grassy organic materials**.—see organic materials.
- (460) **gravel pit**.—A depression, ditch or pit excavated to furnish gravel for roads or other construction purposes; a type of borrow pit. SW
- (461) **greensands**
- (i) An unconsolidated, near-shore marine sediment containing substantial amounts of dark greenish glauconite pellets, often mingled with clay or sand (quartz may form the dominant constituent); prominent in Cretaceous and Tertiary coastal plain strata of New Jersey, Delaware and Maryland; has been commercially mined for potassium fertilizer. The term is loosely applied to any glauconitic sediment.
 - (ii) (not preferred – use glauconitic sandstone) A sandstone consisting of greensand that is commonly poorly cemented, and has a greenish color when unweathered but an orange or yellow color when weathered. Compare – glauconite pellets. SW
- (462) **grike**.—(not preferred) Refer to cutter.
- (463) **groove**.—A small, natural, narrow drainageway on high angle slopes that separate tertiary spur ridges or mini-interfluves and is a constituent part of *rib and groove topography*; common in well dissected uplands. Compare – rib. SW
- (464) **ground moraine**

- (i) Commonly an extensive, low relief area of till, having an uneven or undulating surface, and commonly bounded on the distal end by a recessional or end moraine.
- (ii) A layer of poorly sorted rock and mineral debris (till) dragged along, in, on, or beneath a glacier and deposited by processes including basal lodgment and release from downwasting stagnant ice by ablation. Compare – end moraine, recessional, moraine, terminal moraine. SW
- (465) **ground soil**.—A generic name for any soil at the present-day land surface and actively undergoing pedogenesis, regardless of its history (i.e., relict, exhumed). Compare – buried soil. SW and RR
- (466) **grus**.—The fragmental products of in situ granular disintegration of granite and granitic rocks, dominated by inter-crystal disintegration. Compare – saprolite. SW and GG
- (467) **gulch**.—(colloquial: western United States; not preferred – refer to ravine) A small stream channel, narrow and steep-sided in cross section, and larger than a gully, cut in unconsolidated materials. General synonym – ravine. Compare – arroyo, draw, gully, wash. HP
- (468) **gulf**.—A relatively large part of an ocean or sea extending far into the land, partly enclosed by an extensive sweep of the coast, and opened to the sea through a strait (e.g., Gulf of Mexico); the largest of various forms of inlets of the sea. It is usually larger, more enclosed, and more deeply indented than a bay. Compare – bay. GG
- (469) **gully**.—A small channel with steep sides caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water usually during and immediately following heavy rains or ice and snow melt. A gully generally **is** an obstacle to wheeled vehicles and too deep (e.g., > 0.5 m) to be obliterated by ordinary tillage; (a rill is of lesser depth and can be smoothed over by ordinary tillage). Compare – rill, ravine, arroyo, swale, draw. HP and GSST
- (470) **gut [channel]**.—A tidal stream connecting two larger waterways within a lagoon, estuary, or bay. SW and GG
- (471) **gut [valley]**.—(colloquial: U.S. Virgin Islands, Caribbean Basin) A gully, ravine, small valley, or narrow passage on land.
- (472) **gypsite**.—An earthy gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) variety that contains various quantities (i.e., < 50%) of soil material, silicate clay minerals, and sometimes other salts (e.g., NaCl); found only in arid or semiarid regions as secondary precipitation concentrations or efflorescence associated with rock gypsum or gypsum-bearing strata. Compare – rock gypsum, rock anhydrite. SW and GG
- (473) **half graben**.—An elongate, structural trough or basin bounded on one side by a normal fault. It may or may not produce a topographic basin. Compare – graben. GG
- (474) **hanging valley**.—A tributary valley whose floor at the lower end is notably higher than the floor of the main valley in the area of junction. GG
- (475) **head [geomorphology]**
 - (i) The source, beginning, or upper part of a stream.
 - (ii) The upper part or end of a slope or valley. GG
- (476) **headland [coast]**
 - (i) An irregularity of land, especially of considerable height with a steep cliff face, jutting out from the coast into a large body of water (usually the sea or a lake); a bold promontory or a high cape.
 - (ii) The high ground flanking a body of water, such as a cove.
 - (iii) The steep crag or cliff face of a promontory. GG
- (477) **head-of-outwash**.—A sloping and sometimes high relief landform composed predominantly of glaciofluvial sediment that delimits a former ice-margin of a relatively static, rapidly wasting glacier. A steep *ice-contact slope* forms the ice-proximal face of the

- landform; a more gently sloping surface dips away on the distal slope, if not slumped.
Compare – ice-margin complex. SW
- (478) **head slope**.—[geomorphology] A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway, resulting in converging overland water flow (e.g., sheet wash); head slopes are dominated by colluvium and slope wash sediments (e.g., slope alluvium); contour lines form concave curves. Slope complexity (downslope shape) can range from simple to complex. Headslopes are comparatively moister portions of hillslopes and tend to accumulate sediments (e.g., soils with over-thickened, dark epipedons) where they are not directly contributing materials to channel flow. Compare – side slope, nose slope, free face, interfluvium, crest, base slope. SW
- (479) **headwall**.—A steep slope at the head of a valley (e.g., the rock cliff at the back of a cirque). Compare – cirque headwall. GG
- (480) **headwall**.—[anthropogenic] A sheer slope or cliff face at the head of an excavation; e.g., the rock cliff at the active face of a mine, pit, or quarry, from which material has been extracted; also called a highwall. SW and ICOMANTH
- (481) **herbaceous organic materials**.—see organic materials.
- (482) **herbaceous peat**.—An accumulation of organic material, decomposed to some degree that is predominantly the remains of sedges, reeds, cattails and other herbaceous plants. Compare – moss peat, sedimentary peat, woody peat, peat, muck, and mucky peat. SSM
- (483) **high-center polygon**.—A polygon whose center is raised relative to its boundary. Compare – low-center polygon. NRC
- (484) **high hill**.—A generic name for an elevated, generally rounded land surface with high local relief, rising between 90 meters (approx. 300 ft.) to as much as 300 m (approx. 1000 ft.) above surrounding lowlands. Compare – low hill, hill, hillock. SW
- (485) **highmoor bog**.—A bog, often on the uplands, whose surface is covered by sphagnum mosses that, because of their high degree of water retention, make the bog more dependent upon precipitation than on the water table. The bog often occurs as a raised peat bog or blanket bog. Compare – lowmoor bog, raised bog. GG
- (486) **highwall**.—see headwall – [anthropogenic].
- (487) **hill**.—A generic term for an elevated area of the land surface, rising at least 30 m (100 ft.) to as much as 300 meters (approx. 1000 ft.) above surrounding lowlands, usually with a nominal summit area relative to bounding slopes, a well-defined, rounded outline and slopes that generally exceed 15 percent. A hill can occur as a single, isolated mass or in a group. A hill can be further specified based on the magnitude of local relief: *low hill* (30 – 90 m) or *high hill* (90-300 m). Informal distinctions between a hill and a mountain are often arbitrary and dependent on local convention. Compare – hillock, plateau, mountain, foothills, hills. SW and HP
- (488) **hillock**.—A generic name for a small, low hill, generally between 3 – 30 m in height and slopes between 5 and 50 percent (e.g., bigger than a mound but smaller than a hill); commonly considered a microfeature. Compare – mound, hill. SW
- (489) **hills**.—A landscape dominated by hills and associated valleys. SW
- (490) **hillside**.—(not recommended) Use hillslope.
- (491) **hillslope**.—A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of the hill. Compare – mountain slope. HP
- (492) **hillslope-profile position**.—Discrete slope segments found along a transect line that runs perpendicular to the contour, beginning at a divide and descending to a lower, bounding stream channel or valley floor; a discrete piece of a two-dimensional cross profile of a hill. Positions are commonly separated from one another by inflection points along the line. In descending elevational order, the hillslope-profile positions of a simple hillslope include

- summit, shoulder, backslope, footslope, and toeslope. Not all of these segments (positions) are necessarily present along a particular hillslope. Complex hillslopes include multiple sequences or partial sequences, or partial sequences. Compare – geomorphic components – hills. SW, HP, and RR
- (493) **hillslope terrace**.—[anthropogenic] A raised, generally horizontal strip of earth and/or rock bounded by a down-slope berm or retaining wall, constructed along a contour on a hillslope to make land suitable for tillage and to prevent accelerated erosion; common in steep terrain, both archaic (e.g., Peru) and modern (e.g., Nepal). Compare – conservation terrace, rice paddy. SW and GSST
- (494) **hillslope terrace anthroscape**.—A human-modified “landscape” dominated by permanent alterations to the physical shape and/or internal stratigraphy of the land (i.e. complexes of large berms or walls and artificial terraces on sloping land), due to management for food or fiber production that have substantively altered water flow and sediment transport across or within the regolith; a type of agricultural anthroscape. Commonly excludes areas of minor alterations (e.g. low berms, shallow troughs or furrows) that are easily obscured or obliterated by natural bio-, pedo-, or cryoturbation. Compare –urban anthroscape, suburban anthroscape. SW
- (495) **hilltop**.—(not recommended) Use summit.
- (496) **hogback**.—A sharp-crested, symmetric ridge formed by highly tilted resistant rock layers; a type of homocline produced by differential erosion of interlayered resistant and weak rocks with dips greater than about 25° (or approximately > 45% slopes). Compare – homoclinal ridge, cuesta. SW and HP
- (497) **Holocene**.—The epoch of the Quaternary Period of geologic time following the Pleistocene Epoch (from the present to about 10 to 12 thousand years ago); also corresponding (time-stratigraphic) “series” of earth materials. SW
- (498) **homoclinal**.—[structural geomorphology] (adjective) Pertaining to strata that dip in one direction with a uniform angle. Compare – cuesta, hogback, homoclinal ridge. HP
- (499) **homoclinal ridge**.—A homocline that forms an asymmetric ridge with a dip slope commonly between 10 to 25° (15 to 45%). A homoclinal ridge has steeper dip than a cuesta, but lower dip than a hogback. Compare – cuesta, hogback. SW and RF
- (500) **homocline**.—A general term for a series of rock strata that dip in one direction with a uniform angle (e.g., one limb of a fold, a tilted fault block, or an isocline). Compare – cuesta, homoclinal ridge, hogback. GG
- (501) **hoodoo**.—A bizarrely shaped column, pinnacle, or pillar of rock produced by differential weathering or erosion in a region of sporadically heavy rainfall. Formation is facilitated by joints and layers of varying hardness. Compare – earth pillar. GG
- (502) **horn**.—[glacial geology] A high, rocky, sharp pointed, steep-sided, mountain peak with prominent faces and ridges, bounded by the intersecting walls of three or more cirques that have been cut back into the mountain by headward erosion of glaciers. GG
- (503) **horst**.—An elongate block that is bounded on both sides by normal faults that dip away from the interior of the horst. It is a structural form and may or may not be expressed geomorphically. GG
- (504) **hot spring**.—A natural, geothermally heated spring whose temperature is above that of the human body. Compare – geyser, mud pot. GG
- (505) **human artifact**.—(not preferred) see artifact.
- (506) **human-transported material**.—Organic or mineral soil material (or any other material that can function as a soil material) that has been moved horizontally onto a pedon from a source area outside of that pedon by directed human activity, usually with the aid of machinery. There has been little or no subsequent reworking by wind, gravity, water, or ice. Human-transported materials are most commonly associated with building sites, mining or

- dredging operations, sanitary landfills, or other similar activities that result in the formation of a constructional anthropogenic landform. ICOMANTH
- (507) **hummock** [geomorphology]
 (i) (not preferred – see hillock). An imprecise, general term for a rounded or conical mound or other small elevation.
 (ii) (not preferred, see hummock [patterned ground]) A slight rise of ground above a level surface. GG
- (508) **hummock**.—[patterned ground] A small, irregular knob of earth (earth hummock) or turf (turf hummock). Neither type of hummock is diagnostic of permafrost, but both are most common in subpolar or alpine regions. Both require vegetative cover. GG
- (509) **ice age**.—(not recommended) Use Pleistocene.
- (510) **ice pressure ridge**.—A rugged, irregular wall of broken floating ice buckled upward by the lateral pressure of wind or current forcing or squeezing one floe against another, or against a shore; it may extend for kilometers in length and up to 30 m in height. Along shores they are lower (< 10 m tall) and contribute to the temporary or permanent formation of a beach berm or a rim of boulders and stones. SW and GG
- (511) **ice-contact slope**.—A steep escarpment of predominantly glaciofluvial sediment that was deposited against a wall of glacier ice, marking the position of a relatively static ice-margin; an irregular scarp against which glacier ice once rested. Compare – head-of-outwash. SW and GG
- (512) **ice-margin complex**.—An assemblage of landforms constructed proximal to a relatively static, rapidly wasting continental glacial margin. Constituent landforms can include fosse, head-of-outwash, ice-contact slope, ice-contact delta, kame, kame moraine, kettle, outwash fan, small outwash plain, glacial sluiceway, and small proglacial lake. Moraines, if present, are of limited occurrence (except kame moraines that can be extensive). Glaciofluvial sediments dominate but glaciolacustrine sediments, till, and diamictons can be present in minor amounts. SW
- (513) **ice-marginal stream**.—A stream drainage along the side or front of a glacier. Relict ice-marginal streams are used to trace the former position of a glacier; also called ice-marginal drainage. SW and GG
- (514) **ice-pushed ridge**.—An asymmetrical ridge of local, essentially non-glacial material (such as deformed bedrock, with some drift incorporated in it) that has been pressed up by the shearing action of an advancing glacier. It is typically 10-60 m high, about 150-300 m wide, and as much as 5 km long. Examples are common on the Great Plains where such ridges occur on the sides of escarpments formed of relatively incompetent rocks that face the direction from which the ice moved. GG
- (515) **ice-rafting**.—The transportation of rock fragments of all sizes on or within icebergs, ice floes, or other forms of floating ice. Compare – dropstone, erratic. GG
- (516) **ice segregation**.—The formation of ice by the migration of pore water to the frozen fringe where it forms into discrete layers or lenses. It commonly ranges in thickness from hairline to more than 10 m and often occurs in alternating layers of ice and soil. NRC
- (517) **ice wedge**.—A massive, generally wedge-shaped body with its apex pointing downward, composed of foliated or vertically banded, commonly white, ice. NRC
- (518) **ice wedge cast**.—A filling of sediment in the space formerly occupied by an ice wedge. NRC
- (519) **ice wedge polygon**.—Patterned ground in areas of ice wedges. These polygons are commonly in poorly drained areas and may be high-centered or low-centered. NRC
- (520) **igneous rock**.—Rock formed by cooling and solidification from magma, and that has not been changed appreciably by weathering since its formation; major varieties include plutonic

- (i.e., intrusive) and volcanic (i.e., extrusive) rocks. Examples: andesite, basalt, granite.
Compare – intrusive, extrusive, metamorphic rock. GSST and HP
- (521) **inlet**.—A short, narrow waterway connecting a bay, lagoon, or similar body of water.
Compare – tidal inlet. GG
- (522) **impact crater**
(i) [anthropogenic] A generally circular or elliptical depression formed by hypervelocity impact of an experimental projectile or ordinance into earthy or rock material. Compare – caldera, crater, meteorite crater. SW
(ii) (not recommended: use meteorite crater) A generally circular crater formed by the impact of an interplanetary body (projectile) on a planetary surface. GG
- (523) **inselberg**.—A prominent, isolated, residual knob, hill, or small mountain, usually smoothed and rounded, rising abruptly from an extensive lowland erosion surface in a hot dry region; generally bare and rocky although the lower slopes are commonly buried by colluvium. Compare – monadnock, nunatak. GG
- (524) **inset fan**.—(colloquial: southwestern United States) The flood plain of an ephemeral stream that is confined between the fan remnants, ballenas, basin-floor remnants, or closely opposed fan toeslopes of a basin. FF and SW
- (525) **integrated drainage**.—A general term for a drainage pattern in which stream systems have developed to the point where all parts of the landscape drain into some part of a stream system, the initial or original surfaces have essentially disappeared and the region drains to a common base level. Few or no closed drainage systems are present. SW
- (526) **interbedded**.—Said of beds lying between or alternating with others of different character; especially said of rock material or sediments laid down in sequence between other beds, such as “interbedded” sands and gravels. GG
- (527) **interdrumlin**.—The concave to relatively flat bottomed, roughly linear depressions ranging from small saddles or swales to small valleys that separate drumlins or drumlinoid ridges in drumlin fields. Streams, if present, have not had a dominant impact on the formation of the depression. Compare – drumlin, drumlinoid ridge. SW
- (528) **interdrumlin swale**.—see interdrumlin
- (529) **interdune**.—The relatively flat surface, whether sand-free or sand-covered, between dunes. GG
- (530) **interdune valley**.—A broad interdune area consisting of a low-lying, relatively flat surface commonly found between very large dunes, and that lies in close proximity to the local groundwater table (if present). SW
- (531) **interfluv**.—A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways. Compare – divide. GG and FFP
- (532) **interfluv**.—[geomorphology] A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloped area of a hill; shoulders of backwearing hillslopes can narrow the upland (e.g., ridge) or merge (e.g., crest, saddle) resulting in a strongly convex shape. Compare – crest, side slope, head slope, nose slope, free face, base slope. SW
- (533) **interfurrow**.—A low, commonly linear or arcuate ridge of soil mounded between furrows by a plow or other farm equipment and serves as a slightly elevated bedding area for planted crops; also called row, tillage row, tillage ridge, tillage mound. Interfurrows range from narrow and peaked (tillage ridge) to broad and flat-topped; size and shape depends upon how the elevated areas are made and the crop grown. Compare – furrow. SW
- (534) **interior valley**.—A large, flat-floored closed depression in a karst area whose drainage is ultimately subsurface and its floor is commonly covered by alluvium. Some interior valleys

- may become ephemeral lakes during periods of heavy rainfall, when sinking streams that drain them cannot manage the runoff; also called *polje* (not preferred). Compare – karst valley, sinkhole. GG
- (535) **intermediate position [gilgai]**.—The subsurface location and morphology of the nearly level, transitional area (microslope) between an upwelling morphology (chimney) under a slightly elevated microhigh (i.e., microknoll; *mound* in Russia) and the bowl morphology under an adjacent microlow (i.e., microbasin, microtrough; *depression* in Russia) in gilgai or other patterned ground. It can make up a majority of the ground surface area in gilgai. Compare – chimney, bowl, microslope, gilgai. SW
- (536) **intermittent stream**.—A stream, or reach of a stream, that does not flow year-round (commonly dry for 3 or more months out of 12) and whose channel is generally below the local water table; it flows **only when** it receives base flow (i.e., solely during wet periods) or ground-water discharge or protracted contributions from melting snow or other erratic surface and shallow subsurface sources. Compare – ephemeral stream. HP
- (537) **intermontane basin**.—A generic term for wide structural depressions between mountain ranges that are partly filled with alluvium and called “valleys” in the vernacular. Intermontane basins may be drained internally (bolsons) or externally (semi-bolson). FFP
- (538) **interstream divide**
- (i) (not preferred) A synonym for divide.
 - (ii) (colloquial: esp. southeastern United States). *Broad* interstream divide – A wide, relatively level area between incised drainageways; a broad, nearly level “summit” or interfluve. Compare – broad interstream divide, interfluve. SW
- (539) **intertidal**.—(adjective) The coastal environment between mean low tide and mean high tide that alternates between subaerial and subaqueous depending on the tidal cycle. Compare – subtidal. SSS
- (540) **intramorainal**.—Said of deposits and phenomena occurring within a lobate curve of a moraine (e.g., within the area occupied by a glacier). Compare – extramorainal. GG
- (541) **intrusive**.—Denoting igneous rocks derived from molten matter (magmas) that invaded preexisting rocks and cooled below the surface of the earth. Compare – extrusive. HP
- (542) **island**
- (i) An area of land completely surrounded by water. Compare – barrier island, coral island.
 - (ii) An elevated area of land surrounded by swamp, or marsh, or isolated at high water or during floods. Compare – barrier island. GG
- (543) **joint**.—[geology] A surface of actual or potential fracture or parting in a rock, without displacement; the surface is usually planar and often occurs with parallel joints to form part of a joint set. HP
- (544) **jökulhlaup**.—An Icelandic term for a glacial outburst flood, especially when an ice dam impounding a glacial lake breaks. Such breaks drained glacial Lake Missoula and created the Channeled Scablands in the Pacific Northwest. (Pronounced: yo-kool-loup, the last syllable as in “out.”) Compare – glacier outburst flood, scabland, giant ripple. SW and GG
- (545) **kame**.—A low mound, knob, hummock, or short irregular ridge, composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier; by a supraglacial stream in a low place or hole on the surface of the glacier; or as a ponded deposit on the surface or at the margin of stagnant ice. Compare – crevasse filling, kame moraine, kame terrace, esker, outwash. GG
- (546) **kame moraine**
- (i) An end moraine that contains numerous kames.
 - (ii) A group of kames along the front of a stagnant glacier, commonly comprising the slumped or erosional remnants of a formerly continuous outwash plain built up over the foot of rapidly wasting or stagnant ice. GG

- (547) **kame terrace**.—A terrace-like ridge or bench consisting of stratified sand and gravel deposited by a meltwater stream flowing between a melting glacier and a higher valley wall or lateral moraine, and left standing after the disappearance of the ice. It is commonly pitted with “kettles” and has an irregular ice-contact slope. HP
- (548) **karren**.—Repeating, surficial solution channels, grooves or other forms etched onto massive, bare limestone surfaces; types range in depth from a few millimeters to > 1 m and separated by ridges; the total complex (all varieties) of surficial solution forms found on compact, pure limestone. Many types can be specified. Compare – solution fissure. SW and GG
- (549) **karst**.—A kind of topography formed in limestone, gypsum, or other soluble rocks by dissolution, and that is characterized by closed depressions, sinkholes, caves, and underground drainage. Various types of karst can be recognized depending upon the dominant surface features: karst dominated by closed depressions (*sinkhole karst* – temperate climates; *cockpit karst* – humid tropical climates), closed depressions and large rivers (*fluviokarst*), bare rock dominated by dissolution joints (*pavement karst*), tropical cone-, tower- or domed-hills (*kegel karst*), or karst thinly mantled with glacial drift (*glaciokarst*), etc. SW and WW
- (550) **karst cone**.—A conically-shaped residual hill in karst with a rounded top and relatively steep, convex (e.g., parabolic) side slopes, commonly in tropical climates. Compare – karst tower, mogote. SW and WW
- (551) **karst drainage pattern**.—A drainage pattern that lacks an integrated drainage system associated with soluble rocks with little or no surface drainage but a considerable underground, internal drainage system; characteristic of karst landscapes underlain by limestone, gypsum, or salt. SW
- (552) **karstic**.—(adjective) Having the attributes of karst. SW and GG
- (553) **karstic marine terrace**.—A relict, wave-cut terrace or solution platform formed across soluble bedrock (e.g., limestone), and subsequently subaerially weathered by solution resulting in prominent karst features (e.g., sinkholes, karst valleys, solution pipes, etc.); a type of marine terrace, extensive across the Florida peninsula. Dunefields and sand sheets of reworked coastal or fluviomarine sands are common capping materials. SW
- (554) **karst lake**.—A large area of standing water in an extensive closed depression in soluble bedrock (e.g., limestone) and commonly is directly connected to and controlled by the subsurface karst drainage network. SW and GG
- (555) **karstland**.—(not preferred – use karst) A landscape dominated by dissolution features (e.g., sinkhole, blind valley, closed depressions, underground drainage) formed in soluble rocks. SW and GG
- (556) **karst tower**.—An isolated, separate hill or ridge in a karst region consisting of an erosional remnant of limestone or other sedimentary rocks with vertical or near-vertical, convex side slopes and commonly surrounded by an alluvial plain, lagoon, or deep rugged ravines. Compare – karst cone, mogote. SW
- (557) **karst valley**.—A closed depression formed by the coalescence of multiple sinkholes; an elongate, solutional valley. Its drainage is subsurface, diameters range from several hundred meters to a few kilometers, and it usually has a scalloped margin inherited from the sinkholes. It may have nominal, local channel flow (small streams), sequential sinkhole inlets (springs) and outlets (swallow hole, etc.); also called compound sinkhole (not preferred), uvala (not preferred). Compare – sinkhole, interior valley. SW and GG
- (558) **kegel karst**.—A general name used to describe several types of humid tropical karst landscapes characterized by numerous, closely spaced cone- (cone karst), hemispherical- (halbkugelkarst), or tower-shaped (tower karst) hills with vertical or near-vertical walls and

- having intervening closed depressions and narrow steep-walled karst valleys or passageways.
Compare – cockpit karst. GG and SW
- (559) **kettle**.—A steep-sided, bowl-shaped depression commonly without surface drainage (closed depression) in drift deposits, often containing a lake or swamp, and formed by the melting of a large, detached block of stagnant ice that had been wholly or partly buried in the drift. Kettles range in depth from 1 to tens of meters, and with diameters up to 13 km.
Compare – pothole. GG
- (560) **kipuka**.—A low “island” of land surrounded by a younger (more recent) lava flow.
Compare – steptoe. MA
- (561) **kluftkarren**.—(not preferred) Refer to solution fissure.
- (562) **knickpoint**
- (i) A point of abrupt inflection in the longitudinal profile of a stream or of its valley (e.g., a waterfall); it marks the maximum headward erosion of a new erosion cycle that grades to a new, lower base level.
 - (ii) Any interruption or break in slope. SW
- (563) **knob**
- (i) A rounded eminence, a small hill or mountain; especially a prominent or isolated hill with steep sides, commonly found in the Southern United States.
 - (ii) A peak or other projection from the top of a hill or mountain. Also, a boulder or group of boulders or an area of resistant rocks protruding from the side of a hill or mountain.
Compare – stack [geom.]. GG
- (564) **knoll**.—A small, low, rounded hill rising above adjacent landforms. HP
- (565) **lacustrine deposit**.—Clastic sediments and chemical precipitates deposited in lakes. HP
- (566) **lagoon**.—A shallow stretch of salt or brackish water, partly or completely separated from a sea or lake by an offshore reef, barrier island, sandbank or spit. GG87
- (567) **lagoon [relict]**.—A nearly level, filled trough or depression behind the longshore bar on a barrier beach and built by a receding pluvial or glacial lake. Compare – sewage lagoon, pluvial lake. SW and FFP
- (568) **lagoon bottom**.—The nearly level or slightly undulating central portion of a submerged, low-energy, depositional estuarine basin (McGinn, 1982) characterized by relatively deep water (1.0 to >2.5 m). Compare – bay bottom. SSS
- (569) **lagoon channel**.—A subaqueous, sinuous area within a lagoon that likely represents a relict channel (paleochannel) (Wells et al., 1994) that is maintained by strong currents during tidal cycles. SSS
- (570) **lagoonal deposit**.—Sand, silt or clay-sized sediments transported and deposited by wind, currents, and storm washover in the relatively low-energy, brackish to saline, shallow waters of a lagoon. Compare – estuarine deposit, fluviomarine deposit, marine deposit. SSS
- (571) **lahar**.—The landform and sediments (i.e., lahar deposit) emplaced by, and the process associated with, a mudflow composed mainly of volcanoclastic debris on or near the flank of a volcano. Sediment composition includes pyroclastic material, primary lava-flow blocks and fragments, and nonvolcanic material. Thick lahar deposits may have crude (poorly sorted) upward-fining strata. A lahar is initially unconsolidated material, but through cementation and compression can become bedrock. Compare – mudflow, andesitic lahar deposit, lahar deposit. SW and GG
- (572) **lahar deposit**.—Unconsolidated volcanoclastic material emplaced as mudflows on or near the flanks of a volcano. SW
- (573) **lake**.—[water] An inland body of permanently standing water fresh or saline, occupying a depression on the earth’s surface, generally of appreciable size (larger than a pond) and too deep to permit vegetation (excluding subaqueous vegetation) to take root completely across the expanse of water. GG

- (574) **lake plain**.—A nearly level surface marking the floor of an extinct lake filled by well-sorted, generally fine-textured, stratified deposits, commonly containing varves. GG
- (575) **lake terrace**.—A narrow shelf, partly cut and partly built, produced along a lake shore in front of a scarp line of low cliffs and later exposed when the water level falls. GG
- (576) **lakebed**.—The bottom of a lake; a lake basin. GG
- (577) **lakebed [relict]**.—The flat to gently undulating, exposed ground underlain or composed of fine-grained sediments deposited in a former lake. GG
- (578) **lakeshore**.—The narrow strip of land in contact with or bordering a lake; especially the beach of a lake. GG
- (579) **lamella**
- (i) [soil] A thin (< 7.5 cm thick), discontinuous or continuous, generally horizontal layer of fine material (especially clay and iron oxides) that has been pedogenically concentrated (illuviated) within a coarser (e.g., sandy), eluviated layer (several centimeters to several decimeters thick). Compare – lamina. SW and ST
 - (ii) [mineralogy] A thin scale, leaf, lamina, or layer, e.g., one of the units of a polysynthetically twinned mineral, such as plagioclase. GG
- (580) **lamina**.—(noun) The thinnest recognizable layer (commonly < 1 cm thick) of original deposition in a sediment or sedimentary rock, differing from other layers in color, composition, or particle size. Plural=laminae; Several laminae constitute a bed. Compare – lamella. GG
- (581) **lamination**.—(not recommended) see lamina.
- (582) **landfill**.—(see sanitary landfill). Compare – dump.
- (583) **landform**.—Any physical, recognizable form or feature on the earth's surface, having a characteristic shape, internal composition, and produced by natural causes; a distinct individual produced by a set of processes. Landforms can span a large size (e.g., *dune* encompasses a number of feature including *parabolic dune*, which is tens-of-meters across and *seif dune*, which can be up to a 100 kilometers across. Landforms provide an empirical description of the earth's surface features. SW and GG
- (584) **landscape** .—[soils] A broad or unique land area comprised of an assemblage or collection of landforms that define a general geomorphic form or setting (e.g., mountain range, lake plain, lava plateau, or loess hill) Landforms within a landscape are spatially associated, but may vary in formation processes and age. SW and GSST
- (585) **landslide**.—A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials, caused by gravitational forces and that may or may not involve saturated materials. Names of landslide types generally reflect the dominant process, the resultant landform, or both. The main operational categories of mass movement are *fall* (rockfall, debris fall, soil fall), *topple* (rock topple, debris topple, soil topple), *slide* (rotational landslide, block glide, debris slide, lateral spread), *flow* (rockfall avalanche, debris avalanche, debris flow (e.g., lahar), earthflow, (creep, mudflow)), and *complex landslides*. Compare – solifluction. SW and DV
- (586) **land-surface form**.—The description of a given terrain unit based on empirical analysis of the land surface rather than interpretation of genetic factors. Surface form may be expressed quantitatively in terms of vertical and planimetric slope-class distribution, local and absolute relief, and patterns of terrain features such as interfluvial crests, drainage lines, or escarpments. HP
- (587) **lapilli**.—Nonvesicular or slightly vesicular pyroclastics, 2.0 to 76 mm in at least one dimension, with an apparent specific gravity of 2.0 or more g/cm³. Compare – ash, volcanic block, cinders, tephra. KST

- (588) **lateral moraine**.—A ridge-like moraine carried on and deposited at the side margin of a valley glacier. It is composed chiefly of rock fragments derived from valley walls by glacial abrasion and plucking, or colluvial accumulation from adjacent slopes. GG
- (589) **lateral spread**.—A category of mass movement processes, associated sediments (lateral spread deposit), or resultant landform characterized by a very rapid *spread* dominated by lateral movement in a soil or fractured rock mass resulting from liquefaction or plastic flow of underlying materials; also called spread. Types of lateral spreads can be specified based on the dominant particle size of sediments (i.e., debris spread, earth spread, rock spread). Compare – fall, topple, slide, flow, complex landslide, landslide. SW, DV, and GG
- (590) **lava**.—A general term for a molten extrusive, also the rock solidified from it. Compare – aa lava, block lava, pahoehoe lava, pillow lava. GG
- (591) **lava channel**.—see lava trench.
- (592) **lava dome**.—A rounded or irregular mound, hill or small mountain composed of lava congealed over a volcanic vent on the flanks or within a crater or caldera. Typically composed of silica-rich volcanic rocks (e.g., rhyolite, dacite) with admixtures of obsidian, agglomerate, volcanic breccia, etc. The lava may be uniform or varied in color and texture; also called a resurgent dome. SW, HS, and GG
- (593) **lava field**.—An area covered primarily by lava flows whose terrain can be rough and broken or relatively smooth; it can include vent structures (e.g., small cinder cones, spatter cones, etc.), surface flow structures (e.g., pressure ridges, tumuli, etc.) and small, intermittent areas covered with pyroclastics. Compare – lava plain, volcanic field. SW
- (594) **lava flow**.—A solidified body of rock formed from the lateral, surficial outpouring of molten lava from a vent or fissure, often lobate in form. Compare – aa lava flow, lava flow unit, pahoehoe lava flow. GG
- (595) **lava flow unit**.—A separate, distinct lobe of lava that issues from the main body of a lava flow; a specific outpouring of lava, a few centimeters to several meters thick and of variable lateral extent that forms a subdivision within a single flow. A series of overlapping lava flow-units together comprise a single lava flow. Also called flow unit. Compare – lava flow. GS and GG
- (596) **lava plain**.—A broad area of nearly level land, that can be localized but is commonly hundreds of square kilometers in extent, covered by a relatively thin succession of primarily basaltic lava flows resulting from fissure eruptions. Compare – lava plateau, lava field, volcanic field. SW and GG
- (597) **lava plateau**.—A broad elevated tableland or flat-topped highland that may be localized but commonly is many hundreds or thousands of square kilometers in extent, underlain by a thick succession of basaltic lava flows resulting from fissure eruptions (e.g., Columbia River Plateau). Compare – lava plain, lava field. GG
- (598) **lava trench**.—A natural surface channel in a lava flow that never had a roof, formed by the surficial draining of molten lava rather than by erosion from running water; also called lava channel. Compare – mawae, lava tube. SW
- (599) **lava tube**.—A natural, hollow tunnel beneath the surface of a solidified lava flow through which the lava flow was fed; the tunnel was left empty when the molten lava drained out. MA and GG
- (600) **ledge**
- (i) A narrow shelf or projection of rock, much longer than wide, formed on a rock wall or cliff face, as along a coast by differential wave action on softer rocks; erosion is by combined biological and chemical weathering.
 - (ii) A rocky outcrop; solid rock.
 - (iii) A shelf-like quarry exposure or natural rock outcrop. Compare – structural bench. GG

- (601) **lee**.—(adjective) Said of a side or slope that faces away from an advancing glacier or ice sheet, and facing the downstream (“down-ice”) side of a glacier and relatively protected from its abrasive action. Compare – stoss, stoss and lee, crag and tail. GG
- (602) **levee**.—An artificial or natural embankment built along the margin of a watercourse or an arm of the sea, to protect land from inundation or to confine streamflow to its channel. Compare – artificial levee, natural levee. GG
- (603) **leveled land**.—A land area, usually a field, that has been mechanically flattened or smoothed to facilitate management practices such as flood irrigation; as a result the natural soil has been partially or completely modified (e.g., truncated or buried). SW
- (604) **limestone**.—A sedimentary rock consisting chiefly (more than 50 percent) of calcium carbonate, primarily in the form of calcite. Limestones are usually formed by a combination of organic and inorganic processes and include chemical and clastic (soluble and insoluble) constituents; many contain fossils. HP
- (605) **limestone pavement**.—(not preferred) Refer to pavement karst.
- (606) **limonite**.—A general “field” term for various brown to yellowish brown, amorphous- to cryptocrystalline hydrous ferric oxides that are an undetermined mixture of goethite, hematite, and lepidocrocite formed by weathering and iron oxidation from iron-bearing rocks and minerals. SW and GG
- (607) **linear gilgai**.—A type of gilgai dominated by parallel troughs (microlows) separated by low ridges (microhighs) and oriented perpendicular to the topographic contour (i.e., up and down slopes); the prevailing type of gilgai on sloping terrain (slopes > 8%). Compare – circular gilgai, elliptical gilgai, gilgai. SW
- (608) **lithification**.—The conversion of unconsolidated sediment into a coherent and solid rock, involving processes such as cementation, compaction, desiccation, crystallization, recrystallization, and compression. It may occur concurrently with, shortly after, or long after deposition. HP
- (609) **lithologic**.—(adjective) Pertaining to the physical character of a rock. HP
- (610) **local relief**
- (i) An informal term referring to the prevailing difference in elevation between drainageways or local depressions and adjacent elevated landforms (on a local scale). Compare – relief, microrelief. SW
 - (ii) A generic term referring to the collective, relative differences in elevation of a land surface on a broad scale. SSM
- (611) **lodgment till**.—A subglacial till deposited by an active glacier (flowing ice) commonly characterized by dense, fissile (“platy”) structure and containing rock fragments with their long axes oriented generally parallel to the direction of ice flow. Local bedrock generally dominates the rock fragment composition and fragments exhibit striations or facets. Compare – till, supraglacial till, flow till, melt-out till. SW and GG
- (612) **loess**.—Material transported and deposited by wind and consisting predominantly of silt-size particles. Commonly a loess deposit thins and the mean-particle size decreases as distance from the source area increases. Loess sources are dominantly from either glacial meltwaters (i.e., “cold loess”) or from non-glacial, arid environments, such as deserts (i.e., “hot loess”). [soil survey] Several types of loess deposits can be recognized based on mineralogical composition (calcareous loess, noncalcareous loess). SW and GSST
- (613) **loess bluff**.—A bluff composed of a thick deposit of coarse loess, formed immediately adjacent to the edges of flood plains, as along the Mississippi River valley or China. Sometimes referred to as a bluff formation (not preferred). SW and GG
- (614) **loess hill**.—A hill composed of thick deposits of loess, as in IA, MO, NE and the Palouse Hills of WA and ID. SW

- (615) **log landing**.—A comparatively level area, usually with road access, constructed or cut into steeper slopes and used for sorting logs during timber harvest operations. Compare – skid trail. SW
- (616) **longitudinal dune**.—A long, narrow sand dune, usually symmetrical in cross profile, oriented parallel to the prevailing wind direction; it is wider and steeper on the windward side but tapers to a point on the lee side. It commonly forms behind an obstacle in an area where sand is abundant and the wind is strong and constant. Such dunes can be a few meters high and up to 100 km long. Compare – seif dune, transverse dune. GG
- (617) **long run-out landslide**.—(not recommended) Use rockfall avalanche.
- (618) **longshore bar**.—A low, elongate sand ridge, built chiefly by wave action, occurring at some distance from, and extending generally parallel with, the shoreline. They are submerged at least by high tides and are typically separated from the beach by an intervening trough. GG
- (619) **longshore bar [relict]**.—A narrow, elongate, wave-built sand ridge that originally rose near to, or barely above, the surface of a body of water, and extended generally parallel to the shore but was separated from it by an intervening trough. SW and GG
- (620) **louderback**.—A hill or ridge composed of a lava flow remnant that caps or is exposed in a tilted fault block and bounded by a dip slope; Used as evidence of block faulting in the Basin and Range physiographic province (western United States). Compare – hogback. GG
- (621) **low-center polygon**.—A polygon whose center is depressed relative to its boundary. Compare – high-center polygon. NRC
- (622) **low hill**.—A generic name for an elevated, generally rounded land surface with low local relief, rising between 30 m (100 ft.) to as much as 90 m (approx. 300 ft.) above surrounding lowlands. Compare – high hill, hill, hillock. SW
- (623) **lowland**
- (i) An informal, generic, imprecise term for low-lying land or an extensive region of low-lying land, especially near a coast and including the extended plains or country lying not far above tide level.
 - (ii) (not preferred) A generic, imprecise term for a landscape of low, comparatively level ground of a region or local area, in contrast with the adjacent higher country.
 - (iii) (not recommended: use valley, bolson, etc.) A generic term for a large valley. Compare – upland. SW
- (624) **low marsh**.—(not preferred – refer to mud flat) The flat, usually bare ground situated seaward of a salt marsh and regularly covered and uncovered by the tide; e.g., a mud flat. GG
- (625) **lowmoor bog**.—A bog that is at or only slightly above the water table, on which it depends for accumulation and preservation of peat (chiefly the remains of sedges, reeds, shrubs, and various mosses). Compare – highmoor bog, raised bog. GG
- (626) **maar**.—A low relief, broad volcanic crater formed by multiple, shallow explosive eruptions. It is surrounded by a crater ring in the form of low ramparts of gently dipping (i.e., < 25 degrees), well-bedded tephra; may be partially or completely filled by water (*maar lake*). SW and GG
- (627) **mafic rock**.—A general term for igneous rock composed chiefly of one or more ferromagnesian, dark-colored minerals; also said of those minerals. Compare – felsic rock. GG
- (628) **main scarp**.—The steep surface on undisturbed ground at the upper edge of a landslide, caused by movement of displaced material away from the undisturbed ground; it is visible a part of the surface of rupture (slip surface). Compare – minor scarp, toe. CV and SW

- (629) **mainland cove**.—A subaqueous area adjacent to the mainland or a submerged mainland beach that forms a minor recess or embayment within the larger basin. Compare – cove, barrier cove. SSS
- (630) **mangrove swamp**.—A tropical or subtropical marine swamp formed in a silty, organic, or occasionally a coralline substratum and characterized by abundant mangrove trees along the seashore in a low area of salty or brackish water affected by daily tidal fluctuation but protected from violent wave action by reefs or land; dominated by saturated soils, commonly Fluvaquents formed in marl. SW and GG
- (631) **marine deposit**.—Sediments (predominantly sands, silts and clays) of marine origin; laid down in the waters of an ocean. Compare – estuarine deposit, lagoonal deposit. SW
- (632) **marine lake**.—[water] An inland body of permanently standing brackish or saline water, occupying a depression on the earth's surface whose water level is commonly influenced by ocean tides through subterranean cavities connecting to nearby lagoons; generally of appreciable size (larger than a pond) and too deep to permit emergent vegetation to take root completely across the expanse of water. Such water bodies can have unique biota (e.g., stingless jellyfish of Palau). SW
- (633) **marine terrace**.—A constructional coastal strip, sloping gently seaward, veneered by marine deposits (typically silt, sand, fine gravel). Compare – terrace, wave-built terrace. GG
- (634) **marl**.—A generic term loosely applied to a variety of materials, most of which occur as an earthy, unconsolidated deposit consisting chiefly of an intimate mixture of clay and calcium carbonate formed commonly by the chemical action of algae mats and organic detritus (periphyton); specifically an earthy substance containing 35 to 65 percent clay and 65 to 35 percent calcium carbonate mud; formed primarily under freshwater lacustrine conditions, but varieties associated with more saline environments and higher carbonate contents also occur. Compare – coastal marl, freshwater marl. SW and HP
- (635) **marsh**.—Periodically wet or continually flooded areas with the surface not deeply submerged. Covered dominantly with sedges, cattails, rushes, or other hydrophytic plants. Compare – salt marsh, swamp, bog, fen. GSST
- (636) **mass movement**.—A generic term for any process or sediments (mass movement deposit) resulting from the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress. The process includes slow displacements such as creep and solifluction, and rapid movements such as landslides, rock slides, and falls, earthflows, debris flows, and avalanches. Agents of fluid transport (water, ice, air) may play an important, if subordinate role in the process. HP
- (637) **mass-movement till**.—(not preferred) Refer to till.
- (638) **mass wasting**.—(not preferred) Refer to mass movement.
- (639) **mawae**.—(colloquial: Hawaii) A natural surface channel commonly found near the middle of an aa lava flow, formed by the surficial draining of molten lava rather than by erosion from running water; a type of lava trench. Compare – lava tube. MA
- (640) **meander**.—[streams] One of a series of regular freely developing sinuous curves, bends, loops, turns, or windings in the course of a stream. GG
- (641) **meander belt**.—The zone within which migration of a meandering channel occurs; the flood plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops. Landform components of the meander-belt surface are produced by a combination of gradual (lateral and down-valley) migration of meander loops and avulsive channel shifts causing abrupt cut-offs of loop segments. Landforms flanking the sinuous stream channel include: point bars, abandoned meanders, meander scrolls, oxbow lakes, natural levees, and flood-plain splays. Meander belts may not exhibit prominent natural levee or splay forms. Flood plains of broad valleys may contain one or more abandoned meander belts in addition to the zone flanking the active stream channel. HP

(642) **meander scar**

- (i) A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream that impinged upon and undercut the bluff; if it's no longer adjacent to the modern stream channel, it indicates an abandoned route of the stream. SW.
- (ii) (not recommended: refer to oxbow) An abandoned meander, commonly filled in by deposition and vegetation, but still discernable. GG

(643) **meander scroll**

- (i) One of a series of long, parallel, close fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank. Compare – meander belt, point bar.
- (ii) (not recommended: use oxbow lake) A small, elongate lake on a flood plain in a well-defined part of an abandoned stream channel. GG

(644) **meandering channel**.—The term “meandering” should be restricted to loops with channel length more than 1.5 to 2 times the meander wave length. Meandering stream channels commonly have cross sections with low width-to-depth ratios, cohesive (fine-grained) bank materials, and low gradient. At a given bank-full discharge, meandering streams have gentler slopes, and deeper narrower, and more stable channel cross sections than braided streams. Compare – meander, braided stream, flood-plain landforms. HP and RR

(645) **medial moraine**

- (i) An elongate moraine carried in or upon the middle of a glacier and parallel to its sides, usually formed by the merging of adjacent and inner lateral moraines below the junction of two coalescing valley glaciers.
- (ii) A moraine formed by glacial abrasion of a rocky protuberance near the middle of a glacier and whose debris appears at the glacier surface in the ablation area.
- (iii) The irregular ridge left behind in the middle of a glacial valley, when the glacier on which it was formed has disappeared. GG

(646) **melt-out till**.—A till that may be either subglacial or supraglacial in origin. Melt-out till forms by slow melting of debris-rich stagnant ice, but without secondary flow processes. The fabric and clast orientations, imparted by ice processes, remain mostly intact. Compare – subglacial till, supraglacial till, flow till, lodgment till. GG

(647) **mesa**.—An isolated, flat-topped landform that stands distinctly above the adjacent land area, is bounded by steep slopes or cliffs, and is generally capped by erosion-resistant, nearly horizontal rock (often lava). Mesas and buttes have similar forms and isolated occurrence. A mesa has a summit area broader than the bounding cliff height. Mesas are most common in arid and semiarid regions, but are not climatically restricted. Compare – butte, plateau, cuesta. HP and GG

(648) **metamorphic rock**.—Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth's crust.

Nearly all such rocks are crystalline. Examples: schist, gneiss, quartzite, slate, marble. HP

(649) **metasediment**.—A sediment or sedimentary rock that shows evidence of having been subjected to metamorphism. GG

(650) **metastable slope**.—(not recommended: obsolete) A slope that is relatively stable at the present time, but may become active if the environmental balance is disturbed, for instance, by road construction or destruction of vegetation. A metastable slope is often related to base levels of former geomorphic episodes. The regolith is generally moderately deep, may contain stone lines or relict evidence of slope alluvium. Slope gradients usually range from 15 to 45 percent. Compare – active slope. HP

(651) **meteorite crater**.—An impact crater formed by the falling of a large meteorite onto the earth's surface (e.g., Barringer Crater (AZ)). Compare – crater, impact crater. SW and GG

- (652) **microbiotic crust**.—A thin, surface layer (crust) of soil particles bound together primarily by living organisms and their organic byproducts; thickness can range up from < 1 cm up to 10 cm; aerial coverage of the ground surface can range from 10 to 100 percent. Crusts stabilize loose earthy material. Other types of surface crusts include chemical crusts (e.g., salt crusts) and physical crusts (e.g., raindrop-impact crust). SW and SS
- (653) **microdepression**.—(not preferred) Refer to microlow.
- (654) **microfeature**.—[soil survey] Small, local, natural forms (features) on the land surface that are too small to delineate on a topographic or soils map at commonly used map scales (e.g., 1:24,000 to 1:10,000). They are readily identifiable at ground level and typically have substantial impact on local soil geography, local hydrology, and ecological microsites. Examples include earth pillar, patterned ground, frost boil. Compare – microrelief. SW
- (655) **microhigh**.—A generic microrelief term applied to slightly elevated areas relative to the adjacent ground surface; differences in relief range from several centimeters to several meters. Cross-sectional profiles can be simple or complex and generally consist of gently rounded, convex tops with gently sloping sides; also spelled *micro-high*. SW
- (656) **microknoll**.—(not preferred) Refer to microhigh.
- (657) **microlow**.—A generic microrelief term applied to slightly lower areas relative to the adjacent ground surface (e.g., shallow depression); differences in relief range from several centimeters to several meters. Cross-sectional profiles can be simple or complex and generally consist of subdued, concave, open or closed depressions with gently sloping sides; also spelled *micro-low*. SW
- (658) **microrelief**
- (i) [soil survey] Slight variations in the height of a land surface that are too small or intricate to delineate on a topographic or soils map at commonly used map scales (e.g., 1:24,000 through 1:10,000). Examples include microhigh, microslope, and microlow. Compare – microfeature. SW
 - (ii) (not preferred – refer to microfeature) Generically refers to local, slight irregularities in form and height of a land surface that are superimposed upon a larger landform, including such features as low mounds, swales, and shallow pits. GG
- (659) **microslope**.—A generic microrelief term applied to areas of nominal surface relief (slightly sloping to level), relative to the adjacent ground surface; differences in overall local relief range from several centimeters to several meters. Cross-sectional profiles can be simple or complex and generally consist of low and gently rounded, convex tops (microhigh), gently sloping to level sides (microslope), and depressional low areas (microlow). Microslopes commonly constitute the majority of the land surface area in gilgai and other settings with microrelief. SW
- (660) **midden**.—A mound or stratum of refuse (broken pots, ashes, food remains, etc.) normally found on the site of an ancient settlement. GG
- (661) **mima mound**.—A term used for one of numerous low circular or oval domes composed of loose, unstratified, gravelly, silty, or sandy material. The basal diameter varies from 3 meters to more than 30 meters, and the height from 30 centimeters to about 2 meters. Compare – pimple mound, patterned ground, shrub-coppice dune. GG
- (662) **mine spoil, coal extraction**.—Randomly mixed, earthy materials artificially deposited as a result of either surficial or underground coal mining activities; a type of mine spoil. SW
- (663) **mine spoil, metal-ore extraction**.—Randomly mixed, earthy materials artificially deposited as a result of either surficial or underground metal-ore mining activities; a type of mine spoil. SW
- (664) **mine spoil or earthy fill**.—[soil survey] An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. SW and GSST

- (665) **minor scarp**.—A steep surface on the displaced material of a landslide, produced by differential movements within the sliding mass. Compare – main scarp, toe. CV
- (666) **Miocene**.—An epoch of the Tertiary Period of geologic time (approximately 5.2 to 23 million years ago) that immediately follows the Oligocene and precedes the Pliocene Epoch; also the corresponding (time-stratigraphic) “series” of earth materials. HP
- (667) **mogote**.—(colloquial: Caribbean Basin) An isolated, steep-sided, commonly asymmetrical hill or ridge composed of limestone, generally steeper on its leeward side (prevailing downwind side) and surrounded by nearly level to sloping coastal plain composed of marine and alluvial sediments; a type of karst tower. They range in height from a few feet (< 1 m) to over 150 ft (50 m). Most are isolated and cover small areas but some form clusters of hills or ridges rising out of the surrounding blanket deposits. Mogotes are extensive in northern Puerto Rico. SW, Monroe (1976, 1980), and WW
- (668) **monadnock**.—An isolated hill or mountain of resistant rock rising conspicuously above the general level of a lower erosion surface in a temperate climate representing an isolated remnant of a former erosion cycle in an area that has largely been beveled to its base level. Compare – inselberg, nunatak. GG
- (669) **monocline**
- (i) [landform] A unit of folded strata that dips from the horizontal in one direction only, is not part of an anticline or syncline, and occurs at the earth’s surface. This structure is typically present in plateau areas where nearly flat strata locally assume steep dips caused by differential vertical movements without faulting. Compare – anticline, syncline, fold. SW and HP
 - (ii) [structural geology]– A local steepening in an otherwise uniform gentle dip. GG
- (670) **moraine** [glacial geology]
- (i) [material] A mound, ridge, or other topographically distinct accumulation of unsorted, unstratified glacial drift, predominantly till, deposited primarily by the direct action of glacier ice, in a variety of landforms.
 - (ii) [landform] A general term for a landform composed mainly of till that has been deposited by a glacier; a kame moraine is a type of moraine similar in exterior form to other types of moraines but composed mainly of stratified outwash materials. Types of moraine include disintegration, end, ground, kame, lateral, recessional, and terminal. SW
- (671) **mossy organic materials**.—See organic materials.
- (672) **moss peat**.—An accumulation of organic material that is predominantly the remains of mosses (e.g., sphagnum moss). Compare – herbaceous peat, sedimentary peat, woody peat, peat, muck, and mucky peat. SSM
- (673) **mound**
- (i) A low, rounded natural hill of unspecified origin, generally < 3 m high and, composed of earthy material.
 - (ii) A small, human-made hill, composed either of debris accumulated during successive occupations of the site (e.g., tell) or of earth heaped up to mark a burial site (e.g., burial mound).
 - (iii) A structure built by colonial organisms (e.g., termite mound). GG
- (674) **mountain**.—A generic term for an elevated area of the land surface, rising more than 300 meters above surrounding lowlands, usually with a nominal summit area relative to bounding slopes and generally with steep sides (greater than 25-percent slope) with or without considerable bare-rock exposed. A mountain can occur as a single, isolated mass or in a group forming a chain or range. Mountains are primarily formed by tectonic activity, volcanic action, or both and secondarily by differential erosion. Compare – hill, hillock, plateau, foothills, mountains. SW and HP

- (675) **mountainbase**.—A geomorphic component of mountains consisting of the lowermost area, consisting of the strongly to slightly concave colluvial apron or wedge at the bottom of mountain slopes; composed of long-transport colluvium and slope alluvium sediment. It can extend out onto more level valley areas where it ultimately interfingers with, is buried by alluvium or is replaced by reemergent residuum. Compare – mountaintop, mountainflank, free face, geomorphic component. SW
- (676) **mountainflank**.—A geomorphic component of mountains consisting of the side area of mountains, characterized by very long, complex backslopes with comparatively high slope gradients and composed of highly-diverse, colluvial sediment mantles, complex near-surface hydrology, mass movement processes and features (e.g., creep, landslides); rock outcrops or structural benches may be present. The mountainflank can be subdivided by the general location along the mountainside (i.e., upper-third, middle-third, or lower-third mountainflank). Compare – mountaintop, mountainbase, free face, geomorphic component. SW
- (677) **mountain range**.—A single, large mass consisting of a succession of mountains or narrowly spaced mountain ridges, with or without peaks, closely related in position, direction, orientation, formation, and age; a component part of a mountain system. Compare – mountain system, mountains. GG
- (678) **mountains**.—A region or landscape characterized by mountains and their intervening valleys; a generic name for any group, cluster, or sequence of mountains or narrowly spaced mountain ridges, with or without peaks, closely related in position, orientation, direction, formation, or age, and whose summits commonly exceed 300 m (approx. 1000 ft). Compare – foothills, hills, mountain range, mountain system. SW
- (679) **mountainside**.—(not recommended) Use mountain slope.
- (680) **mountain slope**.—A part of a mountain between the summit and the foot. Compare – mountainflank, hillslope. GG
- (681) **mountain system**.—A group of mountain ranges exhibiting certain unifying features, such as similarity in form, structure and alignment, and presumably originating from the same general causes; especially a series of mountain ranges belonging to an orogenic belt. Compare – mountain range, mountains. GG
- (682) **mountaintop**.—A geomorphic component of mountains consisting of the uppermost, comparatively level or gently sloped area of mountains, characterized by relatively short, simple slopes composed of bare rock, residuum, or short-transport colluvial sediments. In humid environments, mountaintop soils can be quite thick and well developed. Compare – mountainflank, mountainbase, free face, geomorphic component. SW
- (683) **mountain valley**
- (i) Any small, externally drained V-shaped depression (in cross-section) cut or deepened by a stream and floored with alluvium, or a broader, U-shaped depression modified by an alpine glacier and floored with either till or alluvium, that occurs on a mountain or within mountains. Several types of mountain valleys can be recognized based on their form and valley floor sediments (i.e., *V-shaped valley*, *U-shaped valley*). Compare – valley. SW
 - (ii) (colloquial: Basin and Range, United States) A relatively small, structural depression within a mountain range that is partly filled with alluvium and commonly drains externally to an intermontane basin, bolson, or semibolson. Compare – valley flat. SW and FFP
- (684) **muck**.—Unconsolidated soil material consisting primarily of highly decomposed organic material in which the original plant parts are not recognizable (e.g., “sapric soil materials” of Soil Taxonomy). It generally contains more mineral matter, fewer plant fibers, and is usually darker in color than peat. Compare – peat, mucky peat, herbaceous peat. GSST

- (685) **mucky peat**.—Unconsolidated soil material consisting primarily of organic matter that is in an intermediate stage of decomposition such that a significant part of the original material can be recognized and a significant part of the material cannot be recognized (e.g., “hemic soil materials” of Soil Taxonomy). Compare – peat, muck, herbaceous peat. SSM
- (686) **mud flat**.—(not preferred – use tidal flat) A relatively level area of fine grained material (e.g., silt) along a shore (as in a sheltered estuary) or around an island, alternately covered and uncovered by the tide or covered by shallow water, and barren of vegetation. Compare – low marsh, tidal flat, tidal marsh. GG
- (687) **mud pot**.—A type of hot spring containing boiling mud, usually sulfurous and often multicolored, as in a paint pot. Mud pots are commonly associated with geysers and other hot springs in volcanic areas, especially in Yellowstone Natl. Park, WY. Compare – geyser, hot spring. GG
- (688) **mudflow**.—The mass movement process, associated sediments (mudflow deposit), or resultant landform characterized by a very rapid type of *earthflow* dominated by a sudden, downslope movement of a saturated mass of rock, soil, and mud (more than 50% of the particles are < 2 mm), that behaves as much as a viscous fluid when moving. Compare – debris flow, flow, landslide. SW and DV
- (689) **mudstone**
- (i) A blocky or massive, fine-grained sedimentary rock in which the proportions of clay and silt are approximately equal.
 - (ii) A general term that includes clay, silt, claystone, siltstone, shale, and argillite, and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified. GG
- (690) **muskeg**.—A bog, usually a sphagnum bog, frequently with grassy tussocks (hummocks), growing in wet, poorly drained boreal regions, with deep accumulations of organic material, often in areas of permafrost; a moss-covered muck or peat bog of boreal regions. GG and HP
- (691) **natural levee**.—A long, broad low ridge or embankment of sand and coarse silt, built by a stream on its flood plain and along both sides of its channel, especially in time of flood when water overflowing the normal banks is forced to deposit the coarsest part of its load. It has a gentle slope away from the river and toward the surrounding flood plain, and its highest elevation is closest to the river bank. Compare – levee, artificial levee, meander belt. GG
- (692) **nearshore zone**.—A subaqueous marine or lacustrine landform area that generally parallels the shore and extends seaward or lakeward from the low water line to beyond the breaker zone including longshore bars. In the nearshore zone, waves steepen, break, and reform during passage to the beach. Sediment transport occurs both along and perpendicular to the shore by means of wave and current action. Compare – nearshore zone [relict]. SW and RF
- (693) **nearshore zone [relict]**.—A former nearshore zone now subaerially exposed due to isostatic rebound or glacial lake drainage. Commonly a raised beach marks the former landward edge of a relict nearshore zone and relict longshore bars may exist in offshore positions. Surficial sediments may display evidence of wave and current action such as sorting or particle-size discontinuities. SW
- (694) **neck [volcanic]**.—(not preferred) Refer to volcanic neck.
- (695) **net (nonsorted)**.—(not preferred) Refer to patterned ground.
- (696) **net (sorted)**.—(not preferred) Refer to patterned ground.
- (697) **nivation**.—The process of excavation of a shallow depression or nivation hollow on a mountain side by removal of fine material around the edge of a shrinking snow patch or snow bank, chiefly through sheetwash, rivulet flow, and solution in melt water. Freeze-thaw action is apparently insignificant. GG

- (698) **nivation hollow**.—A shallow, noncliffed depression or hollow on a mountain side permanently or intermittently occupied by a snow bank or snow patch and produced by nivation. If the snow completely melts each summer the hollow is deepened; otherwise, it is not; may be a cirque precursor if further enlarged and deepened by alpine glaciation. GG
- (699) **nonsorted circle**.—A type of patterned ground whose mesh (shape) is dominantly circular and has a nonsorted appearance due to the absence of a border of rock fragments. Vegetation characteristically outlines the pattern by forming a bordering ridge. Diameters commonly range from 0.5 to 3 m. Nonsorted circles include mud boils, earth hummocks, turf hummocks, and frost boils. Nonsorted circles have various origins. Some, such as mud and earth hummocks and frost boils, involve cryoturbation activity and differential heave of frost-susceptible materials. Others, such as mud boils, involve hydraulic pressures and diapir-like displacement of water-saturated sediments. Compare – sorted circle, frost boil, patterned ground. NRC and GG
- (700) **nonsorted polygon**.—(not preferred) Refer to patterned ground.
- (701) **nose slope**.—[geomorphology] A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside, resulting in predominantly divergent overland water flow (e.g., sheet wash); contour lines generally form convex curves. Nose slopes are dominated by colluvium and slope wash sediments (e.g., slope alluvium). Slope complexity (downslope shape) can range from simple to complex. Nose slopes are comparatively drier portions of hillslopes and tend to have thinner colluvial sediments and profiles. Compare – head slope, side slope, free face, interfluvium, crest, base slope. SW
- (702) **notch**
- (i) (colloquial: northeastern United States) A narrow passageway or short defile between mountains; a deep, close pass. Compare – gap.
 - (ii) A breached opening in the rim of a volcanic crater. GG
- (703) **novaculite**.—A dense, even-textured, extremely finely grained, siliceous, sedimentary rock recrystallized from chert with microcrystalline quartz dominant over chalcedony (cryptocrystalline quartz). It is hard, white to grayish-black in color, translucent on thin edges, has a dull to waxy luster, and displays smooth conchoidal fracture when broken. Novaculite occurs in the Ouachita Mountains of Arkansas and Oklahoma and the Marathon Uplift of Texas, where it forms erosion-resistant ridges. At the Ouachita Mountain type occurrence, novaculite formed by low-grade, thermal metamorphism of bedded chert. This rock serves widely as a whetstone or oilstone. Compare – chert. SW and GG
- (704) **nuée ardente**.—A swiftly flowing, turbulent gaseous cloud, sometimes incandescent, erupted from a volcano and containing ash and other pyroclastics in its lower part; a density current of pyroclastic flow. Compare – pyroclastic flow, lahar. GG
- (705) **nunatak**.—An isolated hill, knob, ridge, or peak of bedrock that projects prominently above the surface of a glacier and is completely surrounded by glacier ice. Compare – inselberg, monadnock. GG
- (706) **Occam's razor**.—The philosophical principle of *parsimony*: the simplest explanation of natural phenomena (or the use of the minimum number of assumptions) until new information requires otherwise, is most likely the correct one; also spelled Ockham's. GG
- (707) **ocean**.—The continuous salt-water body that surrounds the continents and fills the earth's great depressions; also, one of its major geographic divisions. Compare – sea. GG
- (708) **offshore bar**.—(not recommended) Use barrier beach.
- (709) **Oligocene**.—An epoch of the Tertiary Period of geologic time (from 23.3 to 35.4 million years ago), which follows the Eocene Epoch and precedes the Miocene Epoch; also the corresponding (time-stratigraphic) "series" of earthy materials. SW
- (710) **open depression**.—A generic name for any enclosed or low area that has a surface drainage outlet whereby surface water can leave the enclosure; an area of lower ground

- indicated on a topographic map by contour lines forming an incomplete loop or basin indicating at least one surface exit. Compare – closed basin. SW
- (711) **openpit mine**.—A relatively large depression resulting from the excavation of material and redistribution of overburden associated with surficial mining operations. Compare – quarry, surface mine. SW and GG
- (712) **organic materials**.—[soil survey] Unconsolidated sediments or deposits in which carbon is an essential, substantial component. Several types of organic materials (deposits) can be identified based on the composition of the dominant fibers (grassy organic materials, herbaceous organic materials, mossy organic materials, woody organic materials). Compare – herbaceous peat, moss peat, sedimentary peat, woody peat. SW
- (713) **outcrop**
- (i) That part of a geologic formation or structure that appears at the surface of the earth.
 - (ii) [soil survey] An actual exposure of bedrock at or above the ground surface; the miscellaneous area *rock outcrop*. Compare – cliff, slickrock. SW and GG
- (714) **outwash**.—[glacial geology] Stratified and sorted sediments (chiefly sand and gravel) removed or “washed out” from a glacier by melt-water streams and deposited in front of or beyond the end moraine or the margin of a glacier. The coarser material is deposited nearer to the ice. Compare – pitted outwash, drift, esker, kame, till. SW and GG
- (715) **outwash delta**.—A relict (inactive) delta composed of glaciofluvial sediments formed where a sediment laden outwash river emptied into an open lake, commonly a proglacial lake. Sediment attributes include very gently dipping topset beds (coarser textures) and steeply dipping foreset beds (finer textures). SW and GM
- (716) **outwash fan**.—A fan-shaped accumulation of outwash deposited by meltwater streams in front of the end or recessional moraine of a glacier. Coalescing outwash fans form an outwash plain. GG
- (717) **outwash plain**.—An extensive lowland area of coarse textured, glaciofluvial material. An outwash plain is commonly smooth; where pitted, due to melt-out of incorporated ice masses (pitted outwash plain), it is generally low in relief and largely retains its original gradient. Compare – outwash, pitted outwash plain, collapsed outwash plain, kettles; also called sandur. SW and HP
- (718) **outwash terrace**.—A flat-topped bank of outwash with an abrupt outer face (scarp or riser) extending along a valley downstream from an outwash plain or terminal moraine; a valley train deposit. Compare – kame terrace, valley train. SW
- (719) **overbank deposit**.—Fine-grained sediments (silt and clay) deposited from suspension on a flood plain by floodwaters that cannot be contained within the stream channel. GG
- (720) **overburden**
- (i) The upper part of a sedimentary deposit, compressing and consolidating the materials below.
 - (ii) The loose soil or other unconsolidated material overlying bedrock, either transported or formed in place (synonym for regolith). GG
- (721) **overflow stream channel**.—A watercourse that is generally dry but conducts flood waters that have overflowed the banks of a river, commonly from large storms, annual meltwater, or glacial meltwaters. SW
- (722) **overprinting**.—The process of superimposing a new set of features over a preexisting set due to a shift in environmental conditions such as a change in climate or local hydrology. The resulting composite morphology retains features that would not form under present conditions. Compare – overprinted soil. SW
- (723) **overprinted soil**.—A soil in which new soil morphology has developed and is superimposed upon that of a preexisting soil due to a shift in pedogenic conditions such as a change in climate or hydrology; the composite morphology retains some relict features that

- would not form under present-day conditions. Sometimes called welded soil (not preferred).
SW
- (724) **overthrust**.—A low-angle thrust fault of large scale, with displacement generally measured in kilometers. GG
- (725) **overthrust belt**.—(not preferred) Use fold-thrust hills.
- (726) **oxbow**.—A closely looping stream meander having an extreme curvature such that only a neck of land is left between the two parts of the stream. (colloquial: northeastern United States) The land enclosed, or partly enclosed, within an oxbow. Compare – meander belt, oxbow lake, bayou. GG
- (727) **oxbow lake**.—The crescent-shaped, often ephemeral body of standing water situated by the side of a stream in the abandoned channel (oxbow) of a meander after the stream formed a neck cutoff and the ends of the original bend were silted up. Compare – meander belt, oxbow. GG
- (728) **paha**.—(colloquial: Midwestern United States) Commonly a low, elongated, rounded ridge or hill cored by an erosional remnant of drift, rock, or windblown sand, silt, or clay and capped with a thick cover (e.g., up to 10 m) of loess; found especially in northeastern Iowa. Height varies between 10 and 30 m. SW and GG
- (729) **pahoehoe lava**.—A type of basaltic lava (material) with a characteristically smooth, billowy or rope-like surface and vesicular interior. Compare – aa lava, block lava, pillow lava. GG and MA
- (730) **pahoehoe lava flow**.—A type of basaltic lava flow with a characteristically smooth, billowy or rope-like surface. Compare – aa lava flow, block lava flow, pillow lava flow. GG and MA
- (731) **Paleocene**.—The earliest epoch (from 56.5 to 65.0 million years ago) of the Tertiary Period of geologic time that follows the Cretaceous Period and precedes the Eocene Epoch; also the corresponding (time-stratigraphic) “series” of earthy materials. SW
- (732) **paleosol**.—A soil that formed on a landscape in the past with distinctive morphological features resulting from a soil-forming environment that no longer exists at the site. The former pedogenic process was either altered because of external environmental change or interrupted by burial. A paleosol (or component horizon) may be classed as relict if it has persisted in a land-surface position without major alteration of morphology by processes of the prevailing pedogenic environment. An exhumed paleosol is one that formerly was buried and has been reexposed by erosion of the covering mantle. Most paleosols have been affected by some subsequent modification of diagnostic horizon morphologies and profile truncation. HP
- (733) **paleoterrace**.—An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to a present-day stream or drainage network. Compare – alluvial plain remnant, terrace remnant. SW
- (734) **palsa**.—An elliptical dome-like permafrost mound containing alternating layers of ice lenses and peat or mineral soil, commonly 3-10 m high and 2-25 m long, occurring in subarctic bogs of the tundra and often surrounded by water; plural: palsen. NRC
- (735) **parabolic dune**.—A sand dune with a long, scoop-shaped form, convex in the downwind direction so that its horns point upwind, whose ground plan, when perfectly developed, approximates the form of a parabola. GG
- (736) **parallel drainage pattern**.—A drainage pattern in which the streams and their tributaries are regularly spaced and flow parallel or subparallel to one another and tributaries characteristically join the mainstream at approximately the same angle, over a considerable area. It is indicative of a region having a pronounced, uniform slope and a homogeneous lithology and rock structure, such as young coastal plains and large basalt flows. SW, GG, and WA

- (737) **parent material**.—The unconsolidated and more or less chemically weathered mineral or organic matter from which a soil's solum is developed by pedogenic processes. GSST
- (738) **park**.—(colloquial: Rocky Mountains, United States; not preferred – refer to valley, intermontane basin)
- (i) An ecological term for a grassy or shrubby, wide, open valley lying at high elevation and confined between forested mountain slopes, as in a high meadow; sometimes marshy. Compare – glade.
 - (ii) (refer to intermontane basin) A level valley between mountain ranges. GG and SW
- (739) **parna**.—A term used, especially in southeastern Australia and the southwestern United States, for silt and sand-sized aggregates of eolian clay occurring as sheets or dunes. Compare – parna dune. SW and GG
- (740) **parna dune**.—A dune largely composed of silt and sand-sized aggregates of clay; sometimes called a clay dune or lunette. Compare – parna. HP
- (741) **partial ballena**.—(not preferred) Refer to ballena.
- (742) **patina**.—A general term for a colored film or thin outer layer produced on the surface of a rock or other material by weathering after long exposure. Compare – rock varnish. GG
- (743) **patterned ground**.—A general term for any ground surface exhibiting a discernibly ordered, more-or-less symmetrical, morphological pattern of ground and, where present, vegetation. Patterned ground is characteristic of, but not confined to, permafrost regions or areas subjected to intense frost action; it also occurs in tropical, subtropical, and temperate areas. Patterned ground is classified by type of pattern and presence or absence of sorting and includes nonsorted and sorted circles, net, polygons, steps and stripes, garlands, and solifluction features. In permafrost regions, the most common macroform is the ice-wedge polygon and a common microform is the nonsorted circle. Stone polygons generally form on slopes of less than 8 percent, while garlands and stripes occur on slopes of 8 to 15 percent and more than 15 percent, respectively. NRC and HP
- (744) **pavement karst**.—Areas of bare limestone, usually sculpted by solution erosion into karren of various types and where soils have been stripped off, commonly by glaciation in alpine areas (e.g., Rocky Mountains, United States) and high latitudes, and by water erosion in arid karst areas. Compare – fluviokarst, glaciokarst, sinkhole karst, karst. SW and WW
- (745) **peak**.—Sharp or rugged upward extension of a ridge chain, usually at the junction of two or more ridges; the prominent highest point of a summit area. HP
- (746) **peat**.—Unconsolidated soil material consisting largely of undecomposed, or slightly decomposed, organic matter containing abundant plant fibers (e.g., “fibric soil materials” of Soil Taxonomy) and which accumulated under conditions of excessive moisture. Compare – muck, mucky peat, herbaceous peat. GSST
- (747) **peat plateau**.—A generally flat-topped expanse of peat, elevated above the general surface of a peatland, and containing segregated ice that may or may not extend downward into the underlying mineral soil. Controversy exists as to whether peat plateaus and palsen are morphological variations of the same feature. NRC
- (748) **pediment**.—A gently sloping erosional surface developed at the foot of a receding hill or mountain slope, commonly with a slightly concave-upward profile, that cross-cuts rock or sediment strata that extend beneath adjacent uplands. The erosion surface may be essentially bare bedrock (i.e., *rock pediment*), or it may be thinly mantled (e.g., 1 to 3 m) with debris (i.e., *pediment*) such as colluvium, pedisediment, or alluvium that is ultimately in transit from an upland front to basin or valley lowland. In hill-footslope terrain the debris mantle (over an erosional contact) is designated “pedisediment.” The term has been used in several geomorphic contexts: Pediments may be classed with respect to—
- (i) landscape positions (e.g., intermontane-basin piedmont = *apron pediment*, or valley-border footslope surfaces (= *terrace pediment*); Cooke and Warren, 1973).

- (ii) type of material eroded (e.g., bedrock = *rock pediment*, or regolith = *pediment*).
- (iii) combinations of the above. Compare – rock pediment, Piedmont slope, structural bench. SW, HP, and RR
- (749) **pedisediment**.—A sediment layer, eroded from the shoulder and backslope of an erosional slope that lies on and is, or was, being transported across a pediment. FFP
- (750) **pedoturbation**.—The mixing of soil materials by natural processes. Compare – cryoturbation. BHM
- (751) **peneplain**.—(not recommended: obsolete) A low nearly featureless, gently undulating land surface of considerable area, which presumably has been produced by the processes of long-continued subaerial erosion. GG
- (752) **peninsula**
 - (i) An elongated body or stretch of land nearly surrounded by water (e.g., on three sides) and connected with a larger tract of land area, usually by a neck or an isthmus.
 - (ii) A relatively large tract of land jutting out into the water, with or without a well-defined isthmus (e.g., the Italian peninsula). GG
- (753) **perennial stream**.—A stream or reach of a stream that flows continuously throughout the year and whose surface is generally lower than the water table adjacent to the region adjoining the stream. Compare – Ephemeral stream, Intermittent stream. GG
- (754) **periglacial**.—(adjective) Pertaining to processes, conditions, areas, climates, and topographic features occurring at the immediate margins of glaciers and ice sheets, and influenced by cold temperature of the ice. The term was originally introduced to designate the climate and related geologic features peripheral to ice sheets of the Pleistocene. HP
- (755) **permafrost**.—Ground, soil, or rock that remains at or below 0 °C for at least 2 years. It is defined on the basis of temperature and is not necessarily frozen (i.e., cemented by ice). Compare – continuous permafrost, discontinuous permafrost, sporadic permafrost, thaw-sensitive permafrost, thaw-stable permafrost. NRC
- (756) **Physiographic Division**.—A large portion of a continent of which all parts are similar in geologic structure and climate at a small scale (e.g., 1:5,000,000) and that has consequently had a unified geomorphic history and whose pattern of relief or landforms differ significantly from that of adjacent areas. Examples: the Laurentian Upland, Rocky Mountain System, and Interior Highlands of the United States western United States (*the highest level in the Physiographic Location part of the Geomorphic Description System*). SW
- (757) **Physiographic Province**.—A region of which all parts are similar in geologic structure and climate and that has consequently had a unified geomorphic history; a region whose pattern of relief or landforms differ significantly from that of adjacent regions; i.e., a subset within a Physiographic Division. Examples: the Valley and Ridge, Blue Ridge, and Piedmont provinces in the eastern United States, and the Basin and Range, Rocky Mountains, and Great Plains provinces in the western United States (*the second highest level in the Physiographic Location part of the Geomorphic Description System*). SW and GG
- (758) **Physiographic Section**.—An area in which all parts are similar in geologic structure and climate at a relatively small scale and that has consequently had a unified geomorphic history and whose pattern of relief or landforms differ significantly from that of adjacent areas (equivalent to Fenneman's (1957) "Section") (i.e., a subset within a Physiographic Province). Examples: the Mohawk, Green Mountain, and Floridian Sections in the eastern United States and the Sacramento Section, Puget Trough, and Klamath Mountains in the western United States (*the third-highest level in the Physiographic Location part of the Geomorphic Description System*). SW
- (759) **piedmont**.—(adjective) Lying or formed at the base of a mountain or mountain range (e.g., a piedmont terrace or a piedmont pediment). (noun) An area, plain, slope, glacier, or other feature at the base of a mountain (e.g., a foothill or a bajada). In the United States, the

- Piedmont (noun) is a low plateau extending from New Jersey to Alabama and lying east of the Appalachian Mountains. GG
- (760) **piedmont slope**.—(colloquial: western United States) The dominant gentle slope at the foot of a mountain; generally used in terms of intermontane-basin terrain in arid to subhumid regions. Main components include an erosional surface on bedrock adjacent to the receding mountain front (pediment, rock pediment); a constructional surface comprising individual alluvial fans and interfan valleys, also near the mountain front; and a distal complex of coalescent fans (bajada) and alluvial slopes without fan form. Piedmont slopes grade to basin-floor depressions with alluvial and temporary lake plains or to surfaces associated with through drainage (e.g., axial streams). Compare – bolson, fan piedmont. HP
- (761) **pillow lava**.—A general term for lava displaying pillow structure (discontinuous, close-fitting, bun-shaped or ellipsoidal masses, generally < 1 m in diameter); considered to have formed in a subaqueous environment; such lava is usually basaltic or andesitic. Compare – aa lava, block lava, pahoehoe lava. SW, GG, and GS
- (762) **pillow lava flow**.—A lava flow or body displaying pillow structure and considered to have formed in a subaqueous environment (underwater); usually basaltic or andesitic in composition. Compare – aa lava flow, block lava flow, pahoehoe lava flow. SW and GS
- (763) **pimple mound**.—(colloquial: Gulf Coast United States) Low, flattened, approximately circular or elliptical features composed of sandy loam that is coarser than, and distinct from, the surrounding soil; the basal diameter ranges from 3 m to more than 30 m, and the height from 30 cm to more than 2 m. Compare – mima mound, patterned ground, shrub-coppice dune. GG
- (764) **pingo**.—A large frost mound; especially a relatively large conical mound of soil-covered ice (commonly 30 to 50 meters high and up to 400 meters in diameter) raised in part by hydrostatic pressure within and below the permafrost of Arctic regions, and of more than 1 year's duration. GG
- (765) **pinnacle**.—[geomorphology] A tall, slender, tapering tower or spire-shaped pillar of rock, either isolated, as on steep slopes or cliffs formed in karst or other massive rocks, or at the summit of a hill or mountain. Compare – erosional remnant, hoodoo. SW, GG, and WW
- (766) **pinnate drainage pattern**.—A variation of the dendritic drainage pattern in which the main stream receives many closely spaced, subparallel tributaries that join it at slightly acute angles upstream, resembling in plan a feather. They typically form on steep slopes with soils that have a high silt content, such as loess landscapes or fine-textured flood plains. SW, GG, and WA
- (767) **pit and mound topography**.—(not recommended) Use tree-tip pit and mound topography.
- (768) **pitted outwash**.—Outwash deposits with surficial pits or kettles, produced by the partial or complete burial of glacial ice by outwash and the subsequent thaw of the ice and collapse of the surficial materials. Compare – pitted outwash plain. GG
- (769) **pitted outwash plain**.—An outwash plain marked by many irregular depressions such as kettles, shallow pits, and potholes that formed by melting of incorporated ice masses; much of the gradient and internal structures of the original plain remain intact; many are found in WI, MN, MI, and IN. Compare – collapsed outwash plain, outwash, pitted outwash. GG
- (770) **pitted outwash terrace**.—A relict glaciofluvial terrace that retains its original attitude, composed of undistorted outwash sediments and depositional structures and whose surface is pock-marked with numerous potholes or kettle depressions. Compare – collapsed outwash plain. SW
- (771) **plain**.—A general term referring to any flat, lowland area, large or small, at a low elevation. Specifically, any extensive region of comparatively smooth and level gently undulating land. A plain has few or no prominent hills or valleys but sometimes has

- considerable slope, and usually occurs at low elevation relative to surrounding areas. Where dissected, remnants of a plain can form the local uplands. A plain may be forested or bare of trees and may be formed by deposition or erosion. Compare – lowland, plateau. SW and GG
- (772) **plateau**.—[geomorphology] A comparatively flat area of great extent and elevation; specifically an extensive land region considerably elevated (more than 100 meters) above adjacent lower-lying terrain, and is commonly limited on at least one side by an abrupt descent, has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level. Compare – hill, foothill, mountain, mesa, plain. GG
- (773) **playa**.—The usually dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those occurring on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation-runoff events. Playa deposits are fine grained and may or may not have high water table and saline conditions. HP
- (774) **playa dune**.—(colloquial: Southern High Plains) A linear or curvilinear ridge of windblown, granular material (generally sand or parna) removed from the adjacent basin by wind erosion (deflation), and deposited on the leeward (prevailing downwind) margin of a playa, playa basin, or salina basin. The dune may be barren or vegetated. Compare – dune. SW
- (775) **playa floor**.—(colloquial: Southern High Plains) The lowest extensive, flat to slightly concave surface within a playa basin, consisting of a dry lake bed or lake plain underlain by stratified clay, silt or sand, and commonly by soluble salts. Compare – playa step. SW
- (776) **playa lake**.—A shallow, intermittent lake in a arid or semiarid region, covering or occupying a playa in the wet season but drying up in summer; an ephemeral lake that upon evaporation leaves or forms a playa. GG
- (777) **playa rim**.—(colloquial: Southern High Plains) The convex, upper margin (shoulder) of a playa basin where the playa slope intersects the surrounding terrain. Compare – playa slope. SW
- (778) **playa slope**.—(colloquial: Southern High Plains) The generally concave to slightly convex area within a playa basin that lies between the relatively level playa floor below (or playa step, if present) and the convex playa rim above. Overland flow is typically parallel down slope. Compare – playa step, playa rim. SW
- (779) **playa step**.—(colloquial: Southern High Plains) The relatively level or gently inclined “terrace-like” bench or toeslope within a large playa basin flanking and topographically higher than the playa floor and below the playa slope; a bench or step-like surface within a playa basin that breaks the continuity of the playa slope and modified by erosion and/or deposition. Temporary ponding may occur in response to precipitation and runoff events. Compare – playa slope. SW
- (780) **playette**.—A very small, playa-like, shallow, closed depression typically with a salt-encrusted surface, little or no vegetation in semiarid to arid climates and infrequently subject to ponding from precipitation events; commonly lacks the component parts of a playa except for a small *playa floor*. Compare – playa. SW and GHG
- (781) **Pleistocene**.—The epoch of the Quaternary Period of geologic time (from about 10 to 12 thousand to 1.6 million years ago), following the Pliocene Epoch and preceding the Holocene also the corresponding (time-stratigraphic) “series” of earth materials. SW and HP
- (782) **Pliocene**.—The last epoch (from 1.6 to 5.2 million years ago) of the Tertiary Period of geologic time that follows the Miocene and precedes the Pleistocene Epoch; also, the corresponding (time-stratigraphic) “series” of earth materials. HP
- (783) **plowpan**.—[soil survey] A relatively thin, but highly compressed soil layer at the depth of tillage (e.g., 8-25 cm), largely the result of driving tractor wheels in a furrow while plowing. A plowpan can dramatically reduce vertical root penetration, water percolation, internal gas

- exchange and subsequent crop growth; sandy loam soil textures are particularly susceptible. SW and GSST
- (784) **plug** [volcanic].—(not recommended) Use volcanic neck.
- (785) **plug dome**.—A volcanic dome characterized by an upheaved, consolidated conduit filling. GG
- (786) **pluton**.—A deep-seated igneous intrusion. GG
- (787) **plutonic**.—Pertaining to igneous rocks formed at great depth, but also including associated metamorphic rocks. GG
- (788) **pluvial lake**.—A lake formed in an extended period of exceptionally heavy rainfall, commonly the Pleistocene. Compare – playa lake, pluvial lake [relict], glacial lake, proglacial lake. SW and GG
- (789) **pluvial lake [relict]**.—A lake formed in an extended period of exceptionally heavy rainfall, but now greatly reduced or gone; a lake formed in the Pleistocene Epoch during a time of glacial advance (and associated increase in annual precipitation or runoff), and now extinct (relict) (e.g., Lake Bonneville). Compare – pluvial lake, playa, glacial lake, proglacial lake. SW and GG
- (790) **pocosin**.—(colloquial: southeastern United States) A large wet area, commonly a swamp, that occurs on broad, nearly level interfluvies in the Atlantic coastal plain with distinctive, native vegetation relative to adjacent areas. Soils may be either mineral or organic. A Native American term for “swamp on a hill.” Compare – raised bog. RD
- (791) **point bar**.—One of a series of low, arcuate ridges of sand and gravel developed on the inside of a growing meander by the slow addition of individual accretions accompanying migration of the channel toward the outer bank. Compare – meander scroll. GG
- (792) **point bar [coastal]**.—Low, arcuate, subaerial ridges of sand developed adjacent to an inlet and formed by the lateral accretion or movement of the channel. Compare – spit. SSS
- (793) **polder**.—A generally fertile tract of flat, low-lying coastal area that is at or below sea level but has been reclaimed and is constantly protected from the sea, or other body of water by an organized system of maintenance and defense that involves embankments, dikes, dams, or levees (e.g., a brackish marsh that has been drained and brought under cultivation). SW and ICOMANTH
- (794) **polje**.—(not preferred) Refer to interior valley.
- (795) **polygon**.—A type of patterned ground consisting of a closed, roughly equidimensional figure bounded by more or less straight sides; some sides may be irregular. Refer to patterned ground. Compare – high-center polygon, low-center polygon, ice wedge polygon, nonsorted polygon. NRC
- (796) **pond**
- (i) A natural body of standing fresh water occupying a small surface depression, usually smaller than a lake and larger than a pool.
 - (ii) A small artificial body of water, used as a source of water. Compare – salt pond. GG
- (797) **pool**.—A small, natural body of standing water, usually fresh (e.g., a stagnant body of water in a marsh or a transient puddle in a depression following a rain). GG
- (798) **porcellanite**.—A dense, siliceous rock formed as a indurated or baked clay or shale with a dull, light-colored, cherty appearance, often found in the roof or floor of a burned-out coal seam. GG
- (799) **postglacial**.—(not preferred) Refer to Holocene.
- (800) **pothole**.—[geomorphology] (not preferred) A generic, imprecise term for any pot-shaped pit or hole. GG
- (801) **pothole**.—[glacial geology] A type of small pit or closed depression (1 to 15 meters deep), generally circular or elliptical, occurring in an outwash plain, a recessional moraine, or a till plain. GG

- (802) **pothole lake**.—A shallow depression, generally less than 10 hectares in area, occurring on disintegration moraines and commonly containing an intermittent or seasonal pond or marsh. GG
- (803) **proglacial lake**.—A type of glacial lake that formed just beyond the margin of an advancing or retreating glacier; generally in direct contact with the ice. Compare – glacial lake, pluvial lake. GG
- (804) **proglacial lake [relict]**.—Remnant features of a glacial lake that is now extinct that formed just beyond the margin of an advancing or retreating glacier; generally in direct contact with the ice. Compare – proglacial lake, pluvial lake. SW
- (805) **proximal**.—[adjective: sedimentology] Said of a sedimentary deposit consisting of coarse clastics and deposited nearest the source area. Compare – distal. GG
- (806) **puff**.—(gilgai) A surface drape or exposure of up-welled substratum material forced to the surface and outcropping on a low mound or rim; the surface exposure of a chimney [gilgai]; a type of diapir composed of earthy material. Compare – chimney, microslope, gilgai. SW
- (807) **pumice**
- (i) [soils] Volcanic fragments ≥ 2 mm in diameter (i.e., retained upon a standard #10 sieve), or coherent rock layers (pumice flow), made of light-colored, vesicular, glassy rock commonly having the composition of rhyolite. The material commonly has a specific gravity of < 1.0 and is thereby sufficiently buoyant to float on water. SW; pumice-like fragments < 2 mm in size are called pumiceous ash. ST; Compare – scoria, tephra.
 - (ii) [geology] same as (i) but does not include any size restrictions. SW
- (808) **pyroclastic**.—(adjective) Pertaining to elastic rock particles produced by explosive, aerial ejection from a volcanic vent. Such materials may accumulate on land or under water. Compare – epiclastic, volcanoclastic, clastic. G. Smith and HP
- (809) **pyroclastic flow**.—A fast density current of pyroclastic material, usually very hot, composed of a mixture of gasses and a high concentration of pyroclastic particles in a variety of sizes and composition (ash, pumice, scoria, lava fragments, etc.); produced by the explosive disintegration of viscous lava in a volcanic crater, collapse of an eruption column, or by the explosive emission of gas-charged ash from a fissure and that tends to follow topographic lows (e.g., valleys) as it moves; used in a more general sense than *ash flow*. Compare – pyroclastic surge, ash flow, nuée ardente, lahar. SW, SN, and GG
- (810) **pyroclastic surge**.—A low density, dilute, turbulent *pyroclastic flow*, usually very hot, composed of a generally unsorted mixture of gases and comparatively low concentrations of pyroclastic particles (ash, pumice, and dense rock fragments) that travels across the ground at high speed and less constrained by topography than a pyroclastic flow; several types of pyroclastic surges can be specified (e.g., base surge, ash-cloud-surge). Compare – pyroclastic flow. SW, SN, and GG
- (811) **quarry**.—Excavation areas, open to the sky, usually for the extraction of stone. GG
- (812) **Quaternary**.—The period of the Cenozoic Era of geologic time, extending from the end of the Tertiary Period (about 1.6 million years ago) to the present and comprising two epochs, the Pleistocene (Ice Age) and Holocene (Recent); also, the corresponding (time-stratigraphic) “series” of earth materials. GG
- (813) **radial drainage pattern**.—A drainage pattern in which consequent streams radiate or diverge outward, like the spokes of a wheel from a high central area.; a major collector stream is usually found in a curvilinear alignment around the bottom of the elevated topographic feature. It is best developed on the slopes of a young domal structure, a volcanic cone, or isolated hills (erosional remnant). SW, GG, and WA
- (814) **railroad bed**.—The trace or track of a railroad route, commonly constructed slightly above the adjacent land, and composed mostly of earthy materials (gravel, rock fragments, etc.).

- Abandoned or reclaimed beds may no longer be topographically or visually distinct, but the materials used to construct them may still be a significant portion of the soil zone. SW
- (815) **raised beach**.—An ancient (relict) beach occurring above the present shoreline and separated from the present beach, having been elevated above the high-water mark either by local crustal movements (uplift) or by lowering of sea or lake level, and that may be bounded by inland cliffs. GG
- (816) **raised bog**.—An area of acid, peaty soil especially that developed from moss, in which the center is higher than the margins. Compare – pocosin, Carolina Bay, moss peat. (Note: raised peat bog (not preferred) – refer to highmoor bog). SW and GG87
- (817) **ravine**.—A small stream channel; narrow, steep-sided, commonly V-shaped in cross section and larger than a gully, cut in unconsolidated materials. General synonym (not preferred) – gulch. Compare – arroyo, draw, gully. HP
- (818) **recessional moraine**.—An end or lateral moraine, built during a temporary but significant halt in the final retreat of a glacier. Also, a moraine built during a minor readvance of the ice front during a period of general recession. Compare – end moraine, ground moraine, terminal moraine. GG
- (819) **reclaimed land**
- (i) A land area composed of earthy fill material that has been placed and shaped to approximate natural contours, commonly part of land-reclamation efforts after mining operations.
 - (ii) A land area, commonly submerged in its native state, that has been protected by artificial structures (e.g., dikes) and drained for agricultural or other purposes (e.g., polder). SW
- (820) **reclaimed mineland anthroscape**.—A human-modified “landscape” with substantial, permanent alterations to the physical shape, internal stratigraphy, or both of the land due to restoration efforts of a large surface mine (e.g., coal mine) that have substantively altered water flow and sediment transport across and within the regolith. Small dry pits and depressions may remain mixed in with reclaimed fill. Compare – resource extraction anthroscape, hillslope terrace anthroscape, suburban anthroscape, and urban anthroscape. SW
- (821) **rectangular drainage pattern**.—A drainage pattern in which the tributaries join the main streams at right-angles, and exhibit sections of approximately the same length that form rectangular shapes; it is indicative of streams following prominent bedrock fault, joint, or foliation systems that break the rocks into rectangular blocks. It is more irregular than the trellis drainage pattern, as the side streams are not perfectly parallel and not necessarily as conspicuously elongated, and secondary tributaries need not be present. The stronger or more harsh the pattern, the thinner the soil cover. These patterns commonly form in slate, schist, and gneiss, in resistive sandstone in arid climates, or in sandstone in humid climates if little soil has developed. SW, GG, and WA
- (822) **reef**.—A ridge-like or mound-like structure, layered or massive, built by sedentary calcareous organisms, especially corals, and consisting mostly of their remains; it is wave-resistant and stands above the surrounding contemporaneously deposited sediment. Reefs can also include a mass or ridge of rocks, especially coral and sometimes sand, gravel, or shells, rising above the surrounding estuary, sea or lake bottom to or nearly to the surface. SSS, SW, and GG
- (823) **regolith**.—All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial, glacial, eolian, lacustrine, and pyroclastic deposits. Soil scientists regard as soil only that part of the regolith that is modified by organisms and soil-forming processes. Most engineers describe the whole regolith, even to a great depth, as “soil.” Compare – residuum, bedrock. HP

- (824) **relict**.—(adjective) Pertaining to surface landscape features (e.g., landforms, geomorphic surfaces, and paleosols) that have never been buried and yet are predominantly products of past environments. Compare – exhumed, buried, ground soil. HP
- (825) **relict-tidal inlet**.—(not preferred) see tidal inlet [relict]
- (826) **relief**.—The relative difference in elevation between the upland summits and the lowlands or valleys of a given region. Compare – local relief. GG
- (827) **remnant**.—(not preferred) Refer to erosion remnant.
- (828) **residuum**.—(residual soil material) Unconsolidated, weathered, or partly weathered mineral material that accumulates by disintegration of bedrock in place. Compare – colluvium, regolith, saprolite. HP
- (829) **resource extraction anthroscape**.—A human-modified “landscape” dominated by substantial, permanent alterations to the physical shape, internal stratigraphy, or both of the land due to removal of materials (e.g., unreclaimed or unfilled surface mines or quarries, typically intercepting and partially filled with groundwater) that have substantively altered water flow and sediment transport across and within the regolith. Commonly excludes areas of minor alterations (e.g., farm ponds and small reservoirs) that are designed impoundments of surface water. Compare – reclaimed mineland anthroscape, hillslope terrace anthroscape, suburban anthroscape, and urban anthroscape. SW
- (830) **reworked lake plain**.—(obsolete) – See till-floored lake plain.
- (831) **rhythmite**.—An individual unit of a succession of beds developed by rhythmic sedimentation (e.g., a cyclothem). The term implies no limit as to bedding thickness or complexity and denotes no time or seasonal connotation. Compare – varves, cyclothem. GG
- (832) **rib**.—A small, high angle, tertiary spur ridge or mini-interfluvium that is a constituent part of rib and groove topography; (slopes generally 20-90%); common on the mid and lower hillslopes of well dissected uplands. Compare – finger ridge, groove, rib and groove topography. SW
- (833) **rib and groove topography**.—A local scale topography composed of repeating, small, high-angle (slopes generally 20-90%), tertiary spur ridges or mini-interfluviums (ribs) separated by small, natural, narrow drainageways (grooves); the overall effect is a corrugated transverse surface, common on the mid and lower slopes of well dissected uplands in semiarid to humid environments (e.g., Basin and Range, Ozarks, etc.). Microelevational differences generally range from < 3 to < 15 m. SW
- (834) **ribbed fen**.—A nutrient-rich wetland with a surface pattern of ridges and depressions.
- (835) **rice paddy**.—An anthropogenic, nearly level impoundment that is inundated for long periods typically for wetland rice production. It is applied to areas that have been used in this fashion for a long enough period of time to significantly change the original soil morphology (especially redoximorphic features). SW
- (836) **ridge**.—A long, narrow elevation of the land surface, usually sharp crested with steep sides and forming an extended upland between valleys. The term is used in areas of both hill and mountain relief. HP
- (837) **rift valley**.—A valley that has developed along a long, narrow continental trough that has down-dropped and is bounded by normal faults; a graben of regional size. It marks part of a zone along which the entire thickness of the lithosphere has ruptured under crustal extension. SW and GG
- (838) **rill**.—A very small channel with steep sides caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water, usually during and immediately following moderate rains or after ice or snow melt. Generally, a rill is **not** an obstacle to wheeled vehicles and is shallow enough (e.g., < 0.5 m) to be obliterated by ordinary tillage. Compare – gully. SW and GSST

- (839) **rim**.—The border, margin, edge, or face of a landform, such as the curved brim surrounding the top part of a crater or caldera; specifically the rimrock of a plateau or canyon. GG
- (840) **ripple mark**.—An undulating surface of alternating, subparallel, small-scale ridges and depressions, commonly composed of loose sand. It is produced on land by wind and under water by the agitation of water by currents or wave action, and generally tends at right angles or obliquely to the direction of flow of the moving fluid. Compare – giant ripple mark. GG
- (841) **rise**.—[soil survey] A general term for a slight increase in slope (e.g., $\leq 3\%$) and elevation of the land surface, usually with a broad, low summit and gently sloping sides. The term is restricted to landforms and microfeatures in areas of very low relief such as lake plains or coastal plains. SW and GG
- (842) **rise**.—[geomorphology] A geomorphic component of flat plains (e.g., lake plain, low coastal plain, low-gradient till plain) consisting of a slightly elevated but low, broad area with low slope gradients (e.g., 1-3% slopes); typically a microfeature but can be fairly extensive. Commonly soils on a rise are better drained than those on the surrounding talus. Compare – talus. SW
- (843) **riser**.—[geomorphology] A geomorphic component of terraces, flood-plain steps, and other stepped landforms consisting of the vertical or steep side slope (e.g., escarpment) typically of minimal aerial extent. Commonly a recurring part of a series of natural, step-like landforms such as successive stream terraces. Its characteristic shape and alluvial sediment composition are derived from the cut and fill processes of a fluvial system. Compare – tread. SW
- (844) **river** [streams]
- (i) A general term for a natural, freshwater surface stream of considerable volume and generally with a permanent base flow, moving in a defined channel toward a larger river, lake, or sea.
 - (ii) (not recommended: colloquial – New England, United States) A small watercourse that elsewhere in the United States is known as a *creek*. Compare – stream. GG
- (845) **river valley**.—an elongate depression of the Earth's surface carved by a river during the course of its development. Compare – valley side, valley floor. GG
- (846) **road bed**.—The trace or track of a wheeled vehicle route that may or may not be raised slightly above the adjacent land, and composed of earthy fill material (gravel, rock fragments, etc.) or local soil material. Traffic can alter various soil properties primarily by compaction. Abandoned or reclaimed beds may no longer be topographically or visually distinct. However, materials used to construct beds or changes in soil properties may continue to have a significant impact on soil management or plant growth. SW
- (847) **road cut**.—A common anthropogenic feature, typically a microfeature, consisting of the sloping, cut surface flanking a road bed on one or both sides, that remains after local topography is minimized by cutting an elongated depression through higher ground during road construction; a type of cutbank. Compare – cut, cutbank. SW
- (848) **roche moutonnée**.—A small elongate protruding knob or hillock of bedrock, so sculptured by a large glacier as to have its long axis oriented in the direction of ice movement, an upstream (stoss or scour) side that is gently inclined, smoothly rounded, and striated, and a downstream (lee or pluck) side that is steep and rough. It is usually a few meters in height, length, and breadth. GG
- (849) **rock anhydrite**.—A sedimentary rock (evaporite) composed chiefly of mineral anhydrite (anhydrous CaSO_4); The rock is generally massive, cryptocrystalline, and may exhibit rhythmic sedimentation (rhymites). Compare – rock gypsum, rock halite. SW
- (850) **rockfall**.—The mass movement process, associated sediments (rockfall deposit), or resultant landform characterized by a very rapid type of *fall* dominated by downslope

- movement of detached rock bodies that fall freely through the air or by leaps and bounds (lacks an underlying slip face); also spelled *rock fall*. Compare – debris fall, soil fall, landslide. SW
- (851) **rockfall avalanche**.—The mass movement process, associated sediments (rockfall avalanche deposit), or resultant landform characterized by an extremely rapid, large type of *flow* (a type of landslide) that starts as a rockfall but turns into a flow and characteristically deposits rock-dominated debris long distances from the failure face (such as 10-20 times the fall height); occurs only when huge rockfalls and rockslides involving millions of metric tons of material attain extremely rapid speeds; most common in a rugged mountainous area; for example, the 1903 Franks, Alberta, Canada avalanche. Sometimes loosely referred to as a long run-out landslide. Compare – debris flow, flow, landslide. SW
- (852) **rock glacier**.—A mass of poorly sorted angular boulders and fine material, with interstitial ice a meter or so below the surface (ice-cemented) or containing a buried ice glacier (ice-cored). It occurs in a permafrost area, and is derived from a cirque wall or other steep cliff. Rock glaciers have the general appearance and slow movement of small valley glaciers, ranging from a few hundred meters to several kilometers in length, and having a distal area marked by a series of transverse, arcuate ridges. GG
- (853) **rock gypsum**.—A sedimentary rock (evaporite) composed primarily of mineral gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). The rock is generally massive, ranges from coarse crystalline to fine granular, may show disturbed bedding due to hydration expansion of parent anhydrite (anhydrous CaSO_4), and may exhibit rhythmic sedimentation (rhymites). Compare – gypsite. GG
- (854) **rock halite**.—A sedimentary rock (evaporite) composed primarily of halite (NaCl). SW
- (855) **rock pediment**.—An erosion surface of low relief, cut directly into and across bedrock and composed of either bare rock or thinly veneered pedisegment or residuum (e.g., < 1.5 m) over bedrock; it occurs along the flanks of mountain fronts, or at the base of mountains or high hills. Its surface grades to the backwearing mountain slopes or hillslopes above, and generally grades down to and merges with a lower-lying alluvial plain, piedmont slope or valley floor below. SW and FFP
- (856) **rock spread**.—The mass movement process, associated sediments (rock spread deposit), or resultant landform characterized by a very rapid type of *spread* dominated by lateral movement in a rock mass resulting from liquefaction or plastic flow of underlying materials that may be extruded out between intact units; rock bodies predominate. Compare – debris spread, earth spread, landslide. SW and DV
- (857) **rock topple**.—The mass movement process, associated sediments (rock topple deposit), or resultant landform characterized by a localized, very rapid type of fall in which large blocks of rock material literally fall over, rotating outward over a low pivot point; rock bodies predominate (little fine earth). Portions of the original material may remain intact, although reoriented, within the resulting deposit. Compare – earth topple, debris topple, landslide. SW
- (858) **rock varnish**.—A thin, dark red, or orange-yellow stain to black, shiny film or coating, primarily composed of iron oxide accompanied by traces of manganese oxide and silica, formed on the subaerially exposed surfaces of pebbles, boulders, and other rock fragments, commonly on rock outcrops in arid regions. It is believed to be caused by exudation of mineralized solutions from within and deposition by evaporation on the surface; also called desert varnish, desert patina. GG and RF
- (859) **rotational debris slide**.—The mass movement process, associated sediments (rotational debris slide deposit), or resultant landform characterized by an extremely slow to moderately rapid type of slide, composed of comparatively dry and largely unconsolidated earthy material, portions of which remain largely intact and in which movement occurs along a well-defined, concave shear surface and resulting in a backward rotation of the displaced mass;

- sediments have substantial proportions of both fine earth and rock fragments. The landform may be single, successive (repeated up and down slope), or multiple (as the number of slide components increase). Compare – rotational earth slide, rotational rock slide, translational slide, lateral spread, landslide. SW and DV
- (860) **rotational earth slide**.—The mass movement process, associated sediments (rotational earth slide deposit), or resultant landform characterized by an extremely slow to moderately rapid type of slide, composed of comparatively dry and largely unconsolidated earthy material, portions of which remain largely intact and in which movement occurs along a well-defined, concave shear surface and resulting in a backward rotation of the displaced mass; sediments predominantly fine earth (< 2 mm). The landform may be single, successive (repeated up and down slope), or multiple (as the number of slide components increase). Compare – rotational debris slide, rotational rock slide, translational slide, lateral spread, landslide. SW and DV
- (861) **rotational landslide**.—(not preferred) Use rotational slide.
- (862) **rotational rock slide**.—The mass movement process, associated sediments (rotational rock slide deposit), or resultant landform characterized by an extremely slow to moderately rapid type of slide, composed of comparatively dry and largely consolidated rock bodies, portions of which remain largely intact but reoriented, and in which movement occurs along a well-defined, concave shear surface and resulting in a backward rotation of the displaced mass. The landform may be single, successive (repeated up and down slope), or multiple (as the number of slide components increase). Compare – rotational debris slide, rotational earth slide, translational slide, lateral spread, landslide. SW and DV
- (863) **rotational slide**.—The mass movement process, associated sediments (rotational slide deposit), or resultant landform characterized by an extremely slow to moderately rapid type of slide, composed of comparatively dry and largely soil-rock materials, portions of which remain largely intact and in which movement occurs along a well-defined, concave shear surface and resulting in a backward rotation of the displaced mass. The landform may be single, successive (repeated up and down slope), or multiple (as the number of slide components increase). Compare – rotational debris slide, rotational earth slide, rotational rock slide, translational slide, lateral spread, landslide. SW and DV
- (864) **rotational slump**.—(not recommended) Use rotational slide.
- (865) **rubble**.—An accumulation of loose angular rock fragments, commonly overlying outcropping rock; the unconsolidated equivalent of a breccia. Compare – scree, talus. GG
- (866) **sabkha**.—A flat area of eolian sedimentation and erosion formed under semiarid or arid conditions in interior areas (e.g., on basin floors slightly above playa lake beds (e.g., playa step)) or along coastal areas (e.g., just above intertidal zones), where, through deflation and evaporation, gypsum, halite, or other soluble minerals crystallize at or near the surface to form a thin, irregular mineral crust that is intermittently deflated away. Microbiotic crusts are not extensive and vegetation is very sparse and consists primarily of small, halophytic shrubs (e.g., iodine bush). SW, RF, and GG
- (867) **saddle**.—A low point on a ridge or interfluvium, generally a divide (pass, col) between the heads of streams flowing in opposite directions. Compare – summit, crest. HP
- (868) **sag**.—A small, partially or completely closed depression formed by movement along a strike-slip fault, or by mass movement (i.e., landslide) that may or may not temporarily pond water from impounded drainage or surface runoff. For example, a closed depression formed between a scarp or headwall and an adjacent rotated slump block of a landslide. SW
- (869) **sag pond**.—A small, permanent body of water in a semiclosed or closed depression formed by movement along a strike-slip fault or by mass movement (i.e., landslide) that ponds water from impounded drainage or surface runoff. Also spelled sagpond. SW and GG

- (870) **salt marsh**.—Flat, poorly drained area that is subject to periodic or occasional overflow by salt water, containing water that is brackish to strongly saline, and usually covered with a thick mat of grassy halophytic plants (e.g., a coastal marsh periodically flooded by the sea, or an inland marsh, (or salina) in an arid region and subject to intermittent overflow by salty water). Compare – tidal marsh, mud flat. GG
- (871) **salt pond**.—A large or small body of salt water in a marsh or swamp along the seacoast. GG
- (872) **sand boil**.—An accumulation of sand commonly in the form of a low mound, produced by the expulsion of liquefied sand to the ground surface; sometimes called sand volcanoes (not preferred). Examples are found on top of some landslide deposits (i.e., spreads) or on the upper surface of highly contorted layers of laminated sediments. SW and GG
- (873) **sand dune**.—see dune.
- (874) **sandur**.—(not preferred) Use outwash plain.
- (875) **sand flow**
- (i) A flow of wet sand, as along banks of noncohesive clean sand that is subject to scour and to repeated fluctuations in pore-water pressure due to rise and fall of the tide.
 - (ii) A flow of loose, dry sand, as along the slip face of a sand dune; typically a microfeature. SW, CV, and GG
- (876) **sandhills**.—A region of semistabilized sand dunes or sandy hills, either covered with vegetation or bare, as in north-central Nebraska and the midlands of the Carolinas. GG
- (877) **sand pit**.—A depression, ditch or pit excavated to furnish sand for roads or other construction purposes offsite; a type of borrow pit. SW
- (878) **sand plain**
- (i) [geomorphology] A sand-covered plain, which may originate by deflation of sand dunes, and whose lower limit of erosion is governed by the water table. Also spelled *sandplain*. GG.
 - (ii) [glacial geology] (not preferred – refer to *sandy* outwash plain) A small outwash plain composed chiefly of sand deposited by meltwater streams flowing from a glacier. GG
- (879) **sand ramp**.—A sand sheet blown up onto the lower slopes of a bedrock hill or mountain and forming an inclined plane, sometimes filling small mountain-side valleys and even crossing low passes. Compare – climbing dune, sand sheet. FFP and SW
- (880) **sand ridge**
- (i) (not preferred) An imprecise, generic name for any low ridge of sand, formed at some distance from shore (e.g., submerged (longshore bar) or emergent (barrier beach)).
 - (ii) One of a series of long, wide, extremely low, parallel ridges believed to represent the eroded stumps of former longitudinal sand dunes, as in western Zimbabwe. GG
- (881) **sand sheet**.—A large, irregularly shaped, commonly thin, surficial mantle of eolian sand, lacking the discernible slip faces that are common on dunes. GG
- (882) **sand volcano**.—(not preferred) Use sand boil.
- (883) **sand wedge**.—(not preferred) Refer to ice wedge cast.
- (884) **sandstone**.—Sedimentary rock containing dominantly sand-size clastic particles. HP
- (885) **sanitary landfill**.—A land area where municipal solid waste is buried in a manner engineered to minimize environmental degradation. Commonly the waste is compacted and ultimately covered with soil or other earthy material. Compare – dump. GG
- (886) **saprolite**.—Soft, friable, isovolumetrically weathered bedrock that retains the fabric and structure of the parent rock (Colman and Dethier, 1986) and exhibiting extensive intercrystal and intracrystal weathering. In pedology, saprolite was formerly applied to any unconsolidated residual material underlying the soil and grading to hard bedrock below. Compare – grus, residuum. SW and HP

- (887) **scabland**.—An elevated, flat-lying, basalt-floored area, with little if any soil cover, sparse vegetation, and usually deep, dry channels scoured into the surface, especially by glacial meltwaters such as the Channeled Scablands of eastern Washington. Compare – coulee. GG
- (888) **scalped area**.—A modified slope, feature, or land area where much or all of the natural soil has been mechanically removed (e.g., scraped off) due to construction or other management practices. Compare – truncated soil. SW
- (889) **scarp**.—An escarpment, cliff, or steep slope of some extent along the margin of a plateau, mesa, terrace, or structural bench. A scarp may be of any height. Compare – escarpment. GG
- (890) **scarp slope**.—The relatively steeper face of a cuesta, facing in a direction opposite to the dip of the strata. Compare – dip slope. GG
- (891) **scoria**
- (i) [soils] Vesicular rock fragments ≥ 2 mm in at least one dimension and a specific gravity > 2.0 , or a cindery crust of such material on the surface of andesitic or basaltic lava; the vesicular nature is due to the escape of volcanic gases before solidification; it is usually heavier, darker, and more crystalline than pumice. Compare – cinders, pumice, tephra.
 - (ii) [geology] The same as (a) except no size restrictions are applied. SW
- (892) **scour**.—[geomorphology] The powerful and concentrated clearing and digging action of flowing air, water, or ice, especially the downward erosion by stream water in sweeping away mud and silt on the outside curve of a bend, or during the time of a flood; a process. GG
- (893) **scour and fill**.—[geomorphology] A *process* of alternate excavation and refilling of a channel, as by a stream or the tides, especially occurring in time of flood, when the discharge and velocity of an aggrading stream are suddenly increased, causing the digging of new channels that become filled with sediment when the flood subsides. Compare – cut and fill. GG
- (894) **scour channel**.—A large, groove-like erosional feature in a stream bed swept (scoured) by running water, generally leaving a gravel bottom. GG
- (895) **scree**.—A collective term for an accumulation of coarse rock debris or a sheet of coarse debris mantling a slope. Scree is not a synonym of talus, as scree includes loose rock fragments on slopes without cliffs. Compare – talus, colluvium, mass movement. HP
- (896) **scree slope**.—A portion of a hillside or mountainslope mantled by scree and lacking an upslope rockfall source (i.e., cliff). Compare – talus slope, scree, talus. SW
- (897) **scroll**.—(not preferred) Refer to meander scroll.
- (898) **sea**
- (i) A large inland body of salt water (e.g., the Salton Sea, CA).
 - (ii) A geographic subdivision of an ocean (e.g., the South China Sea). Compare – gulf, ocean, salt pond. GG
- (899) **sea cliff**.—[coastal] A cliff or slope produced by wave erosion, situated at the seaward edge of the coast or the landward side of the wave-cut platform. It may vary from an inconspicuous slope to a high, steep escarpment. GG
- (900) **sediment**.—Material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by water, wind, ice or mass-wasting and has come to rest on the earth's surface either above or below sea level. Sediment in a broad sense also includes materials precipitated from solution or emplaced by explosive volcanism, as well as organic remains (e.g., peat that has not been subject to appreciable transport). HP
- (901) **sedimentary peat**.—An accumulation of organic material that is predominantly the remains of floating aquatic plants (e.g., algae) and the remains and fecal material of aquatic animals, including coprogenous earth. Compare – herbaceous peat, moss peat, woody peat, peat, muck, and mucky peat. SSM

- (902) **sedimentary rock**.—A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under “normal” low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, marine deposits (e.g., sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal). Compare – sediment. HP
- (903) **seep**.—(noun) An area, generally small, where water outflows slowly at the land surface. Flow rates for seeps are too small to be considered as springs, but reflow, lateral subsurface flow, or both keep the surface or near soil saturated during dry periods. SW and GG
- (904) **seif dune**.—A large, sharp-crested, elongated, longitudinal (linear) dune or chain of sand dunes, oriented parallel, rather than transverse (perpendicular), to the prevailing wind. If unmodified, the crest, in profile, commonly consists of a succession of curved slip faces produced by strong, but infrequent cross winds. A seif dune may be as much as 200 m high and from 400 m to more than 100 km long. Compare – longitudinal dune. GG and HP
- (905) **semibolson**.—(colloquial: western United States) A wide desert basin or valley that is drained by an intermittent stream, an externally drained (open) intermontane basin. Compare – bolson. GG
- (906) **semiopen depression**.—A topographically enclosed basin that generally functions as a closed depression and lacks a defined exit channel. Surface water loss may occur by overland flow through a topographic low area or gap in response to large storm events. Semiopen depressions commonly contain small lakes, ponds, or wet meadows dominated by hydric soils (e.g., in karst valleys, or in low areas on marine terraces with < 1% slopes). SW
- (907) **sewage lagoon**.—Any artificial pond or other water-filled excavation for the natural oxidation of sewage or disposal of animal manure. GG
- (908) **shale**.—Sedimentary rock formed by induration of a clay, silty clay, or silty clay loam deposit and having the tendency to split into thin layers (i.e., fissility). HP
- (909) **sheep tracks**.—(not recommended) Use terracettes.
- (910) **shield volcano**.—A volcano having the shape of a very broad, gently sloping dome, built by flows of very fluid basaltic lava or rhyolitic ash flows. Compare – stratovolcano. GG and MA
- (911) **shoal** (noun)
- (i) A relatively shallow place in a stream, lake, sea, or other body of water; a shallows.
 - (ii) A natural, subaqueous ridge, bank, or bar consisting of, or covered by, sand or other unconsolidated material, rising from the bed of a body of water (e.g., estuarine floor) to near the surface. It may be exposed at low water. Compare – reef. SSS and GG
- (912) **shoal [relict]**.—A surficial ridge, bank, or bar consisting of sand or other subaqueous deposit that has become permanently exposed by the retreat or lowering of a proglacial lake or other body of water. Compare – longshore bar [relict]. GG
- (913) **shore**.—The narrow strip of land immediately bordering any body of water, esp. the sea or a large lake; specifically the zone over which the ground is alternately exposed and covered by tides or waves, or the zone between high water and low water. GG
- (914) **shore complex**.—Generally a narrow, elongate area that parallels a coastline, commonly cutting across diverse inland landforms, and dominated by landforms derived from active coastal processes that give rise to beach ridges, washover fans, beaches, dunes, wave-cut platforms, barrier islands, cliffs, etc. SW
- (915) **shoreline**.—The intersection of a specified plane of water with the beach; it migrates with changes of the tide or of the water level. Compare – shore complex, beach, swash zone. GG
- (916) **shoulder**.—The hillslope profile position that forms the convex, erosional surface near the top of a hillslope. If present, it comprises the transition zone from summit to backslope. Compare – summit, crest, backslope, footslope, and toeslope. SW and HP

- (917) **shrub-coppice dune**.—A small, streamlined dune that forms around brush and clump vegetation. GG
- (918) **side slope**.—[geomorphology] A geomorphic component of hills consisting of a laterally planar area of a hillside, resulting in predominantly parallel overland water flow (e.g., sheet wash); contour lines generally form straight lines. Side slopes are dominated by colluvium and slope wash sediments. Slope complexity (downslope shape) can range from simple to complex. Compare – head slope, nose slope, free face, interfluvium, crest, base slope. SW; The slope bounding a drainageway and lying between the drainageway and the adjacent interfluvium. It is generally linear along the slope width. RR
- (919) **sidewall**.—(not preferred) Refer to glacial-valley wall.
- (920) **sill**.—(intrusive rocks) – A tabular, igneous intrusion that parallels the bedding or foliation of the surrounding sedimentary or metamorphic rock. Compare – dike. GG
- (921) **siltite**.—A compact, weakly metamorphosed rock formed by alteration of siltstone, mudstone, or silty shale. Siltite is more indurated than mudstone or shale and lacks either shale fissility or slate-like cleavage. Siltite differs from argillite in that silt-size grains (0.002 to 0.062 mm) dominate the matrix rather than clay-size particles (<0.002 mm). Siltite differs from siltstone, mudstone, or shale in that it exhibits very low to low grade metamorphic or diagenetic layer silicate and feldspar alteration to sericite, chlorite, and albite (subgreenschist to greenschist metamorphic facies) (Maxwell, 1973; Kidder, 1987). SW
- (922) **siltstone**.—An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay. GG
- (923) **sinkhole**.—A closed, circular or elliptical depression, commonly funnel-shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, salt) (*solution sinkhole*) or by collapse of underlying caves within bedrock (*collapse sinkhole*); diameters range from a few meters to as much as 1000 m. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography. Synonym (not preferred) – doline. Compare – karst valley, interior valley, cockpit. SW and WW
- (924) **sinkhole karst**.—A landscape dominated by subsurface drainage and sinkholes (dolines) that range widely in sizes and density; the most common type of karst in upland areas of temperate regions (e.g., Highland Rim of Tennessee, northern Florida, southwestern Missouri, etc.); also called doline karst (not preferred). Compare – fluviokarst, pavement karst, glaciokarst, karst. SW, WW, and GG
- (925) **skid trail**.—Irregularly spaced, roughly linear to radial depressions or small mounds associated with shallow to deep soil disturbance caused by dragging logs across a slope from where they were cut down to a central processing area such as a log landing during timber harvest operations. SW
- (926) **slackwater**.—A quiet part of, or a still body of water in, a stream. Compare – backswamp. GG
- (927) **slickrock**.—(colloquial: southwestern United States) A barren, highly smoothed and subrounded bedrock pavement with considerable, irregular topography sculpted primarily by wind in an arid or semiarid climate; a type of rock outcrop commonly formed on massive sandstone bedrock formations (e.g., Navajo, Wingate, or Entrada Sandstone), especially on summits of ridges and near the rim of plateaus, mesas, and cuestas. Compare – pavement karst. SW
- (928) **slickensides [pedogenic]**.—Shrink-swell produced slip faces on pedo-structure faces (e.g., wedges, bowls); grooves, striations, glossy sheen. Most evident in (but not limited to) Vertisols. Compare – slickensides [geogenic]. SW

- (929) **slickensides [geogenic].**—Vertical or oblique, roughly planar slip face produced by external forces such as tectonics (e.g., fault), or mass movement (e.g., large slump blocks; grooves, striations on slip face). Compare – slickensides [pedogenic]. SW
- (930) **slide**
- (i) A category of mass movement processes, associated sediments (slide deposit), or resultant landform (e.g., rotational slide, translational slide, and snowslide) characterized by a failure of earth, snow, or rock under shear stress along one or several surfaces that are either visible or may reasonably be inferred. The moving mass may or may not be greatly deformed, and movement may be rotational (rotational slide) or planar (translational slide). A slide can result from lateral erosion, lateral pressure, weight of overlying material, accumulation of moisture, earthquakes, expansion owing to freeze-thaw of water in cracks, regional tilting, undermining, fire, and human agencies. Compare – fall, topple, lateral spread, flow, complex landslide. SW and DV.
 - (ii) The track of bare rock or furrowed earth left by a slide.
 - (iii) The mass of material moved in or deposited by a slide. Compare – fall, flow, complex landslide, landslide. SW and GG
- (931) **slip face.**—The steeply sloping surface on the lee side of a dune, standing at or near the angle of repose of loose sand, and advancing downwind by a succession of slides wherever that angle is exceeded. GG
- (932) **slip surface.**—A landslide displacement surface, often slickensided and striated, or brecciated, and subplanar. It is best exhibited in argillaceous materials and in those materials that are highly susceptible to clay alteration when granulated; also called shear surface (not preferred). Compare – main scarp, landslide, escarpment. GG
- (933) **slope.**—(also called slope gradient or gradient) The inclination of the land surface from the horizontal. Percent slope is the vertical distance divided by the horizontal distance, then multiplied by 100. SW
- (934) **slope alluvium.**—Sediment gradually transported down mountain or hill slopes primarily by nonchannel alluvial processes (i.e., slope wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size, specific gravity, or both of rock fragments and may be separated by stone lines. Sorting of rounded or subrounded pebbles or cobbles and burnished peds distinguish these materials from unsorted colluvial deposits. Compare – colluvium, slope wash. SW and HP
- (935) **slope wash.**—A collective term for nonfluvial, incipient alluvial *processes* (e.g., overland flow, minor rills) that detach, transport, and deposit sediments down hill and mountain slopes. Related sediments (*slope alluvium*) exhibit nominal sorting or rounding of particles, peds, etc., and lateral sorting downslope on long slopes; stratification is crude and intermittent and readily destroyed by pedoturbation and frost action. Also called *slope wash processes*. Compare – slope alluvium, colluvium, valley-side alluvium. SW
- (936) **slot canyon.**—A long, narrow, deep and tortuous channel or drainageway with sheer rock walls eroded into sandstone or other sedimentary rocks, especially in the semiarid western United States (e.g., Colorado Plateau); subject to flash flood events; depth to width ratios exceed 10:1 over most of its length and can approach 100:1; commonly containing unique ecological communities distinct from the adjacent, drier uplands. SW
- (937) **slough**
- (i) A small marsh, especially a marshy area lying in a local, shallow, closed depression on a piece of dry land, as on the prairie of the Midwestern United States.
 - (ii) A term used, especially in the Mississippi Valley, for a creek or sluggish body of water in a tidal flat, flood plain, or coastal marshland. Compare – bayou, oxbow.

- (iii) A sluggish channel of water, such as a side channel of a river, in which water flows slowly through low, swampy ground, as along the Columbia River, or a section of an abandoned river channel that may contain stagnant water and occurs in a flood plain or delta.
- (iv) (not preferred) An area of soft, miry, muddy or waterlogged ground, a place of deep mud. GG
- (938) **sloughed till**.—(not recommended) Use flow till.
- (939) **slump**.—(not recommended: obsolete) Refer to rotational slide.
- (940) **slump block**.—A mass of material torn away as a coherent unit during a landslide; a largely intact but displaced and commonly reoriented body of rock or soil. SW and GG
- (941) **slump till**.—(not recommended) Use flow till.
- (942) **snowfield**
 - (i) A broad expanse of terrain covered with snow, relatively smooth and uniform in appearance, occurring usually at high latitudes or in mountainous regions above the snowline and persisting throughout year.
 - (ii) A region of permanent snow cover, as at the head of a glacier; the accumulation area of a glacier. Compare – glacier. GG
- (943) **soil creep**.—(not preferred) Refer to creep.
- (944) **soil fall**.—The mass movement process, associated sediments (soil fall deposit), or resultant landform characterized by a rapid type of *fall* involving the relatively free, downslope movement or collapse of detached, unconsolidated soil material that falls freely through the air (lacks an underlying slip face); sediments predominantly fine earth (< 2 mm); common along undercut stream banks. Also called earth fall and (not recommended) debris fall. Compare – rockfall, debris fall, topple, landslide. SW
- (945) **soil ripples**.—(not recommended) Use terracettes.
- (946) **solifluction**.—Slow, viscous downslope flow of water-saturated regolith. Rates of flow vary widely. The presence of frozen substrate or even freezing and thawing is not implied in the original definition. However, one component of solifluction can be creep of frozen ground. The term is commonly applied to processes operating in both seasonal frost and permafrost areas. Compare – creep. NRC
- (947) **solifluction deposit**.—A deposit of nonsorted, water-saturated, earthy material locally derived that is moving or has moved down slope en masse, caused by the melting of seasonal frost or permafrost, resulting in an over-thickened leading edge of linear, lobate, or irregular forms that loosely parallel or obliquely follow the slope contour; may be surficially armored by rock fragments on the leading edge. SW
- (948) **solifluction lobe**.—An isolated tongue-shaped feature up to 25 m wide and 150 m or more long, formed by rapid solifluction on certain sections of a slope showing variations in gradient. This feature commonly has a steep (e.g., 15°- 60°) front and a relatively smooth upper surface. NRC
- (949) **solifluction sheet**.—A broad deposit of nonsorted, water-saturated, locally derived material that is moving or has moved downslope, en masse. Stripes are commonly associated with solifluction sheets. Compare – stripe. NRC
- (950) **solifluction terrace**.—A low step with a straight or lobate front, the latter reflecting local differences in rate of flow. A solifluction terrace may have bare mineral soil on the upslope part and “folded under” organic matter in both the seasonally thawed and the frozen soil. NRC
- (951) **solution chimney**.—Small diameter (e.g., 1-5 m), irregular, hollow, vertical shaft 5-10+ m deep on karst landscapes, typically covered with a thin layer of soil or plant debris that can collapse and expose the shaft to the surface; represents a significant safety hazard. Locally called “stove-pipe sinkholes” in Florida (not recommended). Compare – solution pipe. SW

- (952) **solution corridor**.—A straight, open trench about 3 to 10 m wide in a karst area, formed by vertical and lateral solution zones developed along bedrock fractures; also called (not preferred) bogaz, zanjón (Puerto Rico). Compare – cutter, solution fissure, karst valley. SW and GG
- (953) **solution fissure**.—One of a series of vertical open cracks commonly < 0.5 m wide dissolved along joints or fractures, separating limestone pavement (pavement karst) into blocks (clints); also called kluftkarren (not preferred). Compare – cutter, solution corridor, karren. SW, GG, and WW
- (954) **solution pipe**.—A subsurface, vertical, cylindrical or cone-shaped hole, formed by dissolution in soluble bedrock (e.g., limestone) and often without surface expression, that is filled with detrital material (e.g., soil) and that serves as a bypass route for internal water flow. SW and GG
- (955) **solution platform**.—A broad, nearly horizontal intertidal surface (modern or relict) formed across carbonate rocks, produced primarily by solution with contributions by intertidal weathering and biological erosion and deposition, not by abrasion. Compare – wave-cut platform. SW and GG
- (956) **solution sinkhole**.—The most common type of sinkhole, caused by dissolution that forms fissures or a chimney and a depression in the bedrock surface that grows when closely spaced fissures underneath it enlarge and coalesce. Compare – collapse sinkhole. SW, WW, and GG
- (957) **solution valley**.—(not preferred) Use karst valley.
- (958) **sorted circle**.—A type of patterned ground whose mesh (shape) is largely circular and has a sorted appearance commonly due to a border of rock fragments surrounding finer material, occurring either singly or in groups. Diameters range from a few centimeters to more than 10 meters. The rock fragment border may be 35 cm high and 8 to 12 cm wide. Compare – patterned ground. GG and NRC
- (959) **sorted polygon**.—refer to patterned ground.
- (960) **sound**
- (i) A relatively long, narrow waterway connecting two larger bodies of water (as a sea or lake with the ocean or another sea) or two parts of the same water body, or an arm of the sea forming a channel between the mainland and an island (e.g., Puget Sound, WA); it is generally wider and more extensive than a strait [coast].
 - (ii) A long, large, rather broad inlet of the ocean, generally extending parallel to the coast (e.g., Long Island Sound, NY).
 - (iii) A lagoon along the southeast coast of the United States (e.g., Pamlico Sound, NC).
 - (iv) A long bay or arm of a lake; a stretch of water between the mainland and a long island in a lake. Compare – sound, lagoon, gulf, ocean. GG
- (961) **spatter cone**.—A small, steep-sided cone (e.g., 3 to 15 m high, or more) built up on a lava flow, usually pahoehoe, composed of clots of lava ejected with escaping gases from a vent or fissure that spatters and congeals as it hits the ground to form a small cone; rougher lava clots than a spiracle. Compare – spiracle. SW
- (962) **specific gravity**.—The ratio of a material's density to that of water (material weight in air ÷ (weight in air - weight in water)). Used to differentiate different kinds of volcaniclastics and other materials. SW
- (963) **spiracle**.—[volcanic] A small tubular opening or chimney formed by fluid lava congealing and mounding around a fumarolic vent in a basaltic lava flow, usually about 1 m in diameter and up to 5 m high, although in the northwestern United States where spiracles are common they generally are 10 m in diameter and 12 m high or more; formed by a gaseous explosion in lava that is still fluid, probably due to steam generated from underlying wet material;

- smoother lava clots and drapes than a spatter cone. Compare – spatter cone. SW, GS, and GG
- (964) **spit**
- (i) A small point or low tongue or narrow embankment of land, commonly consisting of sand or gravel deposited by longshore transport and having one end attached to the mainland and the other terminating in open water, usually the sea; a finger-like extension of the beach.
 - (ii) A relatively long, narrow shoal or reef extending from the shore into a body of water. GG
- (965) **splay**.—(not preferred) Refer to flood-plain splay.
- (966) **spoil bank**.—A bank, mound, or other artificial accumulation of rock debris and earthy dump deposits removed from ditches, strip mines, or other excavations. Compare – dredge spoil bank. SW
- (967) **spoil pile**
- (i) A bank, mound, or other artificial accumulation composed of spoil (e.g., an embankment of earthy material removed from a ditch and deposited alongside it). Compare – dredge spoil bank.
 - (ii) A pile of refuse material from an excavation or mining operation (e.g., a pile of dirt removed from, and stacked at the surface of a mine in a conical heap or in layers). SW and GG
- (968) **sporadic permafrost**.—The area near the southern boundary of discontinuous permafrost where permafrost occurs in isolated patches or islands. Compare – continuous permafrost, discontinuous permafrost. NRC
- (969) **spread**.—see lateral spread.
- (970) **spur**.—[geomorphology] A subordinate ridge or lesser elevation that projects sharply from the crest or side of a hill, mountain, or other prominent range of hills or mountains. GG
- (971) **spur ridge**.—(not recommended) Use spur.
- (972) **stack [coast]**.—An isolated pillar-like rocky island or mass near a cliffy shore, detached from a headland by wave erosion assisted by weathering; especially one showing columnar structure with horizontal stratification. Examples occur along the Oregon coast and the Lake Superior shore. SW and GG
- (973) **stack [geom.]**.—A steep-sided mass of rock rising above its surroundings on all sides from a slope or hill. Compare – knob. GG
- (974) **stagnant ice**
- (i) Glacial ice that is not flowing forward and is not receiving material from an accumulation area.
 - (ii) Detached blocks of ice left behind by a retreating glacier, usually buried in a moraine and melting very slowly. GG
- (975) **star dune**.—A large, isolated sand dune whose base, in plan view, resembles a star, with sharp-crested ridges converging from basal points to a central peak that may be as high as 100 m above the surrounding plain. It tends to remain fixed for centuries in an area where the wind blows from all directions. Compare – dune. GG
- (976) **State Physiographic Area**.—An area of relatively local extent and whose parts are similar in geologic structure and climate and that has consequently had a unified geomorphic history, and whose pattern of relief or landforms differ significantly from that of adjacent areas (i.e., a subset within a Physiographic Section (*the fourth-highest level in the Physiographic Location part of the Geomorphic Description System*)). SW
- (977) **steptoe**.—An island-like area of older rock surrounded by a lava flow. Compare – kipuka. HP

- (978) **stock**.—A relatively small, concordant and/or discordant plutonic rock body exposed at the land surface, with an aerial extent < 40 sq. mi. (100 km²) and no known bottom. Compare – batholith. GG
- (979) **stone line**.—In vertical cross-section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments, commonly a gravel- or cobble-sized lag concentration that drape across a former topographic surface and later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface. It can best be observed as outcrops in natural and artificial cuts. Also called a carpedolith. Compare – erosional pavement, desert pavement. SW and RR
- (980) **stone net**.—(not preferred) Refer to patterned ground. Synonym – sorted polygon, stone polygon.
- (981) **storm surge**.—An abnormal, sudden rise of sea level along an open coast during a storm, caused primarily by onshore-wind stresses, or less frequently by atmospheric pressure reduction, resulting in water piled up against the coast. It is most severe when accompanied by a high tide. GG
- (982) **strait**.—A relatively narrow waterway connecting two larger bodies of water, as the Straits of Mackinac linking Lake Michigan and Lake Huron; a large channel. Compare – sound. GG
- (983) **strandline**
- (i) The shoreline, especially a former (relict) shoreline now elevated above the present water level, that commonly appears as a bench or line wrapping around the landscape at a common elevation. SW.
 - (ii) A beach, especially one raised above the present sea or lake level. GG
- (984) **strand plain**.—A prograded shore built seaward by waves and currents, and continuous for some distance along the coast. It is characterized by subparallel beach ridges and swales, in places with associated dunes. GG
- (985) **strath terrace**.—A type of stream terrace, formed as an erosional surface cut on bedrock and thinly mantled (e.g., < 3 m) with stream deposits (alluvium), commonly with a gravel lag deposit immediately above the bedrock. SW and GG
- (986) **stratified**.—(adjective) Formed, arranged, or laid down in layers. The term refers to geologic deposits. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata. HP
- (987) **stratigraphy**.—The branch of geology that deals with the definition and interpretation of layered earth materials; the conditions of their formation; their character, arrangement, sequence, age, and distribution; and especially their correlation by the use of fossils and other means. The term is applied both to the sum of the characteristics listed and a study of these characteristics. HP
- (988) **stratovolcano**.—A volcano that is constructed of alternating layers of lava and pyroclastic deposits, along with abundant dikes and sills. Viscous, acidic lava may flow from fissures radiating from a central vent, from which pyroclastics are ejected. Compare – shield volcano. GG
- (989) **stream**
- (i) Any body of running water that moves under gravity to progressively lower levels, in a relatively narrow but clearly defined channel on the ground surface, in a subterranean cavern, or beneath or in a glacier. It is a mixture of water and dissolved, suspended, or entrained matter.
 - (ii) A term used in quantitative geomorphology interchangeably with channel. Compare – river. GG

- (990) **stream channel**.—(not preferred) Refer to channel.
- (991) **stream order**.—An integer system applied to tributaries (stream segments) that documents their relative position within a drainage basin network as determined by the pattern of its confluences. The order of the drainage basin is determined by the highest integer. Several systems exist. In the Strahler system, the smallest unbranched tributaries are designated order 1; the confluence of two first-order streams produces a stream segment of order 2; the junction of two second-order streams produces a stream segment of order 3, etc. GG
- (992) **stream terrace**.—One, or a series of flat-topped landforms in a stream valley that flank and are parallel to the stream channel, originally formed by a previous stream level, and representing remnants of an abandoned flood plain, stream bed, or valley floor produced during a past state of fluvial erosion or deposition (i.e., currently very rarely or never flooded; inactive cut and fill, scour and fill, or both processes). Erosional surfaces cut into bedrock and thinly mantled with stream deposits (alluvium) are called “strath terraces.” Remnants of constructional valley floors thickly mantled with alluvium are called alluvial terraces. Compare – alluvial terrace, flood-plain step, strath terrace, terrace. HP and SW
- (993) **strike**.—[structural geology] The compass direction or trend taken by a structural surface (e.g., a bed or fault plane) as it intersects the horizontal; used in combination with “dip” to describe the orientation of bedrock strata. SW and GG
- (994) **strike valley**.—A subsequent valley eroded in, and developed parallel to the strike of, underlying weak strata, such as a cuesta; a valley that commonly, but not necessarily contains a stream valley. SW and GG
- (995) **string bog**.—A peatland with roughly parallel, narrow ridges of peat dominated by peat vegetation interspersed with slight depressions, many of which contain shallow pools. The ridges are at right angles to low ($< 2^\circ$) slopes. They are typically 1 to 3 m wide, up to 1 m high and may be over 1 km long. The ridges are slightly elevated and are better drained allowing shrubs and trees to grow. They are best developed in areas of discontinuous permafrost. NRC
- (996) **stripe**.—A type of patterned ground; one of the alternating bands of fine and coarse surface material, or of rock or soil and vegetation-covered ground, commonly found on steeper slopes. It is usually straight, but may be sinuous or branching. Compare – patterned ground. GG
- (997) **stoss**.—(adjective) Said of the side of the hill or knob that faces the direction from which an advancing glacier or ice-sheet moved; facing the upstream (“up-ice”) side of a glacier, and most exposed to its abrasive action. Compare – lee, stoss and lee, crag and tail. GG
- (998) **stoss and lee**.—An arrangement of small hills or prominent rocks, in a strongly glaciated area, having gentle slopes on the stoss (“up-ice”) side and somewhat steeper, plucked slopes on the lee (“down-ice”) side. This arrangement is the opposite of crag and tail. Compare – crag and tail, drumlin, drumlinoid ridge, flute. GG
- (999) **structural back slope**.—(not recommended) Use dip slope.
- (1000) **structural bench**.—A shelf or step-like landform produced or controlled by erosion resistant, horizontally-bedded rock. Erosion removes overlying weaker rock or sediment forming a nearly level to gently inclined surface that rests on a relatively resistant strata or rock that ascends to a higher slope or platform. Structural benches may occur as a single feature or as a series of stepped-surfaces where alternating weak and resistant strata exist. Due to erosion resistance, structural benches may have little or no geomorphic implication regarding fluvial deposition, past erosion cycles or former stream, basin, or base levels. Compare – mesa, pediment, ledge; see scarp. SW
- (1001) **subaerial**.—(adjective) Said of conditions and processes, such as erosion, that exist or operate in the open air on or immediately adjacent to the land surface; or of features and

- materials, such as eolian deposits, that are formed or situated on the land surface. Compare – subaqueous. GG
- (1002) **subaqueous**.—(adjective) Said of conditions and processes, features or deposits, that exist or operate in or under water. Compare – subaerial. SSS and GG
- (1003) **subaqueous landscapes**.—Permanently submerged areas that are fundamentally the same as subaerial (terrestrial) systems in that they have a discernable topography composed of mappable, subaqueous landforms. SSS
- (1004) **subaqueous soil**.—Soil that forms in sediment found in shallow, permanently flooded environments. Excluded from the definition of these soils are any areas “permanently covered by water too deep (typically greater than 2.5 m) for the growth of rooted plants.” SSS
- (1005) **subglacial**
- (i) Formed or accumulated in or by the bottom parts of a glacier or ice sheet; said of meltwater streams, till, moraine, etc.
 - (ii) Pertaining to the area immediately beneath a glacier, as subglacial eruption or subglacial drainage. GG
- (1006) **subglacial flow till**.—refer to flow till.
- (1007) **subglacial melt-out till**.—refer to melt-out till.
- (1008) **subglacial till**.—Till deposited beneath, in, or by the bottom part of a glacier or ice sheet; subglacial till types include lodgment till, subglacial flow till, and subglacial melt-out till. Compare – till and supraglacial till. SW and GM
- (1009) **submerged back-barrier beach**.—A permanently submerged extension of the back-barrier beach that generally parallels the boundary between estuary and the barrier island. Compare – submerged mainland beach, barrier beach. SSS
- (1010) **submerged mainland beach**.—A permanently submerged extension of the mainland beach that generally parallels the boundary between an estuary or lagoon and the mainland. Compare – submerged back-barrier beach, barrier beach. SSS
- (1011) **submerged point bar [coast]**.—The submerged extension of an exposed (subaerial) point bar. SSS
- (1012) **submerged wave-built terrace**.—A subaqueous, relict depositional landform originally constructed by river or longshore sediment deposits along the outer edge of a wave-cut platform and later submerged by rising sea level or subsiding land surface. Compare wave – built terrace, wave-cut platform. GG
- (1013) **submerged wave-cut platform**.—A subaqueous, relict erosional landform that originally formed as a wave-cut bench and abrasion platform from coastal wave erosion and later submerged by rising sea level or subsiding land surface. Compare – wave-built terrace, wave-cut platform. GG
- (1014) **submerged-upland soil**.—Mineral or organic soil that primarily formed in a subaerial setting but is now under water, commonly in intertidal or subaqueous settings. Inundation could occur for various reasons (e.g., sea-level rise in a marine or estuarine system or ponding from a dam). In intertidal settings, tidal marsh soils may occur above former subaerial soils (see *submerged-upland tidal marsh*). In subaqueous settings (permanently submerged), submerged-upland soils typically occur below a cap of subaqueous soil forming in the subaqueous environment. SW
- (1015) **submerged-upland tidal marsh**.—An extensive nearly level, intertidal landform composed of unconsolidated sediments (clays, silts, sand and organic materials, or some combination of these), a resistant root mat, vegetated dominantly by hydrophytic (water loving) plants. The mineral sediments largely retain pedogenic horizonation and morphology (e.g., argillic horizons) developed under subaerial conditions prior to submergence due to sea level rise; a type of tidal marsh. Compare – tidal marsh. SW

- (1016) **subsoil**.—Pedogenically altered, subsurface soil horizons below a topsoil. Frequently characterized by developed soil structural units, deposition of illuvial clays and oxides, and precipitation of soluble soil constituents (carbonates, gypsum). (Generally B horizons, but may include subsurface organic horizons, and also includes pedogenically cemented layers such as Bkkm, Bqm, Bsm, Byym, Bzm) (also topsoil, substratum)
- (1017) **substratum**.—Relatively unaltered and unconsolidated, earthy materials below topsoil or subsoil showing little or no evidence of pedogenic features other than reduction (gleying). Generally consists of C horizons, but may include L and M horizons., but is exclusive of consolidated bedrock layers –R horizons, weathered bedrock layers – Cr horizons, or pedogenically cemented layers. (also topsoil, subsoil)
- (1018) **subtidal**.—(adjective) Continuous submergence of substrate in an estuarine or marine ecosystem; these areas are below the mean low tide. Compare – intertidal. SSS and CC
- (1019) **subtidal wetlands**.—Permanently inundated areas within estuaries dominated by subaqueous soils and submerged aquatic vegetation. SSS
- (1020) **suburban anthroscape**.—A human-modified “landscape” with substantial, permanent alterations to the physical shape of the land, its internal stratigraphy, or both due to management for habitation or commerce that have substantively altered water flow and sediment transport across and within the regolith. This includes extensive areas dominated by nominally or nonmodified soils in greenspace (yards, parks, riparian buffers), with substantial but secondary areas of impervious surfaces, buildings and roads. Commonly excludes areas of minor alterations (e.g. shallow landscaping) that are easily obscured or obliterated by natural bio-, pedo-, or cryoturbation. Compare –hillslope terrace anthroscape, and urban anthroscape. SW
- (1021) **summit**
- (i) The topographically highest position of a hillslope profile with a nearly level (planar or only slightly convex) surface. Compare – shoulder, backslope, footslope, and toeslope, crest.
 - (ii) A general term for the top, or highest area of a landform such as a hill, mountain, or tableland. It usually refers to a high interfluvial area of relatively gentle slope that is flanked by steeper slopes, e.g., mountain fronts or tableland escarpments. HP
- (1022) **superglacial**.—(not recommended) Refer to supraglacial.
- (1023) **supraglacial**.—Carried upon, deposited from, or pertaining to the top surface of a glacier or ice sheet; said of meltwater streams, till, drift, etc. GG
- (1024) **supraglacial debris-flow sediment**.—(not preferred) Refer to till.
- (1025) **supraglacial flow till**.—refer to flow till.
- (1026) **supraglacial melt-out till**.—refer to melt-out till.
- (1027) **supraglacial till**.—Till deposited on top of or within the upper part of a glacier or ice sheet. Melting of glacial ice deposits supraglacial till atop subjacent material, which forms topographic highs on a resultant landscape. Supraglacial till types include supraglacial flow till and supraglacial melt-out till. Compare – till and subglacial till. SW and GM.
- (1028) **surface mine**.—A depression, open to the sky, resulting from the surface extraction of earthy material (e.g., soil and fill) or bedrock material (e.g., coal). Compare – borrow pit, openpit mine, quarry. SW
- (1029) **swale**
- (i) A shallow, open depression in unconsolidated materials that lacks a defined channel but can funnel overland or subsurface flow into a drainageway. Soils in swales tend to be moister and thicker (cumulic) compared to surrounding soils. SW.
 - (ii) A small, shallow, typically closed depression in an undulating ground moraine formed by uneven glacial deposition; Compare – swell-and-swale topography.

- (iii) (not preferred; refer to interdune) A long, narrow, generally shallow, trough-like depression between two beach ridges, and aligned roughly parallel to the coastline. GG
- (1030) **swallow hole**.—A closed depression or doline into which all or part of a stream disappears underground. GG
- (1031) **swamp**.—An area of low, saturated ground, intermittently or permanently covered with water, and predominantly vegetated by shrubs and trees, with or without the accumulation of peat. Compare – marsh, bog, fen. GG
- (1032) **swash zone**.—The sloping part of the beach that is alternately covered and uncovered by the uprush of waves, and where longshore movement of water occurs in a zigzag (upslope-downslope) manner. Compare – shoreline. GG
- (1033) **swell**.—(not recommended) Refer to swell-and-swale topography.
- (1034) **swell and swale topography**.—A local scale topography composed of small, well-rounded hillocks and shallow, closed depressions irregularly spaced across low-relief ground moraine (slopes generally 2-6%); the effect is a subdued, irregularly undulating surface that is common on ground moraines. Microelevational differences generally range from < 1 to < 5 m. SW
- (1035) **syncline**
 - (i) [landform] A unit of folded strata that is concave upward whose core contains the stratigraphically younger rocks, and occurs at the earth's surface. In a single syncline, beds forming the opposing limbs of the fold dip toward its axial plane. Compare – monocline, syncline, fold. SW and HP
 - (ii) [structural geology] A fold, at any depth, generally concave upward whose core contains the stratigraphically younger rocks. GG
- (1036) **tableland**.—A general term for a broad upland mass with nearly level or undulating summit area of large extent and steep side slopes descending to surrounding lowlands (e.g., a large plateau). Compare – plateau, mesa, cuesta. HP
- (1037) **talff**.—[geomorphology] A geomorphic component of flat plains (e.g., lake plain, low coastal plain, low-gradient till plain) consisting of an essentially flat (e.g., 0-1% slopes) and broad area dominated by closed depressions and a nonintegrated or poorly integrated drainage system. Precipitation tends to pond locally and lateral transport is slow both above and below ground, which favors the accumulation of soil organic matter and a retention of fine earth sediments; better drained soils are commonly adjacent to drainageways. Compare – rise. SW
- (1038) **talus**.—Rock fragments of any size or shape (usually coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding. Compare – talus slope, colluvium, mass movement, scree. GG
- (1039) **talus cone**.—A steep (e.g., 30-40°), cone-shaped landform at the base of a cliff or escarpment that heads in a relatively small declivity or ravine, and composed of poorly sorted rock and soil debris that has accumulated primarily by episodic rockfall or, to a lesser degree, by slope wash. Finest material tends to be concentrated at the apex of the cone. Not to be confused with an *alluvial cone*, a similar feature but of fluvial origin, composed of better-stratified and more-sorted material, and that tapers up into a more extensive drainageway. Compare – alluvial cone, beveled base, talus slope. SW
- (1040) **talus slope**.—a portion of a hillslope or mountainslope mantled by talus and lying below a rockfall source (e.g., cliff). Compare – scree slope, scree, talus. Compare – beveled base. SW
- (1041) **tank**.—(colloquial: southwestern United States) A natural depression or cavity in impervious rocks in which water collects and remains for the greater part of the year. GG

- (1042) **tarn**.—A relatively deep, steep-banked lake or pool occupying an ice-gouged rock basin amid glaciated mountains. A cirque lake. GG
- (1043) **tephra**.—A collective, general term for any and all clastic materials, regardless of size or composition, ejected from a vent during a volcanic eruption and transported through the air, including ash (volcanic; < 2 mm), blocks (volcanic; > 64 mm), cinders (2-64 mm), lapilli (2-76 mm and specific gravity > 2.0), pumice (> 2 mm and specific gravity < 1.0), and scoria (> 2 mm and specific gravity < 2.0). Tephra, unlike many volcanoclastic terms, does not denote properties of composition, vesicularity, or grain size. SW
- (1044) **terminal moraine**.—An end moraine that marks the farthest advance of a glacier and usually has the form of a massive arcuate or concentric ridge, or complex of ridges, underlain by till and other drift types. Compare – end moraine, recessional moraine, ground moraine. HP and GG
- (1045) **terrace**.—[geomorphology] A step-like surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, or lake or sea shore. The term is usually applied to both the relatively flat summit surface (tread), cut or built by stream or wave action, and the steeper descending slope (scarp, riser), graded to a lower base level of erosion. Compare – stream terrace, flood-plain step. HP. [soil survey] Practically, terraces are considered to be generally flat alluvial areas above the 100 yr. flood stage. SW
- (1046) **terrace [soil survey]**.—not used except as an informal abbreviation (shorthand) for stream terrace. Practically, terraces are considered to be generally flat alluvial areas above the 100-year flood stage. SW
- (1047) **terrace remnant**.—A stream terrace eroded and dissected to such an extent that it occurs as a scattered and isolated geomorphic surface generally on interfluve noses, bounded by erosional slopes or valley sides above a younger, more continuous stream terrace. A continuous tread surface no longer exists, but alluvium is present in or below the soil profile. In contrast to a paleoterrace, a terrace remnant corresponds to the present-day drainage system. Compare – stream terrace. SW
- (1048) **terrace slope**.—(not recommended) Use riser.
- (1049) **terraces**.—Small, irregular step-like forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock such as sheep or cattle. Synonyms (not preferred) – catstep, sheep or cattle track. HP
- (1050) **terrain**.—A generic name for a tract or region of the earth's surface considered as a physical feature, an ecological environment, or a site of some planned human activity. GG
- (1051) **Tertiary**.—A period of the Cenozoic Era of geologic time (from 65 to 1.6 million years ago). The Tertiary epoch and series subdivisions comprise, by increasing age, the Pliocene, Miocene, Oligocene, Eocene, and Paleocene. HP
- (1052) **thalweg**.—[geomorphology] The line of continuous, maximum descent from any point on a land surface (e.g., the line connecting the lowest points along the bed of a stream or the line crossing all contour lines at right angles). GG
- (1053) **thaw-sensitive permafrost**.—Perennially frozen ground that, upon thawing, will experience significant thaw settlement and suffer loss of strength to a value significantly lower than that for similar material in an unfrozen condition. Compare – thaw-stable permafrost. NRC
- (1054) **thaw-stable permafrost**.—Perennially frozen ground that, upon thawing, will not experience either significant thaw settlement or loss of strength. Compare – thaw-sensitive permafrost. NRC
- (1055) **thermokarst**.—Karst-like topographic features produced in a permafrost region by local melting of ground ice and subsequent settling of the ground. GG

- (1056) **thermokarst depression**.—A hollow in the ground resulting from subsidence following the local melting of ground ice in a permafrost region. GG
- (1057) **thermokarst drainage pattern**.—Drainage patterns that form polygonal and hexagonal shapes with streams that may connect rounded depressions, exhibiting a beaded appearance; developed in poorly drained, fine-grained sediments and in organic materials in regions of permafrost. Freezing causes many cracks to develop; thawing causes slumping, settlement, and depressions. This type of drainage pattern with its associated hexagons and beaded ponds indicates the existence or previous presence of permafrost conditions. SW and WA
- (1058) **thermokarst lake**.—Lake or pond produced in a permafrost region by melting of ground ice. HP
- (1059) **tidal flat**.—An extensive, nearly horizontal, barren or sparsely vegetated tract of land that is alternately covered and uncovered by the tide, and consists of unconsolidated sediment (mostly clays, silts, sands and organic materials, or some combination of these). Compare – tidal marsh, wind-tidal flat. GG
- (1060) **tidal inlet**.—Any inlet through which water alternately floods landward with the rising tide and ebbs seaward with the falling tide. Compare – inlet, relict tidal inlet. GG
- (1061) **tidal inlet [relict]**.—A channel remnant of a former tidal inlet. The channel was cutoff or abandoned by infilling from migrating shore sediments. Compare – inlet, tidal inlet. SSS
- (1062) **tidal marsh**.—An extensive, nearly level marsh bordering a coast (as in a shallow lagoon, sheltered bay or estuary) and regularly inundated by high tides; formed mostly of unconsolidated sediments (e.g., clays, silts, sands and organic materials, or some combination of these), and the resistant root mat of salt tolerant plants; a marshy tidal flat. Compare – tidal flat. SW and GG
- (1063) **till**.—[glacial] Dominantly unsorted and unstratified drift, generally unconsolidated and deposited directly by a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders; rock fragments of various lithologies are imbedded within a finer matrix that can range from clay to sandy loam. Compare – supraglacial till, subglacial till, flow till, lodgment till, melt-out till, drift, moraine. SW and GG
- (1064) **till-floored lake plain**.—[soil survey] A glaciated land area that has characteristics of a till plain, but that was also inundated by a glacial lake. The area possesses a gently undulating till-topography, rather than a distinctive, low-relief lake plain surface, and has thin (e.g., $\approx 1\text{--}3$ m), continuous or discontinuous lacustrine sediment atop the till. Topography that once existed as islands may exhibit shore features (e.g., wave-cut scarps, strandlines, beach deposits). SW
- (1065) **till plain**.—An extensive, flat to gently undulating area underlain predominantly by till and bounded on the distal end by subordinate recessional or end moraines. Compare – till, ground moraine. SW
- (1066) **tillage mound**.—Refer to interfurrow.
- (1067) **tilted fault block**.—A fault block that has become tilted, perhaps by rotation on a hinge line (fault). Compare – fault-line scarp. GG
- (1068) **toe**.—The lowest, usually curved margin of displaced material of a landslide, most distant from the main scarp. Commonly it has an irregular surface that has ripples and may be breached by radial cracks or gaps. Compare – main scarp, minor scarp. CV and SW
- (1069) **toeslope**.—The hillslope position that forms the gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear, and are constructional surfaces forming the lower part of a hill-slope continuum that grades to valley or closed-depression floors. Compare – summit, shoulder, backslope, footslope, valley floor. HP
- (1070) **tombolo**.—A sand or gravel bar or barrier that connects an island with the mainland or with another island. GG

- (1071) **topography**.—The relative position and elevations of the natural or manmade features of an area that describe the configuration of its surface. HP
- (1072) **topple**.—A category of mass movement processes, associated sediments (topple deposit), or resultant landform characterized by a localized, very rapid type of fall in which large blocks of soil or rock literally fall over, rotating outward over a low pivot point. Portions of the original material may remain intact, although reoriented, within the resulting debris pile. Types of topples can be specified based on the dominant particle size of sediments (i.e., debris topple, soil topple, rock topple). Compare – fall, flow, slide, spread, complex landslide, landslide. SW and DV
- (1073) **topsoil**.—The upper most, generally darker, soil layer or horizon at the earth's surface consisting of unconsolidated sand, silt, clay, rock fragments, and organic matter. It is the zone exhibiting maximum accumulation of organic matter (humification), dissolution and leaching of soluble salts, and eluviation of soil clays. (Generally O, A, and E master horizons, but may include V horizons) (also subsoil, substratum)
- (1074) **tor**.—A high, isolated pinnacle, or rocky peak; or a pile of rocks, much-jointed and usually granitic, exposed to intense weathering, and often assuming peculiar or fantastic shapes. GG
- (1075) **Toreva block**.—A slump block consisting of a single large mass of unjostled material that, during descent, has undergone a backward rotation toward the parent cliff along a horizontal axis that roughly parallels it; a type of rotational landslide. The unit forms a crude, elongated rectangular block rather than a bowl shape or chaotic mass; typically associated with horizontal to gently dipping sequence of coherent bedrock such as sandstone, which overlies a less coherent bedrock formation such as clay shale that is prone to slumping (e.g., southern Black Mesa area, AZ). SW, GG, and RF
- (1076) **tower karst**
- (i) A type of tropical karst topography characterized by isolated, steep-sided, residual limestone hills or ridges with vertical or near-vertical walls, and may be relatively flat-topped; commonly surrounded by a flat alluvial plain or lagoons. (Also called *fenglin*).
 - (ii) A cluster of peaks or ridges with vertical or near-vertical walls, and convex upper side slopes where towers rise from a common base and are separated by deep, rugged ravines or large sinkholes. (Also called *fengcong*, *turmkarst*). Compare – karst tower, cockpit karst, cone karst, fluviokarst, kegel karst, sinkhole karst. SW and GG
- (1077) **translational debris slide**.—The mass movement process, associated sediments (translational debris slide deposit), or resultant landform characterized by an extremely slow to moderately rapid type of slide, composed of comparatively dry and largely unconsolidated earthy material, portions or blocks of which remain largely intact and in which movement occurs along a well-defined, planar slip face roughly parallel to the ground surface and resulting in lateral displacement but no rotation of the displaced mass; sediments have substantial proportions of both fine earth and rock fragments. The landform may be single, successive (repeated up and down slope), or multiple (as the number of slide components increase). Compare – translational earth slide, translational rock slide, rotational slide lateral spread, landslide. SW and DV
- (1078) **translational earth slide**.—The mass movement process, associated sediments (translational earth slide deposit), or resultant landform characterized by an extremely slow to moderately rapid type of slide, composed of comparatively dry and largely unconsolidated earthy material, portions or blocks of which remain largely intact and in which movement occurs along a well-defined, planar slip face roughly parallel to the ground surface and resulting in lateral displacement but no rotation of the displaced mass; sediments predominantly fine earth (< 2 mm). The landform may be single, successive (repeated up and down slope), or multiple (as the number of slide components increase). Compare

- translational debris slide, translational rock slide, rotational slide, lateral spread, landslide. SW and DV
- (1079) **translational rock slide**.—The mass movement process, associated sediments (translational rock slide deposit), or resultant landform characterized by an extremely slow to moderately rapid type of slide, composed of comparatively dry and largely consolidated rock bodies, portions or blocks of which remain largely intact and in which movement occurs along a well-defined, planar slip face roughly parallel to the ground surface and resulting in lateral displacement but no rotation of the displaced mass; sediments predominantly fine earth (< 2 mm). The landform may be single, successive (repeated up and down slope), or multiple (as the number of slide components increase). Compare translational debris slide, translational earth slide, rotational slide, lateral spread, landslide. SW and DV
- (1080) **translational slide**.—A category of mass movement processes, associated sediments (translational slide deposit), or resultant landform characterized by the extremely slow to moderately rapid downslope displacement of comparatively dry soil-rock material on a surface (slip face) that is roughly parallel to the general ground surface, in contrast to falls, topples, and rotational slides. The term includes such diverse *slide* types as translational debris slides, translational earth slide, translational rock slide, block glides, and slab or flake slides. Compare – rotational slide, slide, landslide. SW, DV, and GG
- (1081) **transverse dune**.—A very asymmetric sand dune elongated perpendicular to the prevailing wind direction, having a gentle windward slope and a steep leeward slope standing at or near the angle of repose of sand; it generally forms in areas of sparse vegetation. Compare – longitudinal dune. GG
- (1082) **tread**.—[geomorphology] A geomorphic component of terraces, flood-plain steps, and other stepped landforms consisting of the flat to gently sloping, topmost and laterally extensive slope. Commonly a recurring part of a series of natural, step-like landforms such as successive stream terraces. Its characteristic shape and alluvial sediment composition is derived from the cut and fill processes of a fluvial system. Compare – riser. SW
- (1083) **tree-throw**.—(not preferred) see tree-tip, tree-tip mound, tree-tip pit.
- (1084) **tree-tip**.—The process of uprooting and tipping over of trees by strong winds, commonly resulting in a small depression from which the root-ball is displaced and an adjacent mound from the sediments subsequently sloughed from the root ball. Most prevalent in shallow forested soils over a restrictive layer (e.g., bedrock); also called tree-throw, windthrow. Compare – tree-tip mound, tree-tip pit. SW
- (1085) **tree-tip mound**.—The small mound of debris sloughed from the root plate (root ball) of a tipped-over tree. Sometimes called a cradle knoll (not recommended). Local soil horizons are commonly obliterated and result in heterogeneous strata. Compare – tree-tip pit. SW and BHM
- (1086) **tree-tip pit**.—The small pit or depression resulting from an area vacated by the root plate (ball) resulting from tree-tip (“tree-throw”). Such pits are commonly adjacent to small mounds composed of the displaced material. Subsequent infilling commonly results in a heterogeneous soil matrix that may or may not include a stone line that lines the depression. Compare – tree-tip mound. SW and BHM
- (1087) **tree-tip pit and mound topography**.—A local-scale topography composed of irregularly spaced, small, closed depressions and adjacent mounds caused by the displacement of root balls from trees knocked down by wind (i.e., tree-tip; also called tree-throw). The result is a subdued, irregularly pock-marked or undulating surface; most common in forested areas overlying shallow rooting conditions (e.g., lithic contact, water table, etc). Microelevational differences generally range from 0.5 to < 2 m. Sometimes also referred to as (not preferred:) *cradle and knoll* or *pit and mound* topography. Compare – tree-tip mound, tree-tip pit. SW

- (1088) **trellis drainage pattern**.—A drainage pattern characterized by parallel main streams intersected at, or nearly at, right angles by their tributaries, which in turn are fed by elongated secondary tributaries and short gullies parallel to the main streams, resembling, in plan view, the stems of a vine on a trellis. This pattern indicates marked bedrock structural control rather than a type of bedrock and usually indicates in which the main parallel channels follow the strike of the beds. It is commonly developed where the beveled edges of alternating hard and soft rocks outcrop in parallel belts, as in titled, interbedded sedimentary rocks in a rejuvenated folded-mountain region or in a maturely dissected belted coastal plain of tilted strata. SW, GG, and WA
- (1089) **tripoli**.—A light-colored, porous, friable, siliceous (largely chalcedonic) sedimentary rock, which occurs in powdery or earthy masses that result from the weathering of siliceous limestone. It has a harsh, rough feel and is used to polish metals and stones. GG
- (1090) **trough** [geomorphology]
- (i) Any long, narrow depression in the earth's surface, such as one between hills or with no surface outlet for drainage.
 - (ii) (not preferred – see U-shaped valley, mountain valley) A broad, elongate U-shaped valley, such as a glacial trough. Compare – U-shaped valley. GG
- (1091) **trough bottom**.—(not preferred) Refer to glacial-valley floor.
- (1092) **trough end**.—(not recommended: refer to cirque, cove). The steep, semicircular rock wall forming the abrupt head or end of a U-shaped valley. Compare – headwall. GG
- (1093) **trough valley**.—(not preferred) Refer to U-shaped valley.
- (1094) **trough wall**.—(not preferred) Refer to glacial-valley wall.
- (1095) **truncated soil**.—Soil that has had part or all of the upper soil horizons removed by erosion, excavation, etc., but retains some portion of the original subsoil horizons intact. Compare – scalped area. SW and GSST
- (1096) **tuff**.—A generic term for any consolidated or cemented deposit that is ≥ 50 percent volcanic ash (< 2 mm); various types of tuff can be recognized based on composition: acidic tuff is predominantly composed of acidic particles; basic tuff is predominantly composed of basic particles. SW
- (1097) **tumulus**.—(pl. tumuli) A small dome or mound on the surface of a lava flow formed by the buckling of the congealing crust near the edge of a flow caused by differences in flow rates of the cooler crust above and the hotter, more fluid lava below. Dimensions commonly range from < 1 m to 5 m in height, 3 to 10 m in width and 30 to 40 m in length. Some tumuli are hollow. Compare – volcanic pressure ridge. SW, GG, and GS
- (1098) **tunnel valley**.—A relatively shallow trench or depression cut into drift and other loose material, or in bedrock, by a subglacial stream not loaded with coarse sediment that may or may not be part of the present day drainage pattern. GG
- (1099) **tunnel-valley lake**.—A glacial lake occupying a portion of a tunnel valley. GG
- (1100) **turf hummock**.—A hummock consisting of vegetation and organic matter with or without a core of mineral soil or stones (typically 10-50 cm height; 20-90 cm diameter). Groups of hummocks can form a type of patterned ground common to tundra or wet areas (e.g., marsh). Compare – earth hummock, nonsorted circle, patterned ground. NRC and SW
- (1101) **unconformity**.—A substantial break or gap in the geologic record where a unit is overlain by another that is not in stratigraphic succession. Compare – conformity, discontinuity. GG
- (1102) **underfit stream**.—A stream that appears to be too small to have eroded the valley in which it flows; a stream whose volume is greatly reduced or whose meanders show a pronounced shrinkage in radius. It is a common result of drainage changes effected by capture, glaciers, or climatic variations. GG
- (1103) **upland**.—[geomorphology] An informal, general term for—

- (i) The higher ground of a region, in contrast with a low-lying, adjacent land such as a valley or plain.
- (ii) Land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum. Compare – lowland. HP and GG
- (1104) **uplift**.—[tectonic] A structurally high area in the earth's crust, produced by positive movements that raise or upthrust the rocks, as in a dome or arch. GG
- (1105) **upthrust**
 - (i) An upheaval of rock; said preferably of a violent upheaval.
 - (ii) A high angle gravity or thrust fault in which the relatively upthrown side was the active (moving) element. HP
- (1106) **urban anthroscape**.—A human-modified “landscape” dominated by permanent alterations to the physical shape of the land, its internal stratigraphy, or both due to management for habitation or commerce that have substantively altered water flow and sediment transport across and within the regolith. This includes extensive complexes of impervious surfaces, buildings, and roads, with comparatively minor areas of unmodified or natural land (e.g., parks, recreational land). Commonly excludes areas of minor alterations (e.g., shallow landscaping) that are easily obscured or obliterated by natural bio-, pedo-, or cryoturbation. Compare – agricultural, hillslope terrace anthroscape, and suburban anthroscape. SW
- (1107) **U-shaped valley**.—A valley having a pronounced parabolic cross profile suggesting the form of a broad letter “U,” with steep walls and a broad, nearly flat floor; specifically, a valley carved by glacial erosion. Compare – V-shaped valley. GG
- (1108) **uvala**.—(not preferred) Refer to karst valley.
- (1109) **valley**.—An elongated, relatively large, externally drained depression of the earth’s surface that is primarily developed by stream erosion or glacial activity. Compare – basin. HP
- (1110) **valley fill**.—The unconsolidated sediment deposited by any agent (water, wind, ice, mass wasting) so as to fill or partly fill a valley. HP
- (1111) **valley flat**.—A generic term for the low or relatively level ground lying between valley walls and bordering a stream channel; especially the small plain at the bottom of a narrow, steep-sided valley. The term can be generally applied noncommittally to a flat surface that cannot be identified with certainty as a flood plain or terrace. Compare – backswamp, meander belt. GG
- (1112) **valley floor**.—A general term for the nearly level to gently sloping, lowest surface of a valley. Landforms include axial stream channels, the flood plain, flood-plain steps, and, in some areas, low terrace surfaces. Compare – flood-plain landforms, meander, braided channel, valley side. HP
- (1113) **valley side**.—The sloping to very steep surfaces between the valley floor and summits of adjacent uplands. Well-defined, steep valley sides have been termed valley walls (not recommended). Note: Scale, relief, and perspective may require use of closely related terms, such as hillslope or mountain slope. HP
- (1114) **valley train**.—A long narrow body of outwash confined within a valley beyond a glacier; it may, or may not, emerge from the valley and join an outwash plain. GG
- (1115) **valley wall**.—(not recommended) Use valley side.
- (1116) **valley-border surfaces**.—A general grouping of valley-side geomorphic surfaces of relatively large extent that occur in a stepped sequence graded to successively lower stream base levels, produced by episodic valley entrenchment; for example, multiple stream terrace levels, each with assemblages of constituent landforms (e.g., interfluves, hillslopes, fans, etc.) that dominate the margins of large river valleys. SW and HP

- (1117) **valley-floor remnant**.—Hills that are now erosion remnants of a former valley or basin floor, composed mostly of unconsolidated valley or basin fill sediments (e.g., alluvium) and typically lie well above the modern valley floor and flood plain. Former basin floor surfaces have become dissected and irregular and consist of hillslope positions (shoulder, backslope, etc.) and hill components (interfluvium, headslope, etc.); common in large valleys of the western United States. SW
- (1118) **valley-side alluvium**.—A concave “slope wash” deposit at the base of a hill slope, mountain slope, terrace escarpment, etc., that may or may not include the alluvial toe slope. Compare – base slope, slope alluvium. HP
- (1119) **varve**.—A sedimentary layer, lamina, or sequence of laminae, deposited in a body of still water within 1 year; specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier. Compare – rhythmite. GG
- (1120) **ventifact**.—A stone or pebble that has been shaped, worn, faceted, cut, or polished by the abrasive action of windblown sand, usually under arid conditions. When the pebble is at the ground surface, as in a desert pavement, the upper part is polished while the lower or below ground part is angular or subangular. GG and HP
- (1121) **vernal pool**.—A natural, seasonal pond in a small closed depression (microlow) that supports a semiaquatic or aquatic ecosystem adapted to annual cycles of standing water in the springtime followed by drying in the summer or autumn; commonly recognized in California. SW
- (1122) **vitric**.—Pyroclastic material that is more than 75 percent glass. GG
- (1123) **volcanic**.—(adjective) Pertaining to the deep seated (igneous) processes by which magma and associated gases rise through the crust and are extruded onto the earth's surface and into the atmosphere and the structures, rocks, and landforms produced. Compare – extrusive, volcanoclastic. HP
- (1124) **volcanic block**.—A pyroclast that was ejected in a solid state; it has a diameter greater than 64 mm. Compare – cinders, lapilli, tephra, volcanic bomb. GG
- (1125) **volcanic bomb**.—A pyroclast > 64 mm in at least one dimension that was ejected while still viscous and solidified into its rounded form in flight. Compare – cinders, lapilli, tephra, volcanic block. GG
- (1126) **volcanic breccia**.—A volcanoclastic rock composed mostly of angular rock fragments greater than 2 mm in size. The name volcanic breccia is not synonymous with pyroclastic breccia (volcanic breccia forms in different ways). GG
- (1127) **volcanic cone**.—A conical hill of lava, pyroclastics, or both that is built up around a volcanic vent. GG
- (1128) **volcanic crater**.—A basin-like, rimmed structure, usually at the summit of a volcanic cone. It may be formed by collapse, by an explosive eruption or by the gradual accumulation of pyroclastic material into a surrounding rim. Compare – caldera. GG
- (1129) **volcanic dome**.—A steep-sided, rounded extrusion of highly viscous lava squeezed out from a volcano, and forming a dome-shaped or bulbous mass of congealed lava above and around the volcanic vent. GG
- (1130) **volcanic field**.—A more or less well defined area that is covered with volcanic rocks of much more diverse lithology and distribution than a lava field, or that is so modified by age and erosion that its original topographic configuration, composition and extent is uncertain. Compare – lava field, lava plain. SW
- (1131) **volcanic neck**.—A vertical, pipe-like tower of solidified lava or consolidated fragmental igneous rock that represents a former volcanic vent whose surrounding material (e.g., tuff and tephra) has been largely removed by erosion. Compare – diatreme. SW, GG, and GS
- (1132) **volcanic plug**.—(not recommended) Use volcanic neck.

- (1133) **volcanic pressure ridge**.—An elongate uplift of the congealing crust of a lava flow, probably due to the pressure of the underlying, still-flowing lava; commonly < 5 m in height (but range up to 15 m) and < 100 m length (but can exceed 500 m). Compare – tumulus. SW, GG, and GS
- (1134) **volcaniclastic**.—(adjective) Pertaining to the entire spectrum of fragmental materials with a preponderance of clasts of volcanic origin. The term includes not only pyroclastic materials but also epiclastic deposits derived from volcanic source areas by normal processes of mass movement and stream erosion. Examples: welded tuff, volcanic breccia, lahar deposit. HP
- (1135) **volcano**
- (i) A vent in the surface of the earth through which magma and associated gases and ash erupt; also, the form or structure, usually conical, that is produced by the ejected material.
 - (ii) Any eruption of material, e.g., mud, sand, etc. that resembles a magmatic volcano. GG
- (1136) **V-shaped valley**.—A valley having a pronounced cross profile suggesting the form of the letter “V,” characterized by steep sides and short tributaries; specifically a narrow valley resulting from downcutting by a stream. The “V” becomes broader as the downcutting progresses. Compare – U-shaped valley. GG
- (1137) **wash**.—(dry wash) (colloquial: western United States) The broad, flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in alluvium. Note: When channels reach intersect zones of ground-water discharge, they are more properly classed as “intermittent stream” channels. Synonym - arroyo. Compare – gully. HP
- (1138) **washover fan**.—A fan-like deposit of sand washed over a barrier island or spit during a storm and deposited on the landward side. Washover fans can be small to medium sized and completely subaerial, or they can be quite large and include subaqueous margins extending into adjacent lagoons or estuaries. Large fans can be subdivided into sequential parts: ephemeral washover channel (microfeature) cut through dunes or beach ridges, back-barrier flats, (subaqueous) washover-fan flat, (subaqueous) washover-fan slope. Subaerial portions can range from barren to completely vegetated. SSS
- (1139) **washover-fan apron**.—(not preferred) Use washover-fan flat.
- (1140) **washover-fan flat**.—A gently sloping, fan-like, subaqueous landform created by overwash from storm surges that transports sediment from the seaward side to the landward side of a barrier island (GG). Sediment is carried through temporary overwash channels that cut through the dune complex on the barrier spit (Fisher and Simpson, 1979; Boothroyd et al., 1985; Davis, 1994) and spill out onto the lagoon-side platform where they coalesce to form a broad belt. Also called storm-surge platform flat (Boothroyd et al., 1985) and washover fan apron (GG). Compare – washover fan slope. SSS
- (1141) **washover-fan slope**.—A subaqueous extension of a washover-fan flat that slopes toward deeper water of a lagoon or estuary and away from the washover-fan flat. Compare – washover-fan flat. SSS
- (1142) **water**.—[soil survey] A generic map unit for any permanent, open body of water (pond, lake, reservoir, etc.) that does not support rooted plants. SW
- (1143) **water-lain moraine**.—A terminal, end, or recessional moraine formed subaqueously by a glacier that terminated in a water body (e.g., glacial lake, sea, or ocean). A water-lain moraine may occur at the present land surface as a result of isostatic rebound or lake drainage. Compared to a land-based moraine of similar origin, a water-lain moraine displays sediment (till) modification by wave action, current action, or both and has a somewhat subdued topography. SW
- (1144) **waterway**
- (i) A general term for a way or channel, either natural (as a river) or artificial (as a canal), for conducting the flow of water.

- (ii) A navigable body or stretch of water available for passage; a watercourse. Compare – drainageway. GG
- (1145) **wave-built terrace**.—A gently sloping coastal feature at the seaward or lakeward edge of a wave-cut platform, constructed by sediment brought by rivers or drifted along the shore or across the platform and deposited in the deeper water beyond. Compare – submerged wave-built terrace, beach plain, strand plain. GG
- (1146) **wave-cut platform**.—A gently sloping surface produced by wave erosion, extending into the sea or lake from the base of the wave-cut cliff. This feature represents both the wave-cut bench and the abrasion platform. Compare – submerged wave-cut platform. GG
- (1147) **wave-cut terrace**.—(not recommended) Use wave-built terrace.
- (1148) **wave-worked till plain**.—A glaciated land area that has the characteristics of a till plain, but that was also inundated by a glacial lake. The area possesses a gently undulating till-topography rather than a distinctive, low-relief lake plain surface. Lacustrine sediments, however, are absent or occur only sparsely, but a wave- or current-modified, surficial mantle may commonly exist atop the till. Topographic highs, which were once islands, may possess shore features (e.g., wave-cut scarps, strandlines, beach deposits). Compare – till-floored lake plain. SW
- (1149) **weathering**.—All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth's surface by atmospheric or biologic agents or circulating surface waters with essentially no transport of the altered material. These changes result in disintegration and decomposition of the material. Compare – regolith, residuum, saprolite. HP
- (1150) **welded soil**.—(not preferred) Use overprinted soil.
- (1151) **welded tuff**.—A glass-rich, pyroclastic rock composed of volcanic ash indurated at the time of deposition by the welding together of its glass shards under the combined action of the heat retained by particles, the weight of overlying material, and hot gasses. It is generally composed of silica pyroclasts and appears banded or streaked. GG
- (1152) **welding**
 - (i) Consolidation of sediments (especially of clays) by pressure resulting from the weight of superincumbent material or from earth movement, characterized by cohering particles brought within the limits of mutual molecular attraction as water is squeezed out of the sediments.
 - (ii) the diagenetic process whereby discrete crystals, grains, or both become attached to each other during compaction, often involving pressure solution and pressure transfer. GG
- (1153) **wind gap**.—A former water gap now abandoned by the stream that formed it, suggesting stream piracy or stream diversion. HP
- (1154) **window**.—[tectonic] An eroded area of a thrust sheet, commonly a basin or valley floor, that exposes the incongruous bedrock stratigraphy beneath the thrust-sheet; a particular structural or stratigraphic relationship is implied, rather than a particular topographic form. Common in the Appalachian and Rocky Mountain margins. Synonym: *fenster*. GG, WT, and SW
- (1155) **windthrow**.—(not preferred) see tree-tip.
- (1156) **wind-tidal flat**.—A broad, low-lying, nearly-level sand flat that is alternately inundated by ponded rainwater or by wind-driven bay or estuarine water from storm surges or seiche. Frequent salinity fluctuations and prolonged periods of subaerial exposure preclude establishment of most types of vegetation except for mats of filamentous blue-green algae. Compare – tidal flat. SSS and HF
- (1157) **woody organic materials**.—see organic materials.

- (1158) **woody peat**.—An accumulation of organic material that is predominantly composed of trees, shrubs, and other woody plants. Compare herbaceous peat, moss peat, sedimentary peat, peat, muck, and mucky peat. SSM
- (1159) **yardang**
- (i) A microfeature in the form of a long, irregular, sharp-crested, undercut ridge between two round-bottomed troughs, carved on a plateau or unsheltered plain in a desert region by wind erosion, and cut into soft but coherent deposits (such as clayey sand); it lies in the direction of the dominant wind, and may be up to 6 m high and 40 m wide.
 - (ii) A landform produced in a region of limestone or sandstone by infrequent rains combined with wind action, and characterized by “a surface bristling with a fine lacework of sharp ridges pitted by corrosion.” Compare – pavement karst. GG
- (1160) **yardang trough**.—A long, shallow, round-bottomed groove, furrow, trough, or corridor excavated in the desert floor by wind abrasion, and separating two yardangs. Compare – yardang. GG
- (1161) **zibar**.—A small, low-relief sand dune that lacks discernible slip faces and commonly occurs on sand sheets, in interdune areas, or in corridors between larger dunes. Zibar spacing can range from 50 to 400 m with local relief of less than 10 m. Unlike coppice dunes, zibars are not related to deposition around vegetation. Generally dominated by coarser sands. Compare – dune, coppice dune. SW, GG, NL, and CW

629.3 References

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Part 629 – Glossary of Landform and Geologic Terms

Subpart B – Exhibits

629.10 Lists of Landscape, Landform, Microfeature, and Anthropogenic Feature Terms Contained in the Glossary

(Subset lists arranged by geomorphic process or other groups.) Geomorphic process is a framework for the *Geomorphic Description System* (Schoeneberger and Wysocki, 2012).

Note: Words enclosed in brackets are considered part of the name of a term such as “bay [coast]”. Words enclosed in parentheses are only accessory information and are not part of the name of a term such as “(water body; also Landform)”. Following the terms are italicized letters for the corresponding shorthand code such as *BO* for the landscape term “bolson”).

A. ALPHABETICAL LISTS (Landscapes, Landforms, Microfeatures, Anthropogenic Features).

(1) LANDSCAPES (broad or unique regional groups of spatially-associated landforms).

alluvial plain	<i>AP</i>
alluvial plain remnant	<i>AR</i>
badlands	<i>BA</i>
bajada (also Landform)	<i>BJ</i>
barrier island (also Landform)	<i>BI</i>
basin	<i>BS</i>
basin floor (also Landform)	<i>BC</i>
batholith	<i>BL</i>
bay [coast] (water body; also Landform)	<i>BY</i>
bolsón	<i>BO</i>
breached anticline (also Landform)	<i>BD</i>
breaklands	<i>BR</i>
breaks (also Landform)	<i>BK</i>
caldera (also Landform)	<i>CD</i>
canyonlands	<i>CL</i>
coastal plain (also Landform)	<i>CP</i>
cockpit karst	<i>CPK</i>
cone karst	<i>CK</i>
continental glacier	<i>CG</i>
coppice dune field	<i>CDF</i>
delta plain (also Landform)	<i>DP</i>
dissected breaklands	<i>DB</i>
dissected plateau	<i>DI</i>
drumlin field	<i>DF</i>
dune field (also Landform)	<i>DU</i>
estuary (water body; also Landform)	<i>ES</i>
everglades	<i>EG</i>
fan piedmont (also Landform)	<i>FP</i>
fault-block mountains	<i>FM</i>

fluviokarst	<i>FK</i>
fluviomarine terrace (also Landform)	<i>FT</i>
fold-thrust hills	<i>FTH</i>
foothills	<i>FH</i>
glaciokarst	<i>GK</i>
gulf (water body; also Landform)	<i>GU</i>
hills (singular = Landform)	<i>HI</i>
ice-margin complex	<i>IC</i>
intermontane basin (also Landform)	<i>IB</i>
island (also Landform)	<i>IS</i>
karst	<i>KR</i>
kegel karst	<i>KK</i>
lagoon (water body; also Landform)	<i>LG</i>
lake plain (also Landform)	<i>LP</i>
lava field (also Landform)	<i>LF</i>
lava plain (also Landform)	<i>LV</i>
lava plateau (also Landform)	<i>LL</i>
lowland	<i>LW</i>
marine terrace (also Landform)	<i>MT</i>
meander belt	<i>MB</i>
mountain range	<i>MR</i>
mountain system	<i>MS</i>
mountains (singular = Landform)	<i>MO</i>
ocean (water body)	<i>OC</i>
outwash plain (also Landform)	<i>OP</i>
peninsula	<i>PE</i>
piedmont	<i>PI</i>
piedmont slope	<i>PS</i>
plains (singular = Landform)	<i>PL</i>
plateau (also Landform)	<i>PT</i>
rift valley	<i>RF</i>
river valley (also Landform)	<i>RV</i>
sand plain	<i>SP</i>
sandhills	<i>SH</i>
scabland	<i>SC</i>
sea (water body; also Landform)	<i>SEA</i>
semi-bolson	<i>SB</i>
shield volcano (also Landform)	<i>SV</i>
shore complex (also Landform)	<i>SX</i>
sinkhole karst	<i>SK</i>
sound (water body; also Landform)	<i>SO</i>
strait (water body; also Landform)	<i>ST</i>
tableland	<i>TB</i>
thermokarst	<i>TK</i>
till plain (also Landform)	<i>TP</i>
tower karst	<i>TW</i>
upland	<i>UP</i>
valley (also Landform)	<i>VA</i>
volcanic field (also Landform)	<i>VF</i>

(2) LANDFORMS (natural, individual, earth-surface features mappable at soil survey scales).

aa lava flow	<i>ALF</i>
alas	<i>AA</i>
alluvial cone	<i>AC</i>
alluvial fan	<i>AF</i>
alluvial flat	<i>AP</i>
alpine glacier	<i>AG</i>
anticline	<i>AN</i>
arete	<i>AR</i>
arroyo	<i>AY</i>
ash field	<i>AQ</i>
ash flow	<i>AS</i>
atoll	<i>AT</i>
avalanche chute	<i>AL</i>
axial stream	<i>AX</i>
back-barrier beach	<i>BBB</i>
back-barrier flat	<i>BBF</i>
backshore	<i>AZ</i>
backswamp	<i>BS</i>
bajada (also Landscape)	<i>BJ</i>
ballena	<i>BL</i>
ballon	<i>BV</i>
bar	<i>BR</i>
barchan dune	<i>BQ</i>
barrier beach	<i>BB</i>
barrier beach [relict]	<i>BBR</i>
barrier cove	<i>BAC</i>
barrier flat	<i>BF</i>
barrier island (also Landscape)	<i>BI</i>
basin floor (also Landscape)	<i>BC</i>
basin-floor remnant	<i>BD</i>
bay [coast] (water body; also Landscape)	<i>BAY</i>
bay [geom.]	<i>BYG</i>
bay bottom	<i>BOT</i>
bayou (water body)	<i>WC</i>
beach	<i>BE</i>
beach plain	<i>BP</i>
beach ridge	<i>BG</i>
beach terrace	<i>BT</i>
berm	<i>BM</i>
beveled base	<i>BVB</i>
blind valley	<i>VB</i>
block field	<i>BW</i>
block glide	<i>BLG</i>
block lava Flow	<i>BLF</i>
block stream	<i>BX</i>
blowout	<i>BY</i>
bluff	<i>BN</i>
bog	<i>BO</i>
box canyon	<i>BOX</i>

braided stream	<i>BZ</i>
breached anticline (also Landscape)	<i>BRL</i>
breaks (also Landscape)	<i>BK</i>
broad interstream divide	<i>BID</i>
butte	<i>BU</i>
caldera (also Landscape)	<i>CD</i>
canyon	<i>CA</i>
canyon bench	<i>CYB</i>
canyon wall	<i>CW</i>
Carolina Bay	<i>CB</i>
channel (also Microfeature)	<i>CC</i>
chenier	<i>CG</i>
chenier plain	<i>CH</i>
cinder cone	<i>CI</i>
cirque	<i>CQ</i>
cirque floor	<i>CFL</i>
cirque headwall	<i>CHW</i>
cirque platform	<i>CPF</i>
cliff	<i>CJ</i>
climbing dune	<i>CDU</i>
closed depression (also Microfeature)	<i>CLD</i>
coastal plain (also Landscape)	<i>CP</i>
cockpit	<i>COC</i>
col	<i>CL</i>
collapse sinkhole	<i>CSH</i>
collapsed ice-floored lakebed	<i>CK</i>
collapsed ice-walled lakebed	<i>CN</i>
collapsed lake plain	<i>CS</i>
collapsed outwash plain	<i>CT</i>
colluvial apron	<i>COA</i>
complex landslide	<i>CLS</i>
coral island	<i>COR</i>
coulee	<i>CE</i>
cove	<i>CO</i>
cove [water] (water body)	<i>COW</i>
crag and tail	<i>CAT</i>
creep	<i>CRE</i>
crevasse filling	<i>CF</i>
cuesta	<i>CU</i>
cuesta valley	<i>CUV</i>
cutoff	<i>CV</i>
debris avalanche	<i>DA</i>
debris fall	<i>DEF</i>
debris flow	<i>DF</i>
debris slide	<i>DS</i>
debris spread	<i>DES</i>
debris topple	<i>DET</i>
deflation basin	<i>DB</i>
deflation flat	<i>DFL</i>
delta	<i>DE</i>
delta plain (also Landscape)	<i>DC</i>

depression	<i>DP</i>
diapir	<i>DD</i>
diatreme	<i>DT</i>
dike	<i>DK</i>
dip slope	<i>DL</i>
disintegration moraine	<i>DM</i>
distributary	<i>DIS</i>
divide	<i>DN</i>
dome	<i>DO</i>
drainageway	<i>DQ</i>
drainhead complex	<i>DRC</i>
draw	<i>DW</i>
drumlin	<i>DR</i>
drumlinoid ridge	<i>DRR</i>
dune	<i>DU</i>
dune field (also Landscape)	<i>DUF</i>
dune lake (water body)	<i>DUL</i>
dune slack (also Microfeature)	<i>DUS</i>
earth spread	<i>ESP</i>
earth topple	<i>ETO</i>
earthflow	<i>EF</i>
end moraine	<i>EM</i>
ephemeral stream (also Microfeature)	<i>EPS</i>
eroded fan remnant	<i>EFR</i>
eroded fan remnant sideslope	<i>EFS</i>
erosion remnant	<i>ER</i>
escarpment	<i>ES</i>
esker	<i>EK</i>
estuary (water body; also Landscape)	<i>WD</i>
faceted spur	<i>FS</i>
fall	<i>FB</i>
falling dune	<i>FDU</i>
fan	<i>FC</i>
fan apron	<i>FA</i>
fan collar	<i>FCO</i>
fan piedmont (also Landscape)	<i>FG</i>
fan remnant	<i>FH</i>
fan skirt	<i>FI</i>
fanhead trench	<i>FF</i>
fault block	<i>FAB</i>
fault zone	<i>FAZ</i>
fault-line scarp	<i>FK</i>
fen	<i>FN</i>
fissure vent	<i>FIV</i>
fjord (water body)	<i>FJ</i>
flat	<i>FL</i>
flatwoods	<i>FLW</i>
flood plain	<i>FP</i>
flood-plain playa	<i>FY</i>
flood-plain splay	<i>FM</i>
flood-plain step	<i>FO</i>

flood-tidal delta	<i>FTD</i>
flood-tidal delta flat	<i>FTF</i>
flood-tidal delta slope	<i>FTS</i>
flow	<i>FLO</i>
flute (also Microfeature)	<i>FU</i>
fluviomarine bottom	<i>FMB</i>
fluviomarine terrace (also Landscape)	<i>FMT</i>
fold	<i>FQ</i>
foredune	<i>FD</i>
fosse	<i>FV</i>
free face (also Geom. Component – Hills, Mountains)	<i>FW</i>
fringe-tidal marsh	<i>FTM</i>
gap	<i>GA</i>
geyser	<i>GE</i>
geyser basin	<i>GEB</i>
geyser cone	<i>GEC</i>
giant ripple	<i>GC</i>
glacial drainage channel	<i>GD</i>
glacial lake (water body)	<i>WE</i>
glacial lake [relict]	<i>GL</i>
glacial-valley floor	<i>GVF</i>
glacial-valley wall	<i>GVW</i>
glacier	<i>GLA</i>
gorge	<i>GO</i>
graben	<i>GR</i>
ground moraine	<i>GM</i>
gulch	<i>GT</i>
gulf (water body; also Landscape)	<i>GU</i>
gut [channel] (water body; also Microfeature)	<i>WH</i>
gut [valley]	<i>GV</i>
half graben	<i>HG</i>
hanging valley	<i>HV</i>
headland	<i>HE</i>
head-of-outwash	<i>HD</i>
headwall	<i>HW</i>
high hill	<i>HH</i>
highmoor bog	<i>HB</i>
hill (plural=Landscape)	<i>HI</i>
hillslope	<i>HS</i>
hogback	<i>HO</i>
homoclinal ridge	<i>HCR</i>
homocline	<i>HC</i>
horn	<i>HR</i>
horst	<i>HT</i>
hot spring	<i>HP</i>
ice pressure ridge	<i>IPR</i>
ice-contact slope	<i>ICS</i>
ice-marginal stream	<i>IMS</i>
ice-pushed ridge	<i>IPU</i>
inlet	<i>IL</i>

inselberg	<i>IN</i>
inset fan	<i>IF</i>
interdrumlin	<i>IDR</i>
interdune (also Microfeature)	<i>ID</i>
interfluve (also Geom. Component - Hills)	<i>IV</i>
interior valley	<i>INV</i>
intermittent stream (also Microfeature)	<i>INT</i>
intermontane basin (also Landscape)	<i>IB</i>
island (also Landscape)	<i>IS</i>
kame	<i>KA</i>
kame moraine	<i>KM</i>
kame terrace	<i>KT</i>
karst cone	<i>KC</i>
karst lake	<i>KAL</i>
karst tower	<i>KTO</i>
karst valley	<i>KVA</i>
karstic marine terrace	<i>KMT</i>
kettle	<i>KE</i>
kipuka	<i>KIP</i>
knob	<i>KN</i>
knoll	<i>KL</i>
lagoon (water body; also Landscape)	<i>WI</i>
lagoon bottom	<i>LBO</i>
lagoon channel	<i>LCH</i>
lagoon [relict]	<i>LAR</i>
lahar	<i>LA</i>
lake (water body)	<i>WJ</i>
lake plain (also Landscape)	<i>LP</i>
lake terrace	<i>LT</i>
lakebed (water body)	<i>LB</i>
lakebed [relict]	<i>LBR</i>
lakeshore	<i>LF</i>
landslide	<i>LK</i>
lateral moraine	<i>LM</i>
lateral spread	<i>LS</i>
lava dome	<i>LD</i>
lava field (also Landscape)	<i>LFI</i>
lava flow	<i>LC</i>
lava flow unit (also Microfeature)	<i>LFU</i>
lava plain (also Landscape)	<i>LN</i>
lava plateau (also Landscape)	<i>LL</i>
lava trench (also Microfeature)	<i>LTR</i>
lava tube	<i>LTU</i>
ledge	<i>LE</i>
levee	<i>LV</i>
loess bluff	<i>LO</i>
loess hill	<i>LQ</i>
longitudinal dune	<i>LDU</i>
longshore bar	<i>LON</i>
longshore bar [relict]	<i>LR</i>
louderback	<i>LU</i>

low hill	<i>LH</i>
lowmoor bog	<i>LX</i>
maar	<i>MAA</i>
main scarp (also Microfeature)	<i>MAS</i>
mainland cove	<i>MAC</i>
mangrove swamp	<i>MAN</i>
marine lake (water body)	<i>ML</i>
marine terrace (also Landscape)	<i>MT</i>
marsh	<i>MA</i>
mawae	<i>MAW</i>
meander	<i>MB</i>
meander scar	<i>MS</i>
meander scroll	<i>MG</i>
meandering channel	<i>MC</i>
medial moraine	<i>MH</i>
mesa	<i>ME</i>
meteorite crater	<i>MEC</i>
mogote	<i>MOG</i>
monadnock	<i>MD</i>
monocline	<i>MJ</i>
moraine	<i>MU</i>
mountain (plural = Landscape)	<i>MM</i>
mountain slope	<i>MN</i>
mountain valley	<i>MV</i>
mud pot	<i>MP</i>
mudflow	<i>MW</i>
muskeg	<i>MX</i>
natural levee	<i>NL</i>
nearshore zone	<i>NZ</i>
nearshore zone [relict]	<i>NZR</i>
notch	<i>NO</i>
nunatak	<i>NU</i>
open depression (also Microfeature)	<i>ODE</i>
outwash delta	<i>OD</i>
outwash fan	<i>OF</i>
outwash plain (also Landscape)	<i>OP</i>
outwash terrace	<i>OT</i>
overflow stream channel	<i>OSC</i>
oxbow	<i>OX</i>
oxbow lake (water body)	<i>WK</i>
paha	<i>PA</i>
pahoehoe lava flow	<i>PAF</i>
paleoterrace	<i>PTR</i>
parabolic dune	<i>PB</i>
parna dune	<i>PD</i>
partial ballena	<i>PF</i>
patterned ground	<i>PG</i>
pavement karst	<i>PAV</i>
peak	<i>PK</i>
peat plateau	<i>PJ</i>
pediment	<i>PE</i>

perennial stream (water body; also Microfeature)	<i>PS</i>
pillow lava flow	<i>PIF</i>
pingo	<i>PI</i>
pinnacle (also Microfeature)	<i>PIN</i>
pitted outwash plain	<i>PM</i>
pitted outwash terrace	<i>POT</i>
plain (plural = Landscape)	<i>PN</i>
plateau (also Landscape)	<i>PT</i>
playa	<i>PL</i>
playa dune (also Microfeature)	<i>PDU</i>
playa floor (also Microfeature)	<i>PFL</i>
playa lake (water body)	<i>WL</i>
playa rim (also Microfeature)	<i>PRI</i>
playa slope (also Microfeature)	<i>PSL</i>
playa step (also Microfeature)	<i>PST</i>
plug dome	<i>PP</i>
pluvial lake (water body)	<i>PLL</i>
pluvial lake [relict]	<i>PQ</i>
pocosin	<i>PO</i>
point bar	<i>PR</i>
point bar [coastal]	<i>PRC</i>
pothole (also Microfeature)	<i>PH</i>
pothole lake (water body)	<i>WN</i>
proglacial lake (water body)	<i>WO</i>
proglacial lake [relict]	<i>PGL</i>
pyroclastic flow	<i>PCF</i>
pyroclastic surge	<i>PCS</i>
raised beach	<i>RA</i>
raised bog	<i>RB</i>
ravine	<i>RV</i>
recessional moraine	<i>RM</i>
reef	<i>RF</i>
ribbed fen	<i>RG</i>
ridge	<i>RI</i>
rim	<i>RJ</i>
rise (also Microfeature; also Geom. Component – Flat Plains)	<i>RIS</i>
river (water body)	<i>RIV</i>
river valley (also Landscape)	<i>RVV</i>
roche moutonnée (also Microfeature)	<i>RN</i>
rock glacier	<i>RO</i>
rock pediment	<i>ROP</i>
rock spread	<i>ROS</i>
rock topple	<i>ROT</i>
rockfall (also Microfeature)	<i>ROF</i>
rockfall avalanche	<i>RFA</i>
rotational debris slide	<i>RDS</i>
rotational earth slide	<i>RES</i>
rotational rock slide	<i>RRS</i>
rotational slide	<i>RTS</i>
sabkha	<i>SAB</i>

saddle	<i>SA</i>
sag (also Microfeature)	<i>SAG</i>
sag pond (water body; also Microfeature)	<i>SGP</i>
salt marsh	<i>SM</i>
salt pond (water body; also Microfeature)	<i>WQ</i>
sand flow (also Microfeature)	<i>RW</i>
sand ramp	<i>SAR</i>
sand sheet	<i>RX</i>
scarp	<i>RY</i>
scarp slope	<i>RS</i>
scree slope	<i>SCS</i>
sea (water body; also Landscape)	<i>SEA</i>
sea cliff	<i>RZ</i>
seep (also Microfeature)	<i>SEE</i>
seif dune	<i>SD</i>
semi-open depression	<i>SOD</i>
shield volcano (also Landscape)	<i>SHV</i>
shoal (water body)	<i>WR</i>
shoal [relict]	<i>SE</i>
shore	<i>SHO</i>
shore complex (also Landscape)	<i>SHC</i>
sill	<i>RT</i>
sinkhole	<i>SH</i>
slackwater (water body)	<i>WS</i>
slickrock (also Microfeature)	<i>SLK</i>
slide	<i>SJ</i>
slot canyon	<i>SLC</i>
slough (water body)	<i>SL</i>
slump block	<i>SN</i>
snowfield	<i>SNF</i>
soil fall	<i>SOF</i>
solution platform	<i>SOP</i>
solution sinkhole	<i>SOS</i>
sound (water body; also Landscape)	<i>SO</i>
spit	<i>SP</i>
spur	<i>SQ</i>
stack [coast]	<i>SRC</i>
stack [geom.]	<i>SR</i>
star dune	<i>SDU</i>
steptoe	<i>ST</i>
stock	<i>STK</i>
stoss and lee	<i>SAL</i>
strait (water body; also Landscape)	<i>STT</i>
strand plain	<i>SS</i>
strath terrace	<i>SU</i>
stratovolcano	<i>SV</i>
stream (water body)	<i>STR</i>
stream terrace	<i>SX</i>
strike valley	<i>STV</i>
string bog	<i>SY</i>
structural bench	<i>SB</i>

submerged back-barrier beach	<i>SBB</i>
submerged mainland beach	<i>SMB</i>
submerged point bar [coast]	<i>SPB</i>
submerged wave-built terrace	<i>SWT</i>
submerged wave-cut platform	<i>SWP</i>
submerged-upland tidal marsh	<i>STM</i>
swale (also Microfeature)	<i>SC</i>
swallow hole	<i>TB</i>
swamp	<i>SW</i>
syncline	<i>SZ</i>
talus cone	<i>TC</i>
talus slope	<i>TAS</i>
tarn (water body; also Microfeature)	<i>TAR</i>
terminal moraine	<i>TA</i>
terrace	<i>TE</i>
terrace remnant	<i>TER</i>
thermokarst depression (also Microfeature)	<i>TK</i>
thermokarst lake (water body)	<i>WV</i>
tidal flat	<i>TF</i>
tidal inlet	<i>TI</i>
tidal inlet [relict] (water body)	<i>TIR</i>
tidal marsh	<i>TM</i>
till plain (also Landscape)	<i>TP</i>
till-floored lake plain	<i>TLP</i>
toe (also Microfeature)	<i>TOE</i>
tombolo	<i>TO</i>
topple	<i>TOP</i>
tor	<i>TQ</i>
Toreva block	<i>TOR</i>
translational debris slide	<i>TDS</i>
translational earth slide	<i>TES</i>
translational rock slide	<i>TRS</i>
translational slide	<i>TS</i>
transverse dune	<i>TD</i>
trough	<i>TR</i>
tunnel valley	<i>TV</i>
tunnel-valley lake (water body)	<i>TVL</i>
underfit stream	<i>US</i>
U-shaped valley	<i>UV</i>
valley (also Landscape)	<i>VA</i>
valley flat	<i>VF</i>
valley floor	<i>VL</i>
valley side	<i>VS</i>
valley train	<i>VT</i>
valley-border surfaces	<i>VBS</i>
valley-floor remnant	<i>VFR</i>
volcanic cone	<i>VC</i>
volcanic crater	<i>CR</i>
volcanic dome	<i>VD</i>
volcanic field (also Landscape)	<i>VOF</i>
volcanic neck	<i>VON</i>

volcanic pressure ridge (also Micro.)	<i>PU</i>
volcano	<i>VO</i>
V-shaped valley	<i>VV</i>
wash	<i>WA</i>
washover fan	<i>WF</i>
washover-fan flat	<i>WFF</i>
washover-fan slope	<i>WFS</i>
water-lain moraine	<i>WM</i>
wave-built terrace	<i>WT</i>
wave-cut platform	<i>WP</i>
wave-worked till plain	<i>WW</i>
wind gap	<i>WG</i>
window	<i>WIN</i>
wind-tidal flat	<i>WTF</i>
yardang (also Microfeature)	<i>YD</i>
yardang trough (also Microfeature)	<i>YDT</i>

(3) MICROFEATURES (discrete, natural, earth-surface features too small to delineate at common survey scales).

- (i) Common microfeatures (not used in association with the landform “patterned ground”)

bar	<i>BA</i>
channel (also Landform)	<i>CH</i>
closed depression (also Landform)	<i>CD</i>
corda	<i>CO</i>
cutter	<i>CU</i>
dune slack (also Landform)	<i>DS</i>
dune traces	<i>DT</i>
earth pillar	<i>EP</i>
ephemeral stream (also Landform)	<i>ES</i>
finger ridge	<i>FR</i>
flute (also Landform)	<i>FL</i>
frost boil	<i>FB</i>
glacial groove	<i>GG</i>
groove	<i>GR</i>
gully	<i>GU</i>
gut [channel] (water body; also Landform)	<i>WH</i>
hillock	<i>HI</i>
hoodoo	<i>HO</i>
ice wedge	<i>IWD</i>
ice wedge cast	<i>IWC</i>
interdune (also Landform)	<i>ID</i>
intermittent stream (water body; also Landform)	<i>INT</i>
karren	<i>KA</i>
lava flow unit (also Landform)	<i>LFU</i>
lava trench (also Landform)	<i>LT</i>
main scarp (also Landform)	<i>MAS</i>
minor scarp	<i>MIS</i>

mound	<i>MO</i>
nivation hollow	<i>NH</i>
open depression (also Landform)	<i>OP</i>
perennial stream (water body; also Landform)	<i>PS</i>
pinnacle (also Landform)	<i>PI</i>
playa dune (also Landform)	<i>PD</i>
playa floor (also Landform)	<i>PF</i>
playa rim (also Landform)	<i>PR</i>
playa slope (also Landform)	<i>PSL</i>
playa step (also Landform)	<i>PST</i>
playette	<i>PL</i>
pond (water body)	<i>PON</i>
pool (water body)	<i>POO</i>
pothole (also Landform)	<i>PH</i>
rib	<i>RB</i>
rill	<i>RL</i>
ripple mark	<i>RM</i>
rise (also Landform; ; also Geom. Component – Flat Plains)	<i>RIS</i>
roche moutonnée (also Landform)	<i>POC</i>
rockfall (also Landform)	<i>ROF</i>
sag (also Landform)	<i>SAG</i>
sag pond (water body; also Landform)	<i>SP</i>
salt pond (water body; also Landform)	<i>WQ</i>
sand boil	<i>SB</i>
sand flow (also Landform)	<i>RW</i>
seep (also Landform)	<i>SE</i>
shoreline	<i>SH</i>
shrub-coppice dune	<i>SCD</i>
slickrock (also Landform)	<i>SLK</i>
slip face	<i>SF</i>
solifluction lobe	<i>SOL</i>
solifluction sheet	<i>SS</i>
solifluction terrace	<i>ST</i>
solution chimney	<i>SCH</i>
solution corridor	<i>SCO</i>
solution fissure	<i>SOF</i>
solution pipe	<i>SOP</i>
spatter cone	<i>SPC</i>
spiracle	<i>SPI</i>
strandline	<i>SL</i>
swale (also Landform)	<i>SW</i>
swash zone	<i>SZ</i>
tank (water body)	<i>TA</i>
tarn (water body; also Landform)	<i>TN</i>
terraces	<i>TER</i>
thermokarst depression (also Landform)	<i>TK</i>
toe (also Landform)	<i>TOE</i>
tree-tip mound	<i>TTM</i>
tree-tip pit	<i>TTP</i>
tumulus (tumuli = plural)	<i>TU</i>

vernal pool (seasonal water body)	<i>VP</i>
volcanic pressure ridge (also Landform)	<i>VPR</i>
yardang (also Landform)	<i>YD</i>
yardang trough (also Landform)	<i>YDT</i>
zibar	<i>ZB</i>

- (ii) ***Periglacial*** patterned ground microfeatures (used in association with the landform “patterned ground”; singular forms (e.g., circle) are used for a single feature at point data scale whereas plural forms (e.g., circles) are used for map unit components).

circle	<i>CI</i>
earth hummock	<i>EH</i>
high-center polygon	<i>HCP</i>
ice wedge polygon	<i>IWP</i>
low-center polygon	<i>LCP</i>
nonsorted circle	<i>NSC</i>
palsa (= peat hummock)	<i>PA</i>
polygon	<i>PYG</i>
sorted circle	<i>SCI</i>
stripe	<i>STR</i>
turf hummock	<i>TH</i>

- (iii) ***Other*** patterned ground microfeatures (used in association with the landform “patterned ground”; singular forms (e.g., hummock) are used for a single feature at point data scale whereas plural forms (e.g., hummocks) are used for map unit components).

bar and channel	<i>BC</i>
circular gilgai	<i>CG</i>
elliptical gilgai	<i>EG</i>
gilgai	<i>GI</i>
hummock	<i>HU</i>
linear gilgai	<i>LG</i>
mima mound	<i>MM</i>
pimple mound	<i>PM</i>
puff	<i>PU</i>

- (4) **ANTHROSCAPES** (large, discrete areas of artificial (human-made or extensively modified) “landscapes”)

anthroscape	<i>ANT</i>
agricultural anthroscape	<i>AGT</i>
hillslope terrace anthroscape	<i>HAT</i>
reclaimed mineland anthroscape	<i>RCT</i>
resource extraction anthroscape	<i>RXT</i>
suburban anthroscape	<i>SAT</i>
urban anthroscape	<i>UAT</i>

(5) ANTHROPOGENIC LANDFORMS (discrete, artificial (human-made or extensively modified), earth-surface features).

artificial collapsed depression	<i>ACD</i>
artificial levee (<i>also Anthro Micro</i>)	<i>AL</i>
bioswale (<i>also Anthro Micro</i>)	<i>BS</i>
borrow pit	<i>BP</i>
burial mound (<i>also Anthro Micro</i>)	<i>BM</i>
conservation terrace (modern)	<i>CT</i>
cut (railroad, etc.)	<i>CUT</i>
cutbank	<i>CB</i>
dredge-deposit shoal	<i>DDS</i>
dredge spoil bank	<i>DSB</i>
dredged channel	<i>DC</i>
dump	<i>DU</i>
fill	<i>FI</i>
filled marshland (<i>also Anthro Micro</i>)	<i>FM</i>
floodway	<i>FW</i>
gravel pit	<i>GP</i>
headwall (anthro) (<i>also Anthro Micro</i>)	<i>HW</i>
hillslope terrace (ancient)	<i>HT</i>
landfill (<i>see sanitary landfill</i>)	--
leveled land	<i>LVL</i>
midden (<i>also Anthro Micro</i>)	<i>MI</i>
openpit mine	<i>OM</i>
polder	<i>POL</i>
quarry	<i>QU</i>
railroad bed	<i>RRB</i>
reclaimed land	<i>RL</i>
rice paddy (<i>also Anthro Micro</i>)	<i>RP</i>
road cut	<i>RC</i>
sand pit	<i>SP</i>
sanitary landfill	<i>SL</i>
scalped area (<i>also Anthro Micro</i>)	<i>SA</i>
sewage lagoon	<i>SWL</i>
spoil bank (<i>also Anthro Micro</i>)	<i>SB</i>
spoil pile (<i>also Anthro Micro</i>)	<i>SPP</i>
surface mine	<i>SM</i>
truncated soil (<i>also Anthro Micro</i>)	<i>TS</i>

(6) ANTHROPOGENIC MICROFEATURES (discrete, artificial (human-made or extensively modified), earth surface features too small to delineate at normal mapping scales).

artificial levee	<i>AL</i>
beveled cut	<i>BC</i>
bioswale (<i>also Anthro LF</i>)	<i>BS</i>
borrow pit	<i>BP</i>
burial mound (<i>also Anthro LF</i>)	<i>BM</i>
conservation terrace (modern)	<i>CT</i>
cut (railroad, etc.)	<i>CUT</i>

cutbank	<i>CB</i>
ditch	<i>DI</i>
double-bedding mound (<i>i.e. bedding mound for timber;</i> <i>Lower Coastal Plain</i>)	<i>DBM</i>
drainage ditch	<i>DD</i>
dredged channel (<i>also Anthro LF</i>)	<i>DC</i>
fill	<i>FI</i>
filled marshland (<i>also Anth LF</i>)	<i>FM</i>
floodway	<i>FW</i>
furrow	<i>FR</i>
gravel pit (<i>also Anthro LF</i>)	<i>GP</i>
headwall [anthro] (<i>also Anth LF</i>)	<i>HW</i>
hillslope terrace (<i>ancient</i>)	<i>HT</i>
impact crater	<i>IC</i>
interfurrow	<i>IF</i>
log landing	<i>LL</i>
midden (<i>also Anthro LF</i>)	<i>MI</i>
pond (<i>human-made</i>)	<i>PO</i>
railroad bed	<i>RRB</i>
reclaimed land	<i>RL</i>
rice paddy (<i>also Anthro LF</i>)	<i>RP</i>
road bed	<i>RB</i>
road cut	<i>RC</i>
sand pit	<i>SP</i>
scalped area (<i>also Anthro LF</i>)	<i>SA</i>
sewage lagoon	<i>SWL</i>
skid trail	<i>ST</i>
spoil bank (<i>also Anthro LF</i>)	<i>SB</i>
spoil pile (<i>also Anthro LF</i>)	<i>SPP</i>
tillage mound	<i>TM</i>
truncated soil (<i>also Anthro LF</i>)	<i>TS</i>

B. GEOMORPHIC PROCESS AND OTHER GROUPS (Landscape, Landform, and Microfeature terms grouped by geomorphic process (e.g., Fluvial) or by common settings (e.g., Water Bodies). These lists are not mutually exclusive so some features occur in more than one group, particularly generic terms.)

(1) COASTAL MARINE and ESTUARINE (wave or tidal control or near-shore / shallow marine).

Landscapes:

barrier island (<i>also Landform</i>)	<i>BI</i>
bay [coast] (<i>water body; also Landform</i>)	<i>BY</i>
coastal plain (<i>also Landform</i>)	<i>CP</i>
delta plain (<i>also Landform</i>)	<i>DP</i>
estuary (<i>water body; also Landform</i>)	<i>ES</i>
fluviomarine terrace (<i>also Landform</i>)	<i>FT</i>
gulf (<i>water body; also Landform</i>)	<i>GU</i>

island (also Landform)	<i>IS</i>
lagoon (water body; also Landform)	<i>LG</i>
lowland	<i>LW</i>
marine terrace (also Landform)	<i>MT</i>
ocean (water body)	<i>OC</i>
peninsula	<i>PE</i>
sea (water body; also Landform)	<i>SEA</i>
shore complex (also Landform)	<i>SX</i>
sound (water body; also Landform)	<i>SO</i>
strait (water body; also Landform)	<i>ST</i>

Landforms:

atoll	<i>AT</i>
back-barrier beach	<i>BBB</i>
back-barrier flat	<i>BBF</i>
backshore	<i>AZ</i>
bar	<i>BR</i>
barrier beach	<i>BB</i>
barrier cove	<i>BAC</i>
barrier flat	<i>BF</i>
barrier island (also Landscape)	<i>BI</i>
bay [coast] (water body; also Landscape)	<i>BAY</i>
bay bottom	<i>BOT</i>
beach	<i>BE</i>
beach plain	<i>BP</i>
beach ridge	<i>BG</i>
beach terrace	<i>BT</i>
berm	<i>BM</i>
bluff	<i>BN</i>
chenier	<i>CG</i>
chenier plain	<i>CH</i>
coastal plain (also Landscape)	<i>CP</i>
coral island	<i>COR</i>
cove [water] (water body)	<i>COW</i>
delta	<i>DE</i>
delta plain (also Landscape)	<i>DC</i>
drainhead complex	<i>DRC</i>
estuary (water body; also Landform)	<i>WD</i>
flat	<i>FL</i>
flatwoods	<i>FLW</i>
fluviomarine terrace (also Landscape)	<i>FMT</i>
foredune	<i>FD</i>
fringe-tidal marsh	<i>FTM</i>
gulf (water body; also Landscape)	<i>GU</i>
gut [channel] (also Microfeature)	<i>WH</i>
headland	<i>HE</i>
island (also Landscape)	<i>IS</i>
lagoon (water body; also Landscape)	<i>WI</i>
lagoon [relict]	<i>LAR</i>
longshore bar	<i>LON</i>

longshore bar [relict]	<i>LR</i>
mangrove swamp	<i>MAN</i>
marine lake (water body)	<i>ML</i>
marine terrace (also Landscape)	<i>MT</i>
nearshore zone	<i>NZ</i>
nearshore zone [relict]	<i>NZR</i>
point bar [coastal]	<i>PRC</i>
raised beach	<i>RA</i>
reef	<i>RF</i>
sabkha	<i>SAB</i>
salt marsh	<i>SM</i>
sea (water body; also Landscape)	<i>SEA</i>
sea cliff	<i>RZ</i>
semi-open depression	<i>SOD</i>
shoal [relict]	<i>SE</i>
shore	<i>SHO</i>
shore complex (also Landscape)	<i>SHC</i>
sound (water body; also Landscape)	<i>SO</i>
spit	<i>SP</i>
stack [coast]	<i>SRC</i>
strait (water body; also Landscape)	<i>STT</i>
strand plain	<i>SS</i>
submerged-upland tidal marsh	<i>STM</i>
tidal flat	<i>TF</i>
tidal inlet	<i>TI</i>
tidal inlet [relict]	<i>TIR</i>
tidal marsh	<i>TM</i>
tombolo	<i>TO</i>
washover fan	<i>WF</i>
wave-built terrace	<i>WT</i>
wave-cut platform	<i>WP</i>
wind-tidal flat	<i>WTF</i>

Microfeatures:

gut [channel] (also Landform)	<i>WH</i>
ripple mark	<i>RM</i>
shoreline	<i>SH</i>
swash zone	<i>SZ</i>

(2) LACUSTRINE (related to inland water bodies).

Landscapes:

bay [coast] (also Landform)	<i>BY</i>
delta plain (also Landform)	<i>DP</i>
island (also Landform)	<i>IS</i>
lake plain (also Landform)	<i>LP</i>
peninsula	<i>PE</i>
shore complex (also Landform)	<i>SX</i>

Landforms:

backshore	<i>AZ</i>
bar (also Microfeature)	<i>BR</i>
barrier beach	<i>BB</i>
barrier flat	<i>BF</i>
barrier island	<i>BI</i>
bay [coast] (water body; also Landscape)	<i>BAY</i>
beach	<i>E</i>
beach plain	<i>BP</i>
beach ridge	<i>BG</i>
beach terrace	<i>BT</i>
berm	<i>BM</i>
bluff	<i>BN</i>
delta	<i>DE</i>
delta plain (also Landscape)	<i>DC</i>
flat	<i>FL</i>
flood-plain playa	<i>FY</i>
foredune	<i>FD</i>
headland	<i>HE</i>
island (also Landscape)	<i>IS</i>
karst lake	<i>KAL</i>
lagoon	<i>WI</i>
lagoon [relict]	<i>LAR</i>
lake (water body)	<i>WJ</i>
lake plain (also Landscape)	<i>LP</i>
lake terrace	<i>LT</i>
lakebed	<i>LB</i>
lakebed [relict]	<i>LBR</i>
lakeshore	<i>LF</i>
longshore bar	<i>LON</i>
longshore bar [relict]	<i>LR</i>
oxbow lake	<i>WK</i>
playa	<i>PL</i>
playa floor (also Microfeature)	<i>PFL</i>
playa lake	<i>WL</i>
playa rim (also Microfeature)	<i>PRI</i>
playa slope (also Microfeature)	<i>PSL</i>
playa step (also Microfeature)	<i>PST</i>
pluvial lake	<i>PLL</i>
pluvial lake [relict]	<i>PQ</i>
raised beach	<i>RA</i>
sabkha	<i>SAB</i>
salt marsh	<i>SM</i>
shoal [relict]	<i>SE</i>
shore	<i>SHO</i>
shore complex (also Landscape)	<i>SHC</i>
spit	<i>SP</i>
stack [coast]	<i>SRC</i>
strand plain	<i>SS</i>

till-floored lake plain	<i>TLP</i>
tombolo	<i>TO</i>
water-lain moraine	<i>WM</i>
wave-built terrace	<i>WT</i>
wave-cut platform	<i>WP</i>
wave-worked till plain	<i>WW</i>

Microfeatures:

bar (also Landform)	<i>BA</i>
playa floor (also Landform)	<i>PF</i>
playa rim (also Landform)	<i>PR</i>
playa slope (also Landform)	<i>PSL</i>
playa step (also Landform)	<i>PST</i>
playette	<i>PL</i>
ripple mark	<i>RM</i>
shoreline	<i>SH</i>
strandline	<i>SL</i>
swash zone	<i>SZ</i>
vernal pool	<i>VP</i>

- (3) FLUVIAL** (dominantly related to concentrated water flow (channel flow); includes erosional and depositional features, but excluding glaciofluvial landforms (see Glacial), and permanent water features (see Water Bodies)).

Landscapes:

alluvial plain	<i>AP</i>
alluvial plain remnant	<i>AR</i>
badlands	<i>BA</i>
bajada (also Landform)	<i>BJ</i>
breaks	<i>BK</i>
breaklands	<i>BR</i>
canyonlands	<i>CL</i>
delta plain (also Landform)	<i>DP</i>
dissected breaklands	<i>DB</i>
fan piedmont	<i>FP</i>
meander belt	<i>MB</i>
river valley (also Landform)	<i>RV</i>
scabland	<i>SC</i>

Landforms:

alluvial cone	<i>AC</i>
alluvial fan	<i>AF</i>
alluvial flat	<i>AP</i>
arroyo	<i>AY</i>
axial stream (water body)	<i>AX</i>
backswamp	<i>BS</i>
bajada (also Landscape)	<i>BJ</i>

bar (also Microfeature)	<i>BR</i>
basin-floor remnant	<i>BD</i>
block stream	<i>BX</i>
box canyon	<i>BOX</i>
braided stream	<i>BZ</i>
canyon	<i>CA</i>
channel	<i>CC</i>
coulee	<i>CE</i>
cutoff	<i>CV</i>
delta	<i>DE</i>
delta plain (also Landscape)	<i>DC</i>
drainageway	<i>DQ</i>
drainhead complex	<i>DRC</i>
draw	<i>DW</i>
ephemeral stream (also Microfeature)	<i>EPS</i>
fan apron	<i>FA</i>
fan collar	<i>FCO</i>
fan remnant	<i>FH</i>
fan skirt	<i>FI</i>
fanhead trench	<i>FF</i>
flood plain	<i>FP</i>
flood-plain playa	<i>FY</i>
flood-plain splay	<i>FM</i>
flood-plain step	<i>FO</i>
giant ripple	<i>GC</i>
gorge	<i>GO</i>
gulch	<i>GT</i>
gut [valley]	<i>GV</i>
inset fan	<i>IF</i>
intermittent stream (also Microfeature)	<i>INT</i>
levee	<i>LV</i>
meander scar	<i>MS</i>
meander scroll	<i>MG</i>
meandering channel	<i>MC</i>
natural levee	<i>NL</i>
overflow stream channel	<i>OSC</i>
oxbow	<i>OX</i>
paleoterrace	<i>PTR</i>
point bar	<i>PR</i>
ravine	<i>RV</i>
river valley (also Landscape)	<i>RVV</i>
semi-open depression	<i>SOD</i>
slot canyon	<i>SLC</i>
strath terrace	<i>SU</i>
stream terrace	<i>SX</i>
terrace remnant	<i>TER</i>
valley flat	<i>VF</i>
valley-border surfaces	<i>VBS</i>
valley-floor remnant	<i>VFR</i>
wash	<i>WA</i>
wind gap	<i>WG</i>

Microfeatures:

bar (also Landform)	<i>BA</i>
bar and channel	<i>BC</i>
channel	<i>CH</i>
ephemeral stream (also Landform)	<i>ES</i>
groove	<i>GR</i>
gully	<i>GU</i>
intermittent stream (also Landform)	<i>INT</i>
ripple mark	<i>RM</i>
swash zone	<i>SZ</i>

(4) SOLUTION (dominated by dissolution, and commonly, subsurface drainage).

Landscapes:

cockpit karst	<i>CPK</i>
cone karst	<i>CK</i>
fluviokarst	<i>FK</i>
glaciokarst	<i>GK</i>
karst	<i>KR</i>
kegel karst	<i>KK</i>
sinkhole karst	<i>SK</i>
thermokarst	<i>TK</i>
tower karst	<i>TW</i>

Landforms:

blind valley	<i>VB</i>
cockpit	<i>COC</i>
collapse sinkhole	<i>CSH</i>
interior valley	<i>INV</i>
karst cone	<i>KC</i>
karst lake (water body)	<i>KAL</i>
karst tower	<i>KTO</i>
karst valley	<i>KVA</i>
karstic marine terrace	<i>KMT</i>
mogote	<i>MOG</i>
pavement karst	<i>PAV</i>
pinnacle	<i>PIN</i>
sinkhole	<i>SH</i>
solution platform	<i>SOP</i>
solution sinkhole	<i>SOS</i>
swallow hole	<i>TB</i>
thermokarst depression (also Microfeature)	<i>TK</i>
yardang (also Microfeature)	<i>YD</i>
yardang trough (also Microfeature)	<i>YDT</i>

Microfeatures:

cutter	<i>CU</i>
karren	<i>KA</i>
solution chimney	<i>SCH</i>
solution corridor	<i>SCO</i>
solution fissure	<i>SOF</i>
solution pipe	<i>SOP</i>
thermokarst depression (also Landform)	<i>TK</i>
yardang (also Landform)	<i>YD</i>
yardang trough (also Landform)	<i>YDT</i>

(5) EOLIAN (dominantly wind-related erosion or deposition).

Landscapes:

coppice dune field	<i>CDF</i>
dune field (also Landform)	<i>DU</i>
sand plain	<i>SP</i>
sandhills	<i>SH</i>

Landforms:

barchan dune	<i>BQ</i>
blowout	<i>BY</i>
climbing dune	<i>CDU</i>
deflation basin	<i>DB</i>
deflation flat	<i>DFL</i>
dune	<i>DU</i>
dune field (also Landscape)	<i>DUF</i>
dune lake (water body)	<i>DUL</i>
dune slack (also Microfeature)	<i>DUS</i>
falling dune	<i>FDU</i>
foredune	<i>FD</i>
interdune (also Microfeature)	<i>ID</i>
loess bluff	<i>LO</i>
loess hill	<i>LQ</i>
longitudinal dune	<i>LDU</i>
paha	<i>PA</i>
parabolic dune	<i>PB</i>
parna dune	<i>PD</i>
playa dune (also Microfeature)	<i>PDU</i>
sabkha	<i>SAB</i>
sand ramp	<i>SAR</i>
sand sheet	<i>RX</i>
seif dune	<i>SD</i>
slickrock (also Microfeature)	<i>SLK</i>
star dune	<i>SDU</i>
transverse dune	<i>TD</i>
yardang (also Microfeature)	<i>YD</i>
yardang trough (also Microfeature)	<i>YDT</i>

Microfeatures:

dune slack (also Landform)	<i>DS</i>
dune traces	<i>DT</i>
interdune (also Landform)	<i>ID</i>
playa dune (also Landform)	<i>PD</i>
playette	<i>PL</i>
shrub-coppice dune	<i>SCD</i>
slickrock (also Landform)	<i>SLK</i>
slip face	<i>SF</i>
yardang (also Landform)	<i>YD</i>
yardang trough (also Landform)	<i>YDT</i>
zibar	<i>ZB</i>

- (6) GLACIAL** (directly related to glaciers; includes glaciofluvial, glaciolacustrine, glaciomarine, and outwash features).

Landscapes:

continental glacier	<i>CG</i>
drumlin field	<i>DF</i>
glaciokarst	<i>GK</i>
hills	<i>HI</i>
ice-margin complex	<i>IC</i>
outwash plain (also Landform)	<i>OP</i>
till plain (also Landform)	<i>TP</i>

Landforms:

alpine glacier	<i>AG</i>
arete	<i>AR</i>
cirque	<i>CQ</i>
cirque floor	<i>CFL</i>
cirque headwall	<i>CHW</i>
cirque platform	<i>CPF</i>
col	<i>CL</i>
collapsed ice-floored lakebed	<i>CK</i>
collapsed ice-walled lakebed	<i>CN</i>
collapsed lake plain	<i>CS</i>
collapsed outwash plain	<i>CT</i>
crag and tail	<i>CAT</i>
crevasse filling	<i>CF</i>
disintegration moraine	<i>DM</i>
drumlin	<i>DR</i>
drumlinoid ridge	<i>DRR</i>
end moraine	<i>EM</i>
esker	<i>EK</i>
fjord (water body)	<i>FJ</i>
flute (also Microfeature)	<i>FU</i>
fosse	<i>FV</i>

giant ripple	<i>GC</i>
glacial drainage channel	<i>GD</i>
glacial lake (water body)	<i>WE</i>
glacial lake [relict]	<i>GL</i>
glacial-valley floor	<i>GVF</i>
glacial-valley wall	<i>GVW</i>
glacier	<i>GLA</i>
ground moraine	<i>GM</i>
hanging valley	<i>HV</i>
head-of-outwash	<i>HD</i>
ice pressure ridge	<i>IPR</i>
ice-contact slope	<i>ICS</i>
ice-marginal stream	<i>IMS</i>
ice-pushed ridge	<i>IPU</i>
interdrumlin	<i>IDR</i>
kame	<i>KA</i>
kame moraine	<i>KM</i>
kame terrace	<i>KT</i>
kettle	<i>KE</i>
lateral moraine	<i>LM</i>
medial moraine	<i>MH</i>
moraine	<i>MU</i>
nunatak	<i>NU</i>
outwash delta	<i>OD</i>
outwash fan	<i>OF</i>
outwash plain (also Landscape)	<i>OP</i>
outwash terrace	<i>OT</i>
paha	<i>PA</i>
pitted outwash plain	<i>PM</i>
pitted outwash terrace	<i>POT</i>
pothole (also Microfeature)	<i>PH</i>
pothole lake (intermittent water)	<i>WN</i>
proglacial lake (water body)	<i>WO</i>
proglacial lake [relict]	<i>PGL</i>
recessional moraine	<i>RM</i>
roche moutonnée (also Microfeature)	<i>RN</i>
rock glacier	<i>RO</i>
snowfield	<i>SNF</i>
stoss and lee	<i>SAL</i>
swale (also Microfeature)	<i>SC</i>
tarn (water body; also Microfeature)	<i>TAR</i>
terminal moraine	<i>TA</i>
till plain (also Landscape)	<i>TP</i>
till-floored lake plain	<i>TLP</i>
tunnel valley	<i>TV</i>
tunnel-valley lake (water body)	<i>TVL</i>
underfit stream	<i>US</i>
U-shaped valley	<i>UV</i>
valley train	<i>VT</i>
water-lain moraine	<i>WM</i>
wave-worked till plain	<i>WW</i>

Microfeatures:

flute (also Landform)	<i>FL</i>
glacial groove	<i>GG</i>
ice wedge	<i>IWD</i>
ice wedge cast	<i>IWC</i>
nivation hollow	<i>NH</i>
pothole (also Landform)	<i>PH</i>
roche moutonnée (also Landform)	<i>POC</i>
swale (also Landform)	<i>SW</i>
tarn (water body; also Landform)	<i>TN</i>

- (7) **PERIGLACIAL** (related to nonglacial, cold climate (modern or relict), including periglacial forms of patterned ground. Note: consider “patterned ground” as a Landform, but treat specific types of patterned ground, (singular or plural), as Microfeatures.)

Landscapes:

coastal plain	<i>CP</i>
hills	<i>HI</i>
plains	<i>PL</i>
thermokarst	<i>TK</i>

Landforms:

alas	<i>AA</i>
block field	<i>BW</i>
muskeg	<i>MX</i>
patterned ground	<i>PG</i>
peat plateau	<i>PJ</i>
pingo	<i>PI</i>
rock glacier	<i>RO</i>
string bog	<i>SY</i>
thermokarst depression (also Microfeature)	<i>TK</i>
thermokarst lake (water body)	<i>WV</i>

Microfeatures:

circle	<i>CI</i>
earth hummock	<i>EH</i>
frost boil	<i>FB</i>
high-center polygon	<i>HCP</i>
ice wedge	<i>IWD</i>
ice wedge cast	<i>IWC</i>
ice wedge polygon	<i>IWP</i>
low-center polygon	<i>LCP</i>
nivation hollow	<i>NH</i>
nonsorted circle	<i>NSC</i>
palsa (= peat hummock)	<i>PA</i>
polygon	<i>PYG</i>

solifluction lobe	<i>SOL</i>
solifluction sheet	<i>SS</i>
solifluction terrace	<i>ST</i>
sorted circle	<i>SCI</i>
stripe	<i>STR</i>
thermokarst depression (also Landform)	<i>TK</i>
turf hummock	<i>TH</i>

(8) MASS MOVEMENT (MASS WASTING) (dominated by gravity, including creep forms).

Landscapes: (these generic landscapes are not mass movement features per say, but are commonly modified by, and include localized areas of, mass movement).

breaklands	<i>BR</i>
dissected breaklands	<i>DB</i>
foothills	<i>FH</i>
hills	<i>HI</i>
mountain range	<i>MR</i>
mountains	<i>MO</i>

Landforms:

ash flow	<i>AS</i>
avalanche chute	<i>AL</i>
block glide	<i>BLG</i>
block stream	<i>BX</i>
colluvial apron	<i>COA</i>
complex landslide	<i>CLS</i>
creep	<i>CRE</i>
debris avalanche	<i>DA</i>
debris fall	<i>DEF</i>
debris flow	<i>DF</i>
debris slide	<i>DS</i>
debris spread	<i>DES</i>
debris topple	<i>DET</i>
earth spread	<i>ESP</i>
earth topple	<i>ETO</i>
earthflow	<i>EF</i>
fall	<i>FB</i>
flow	<i>FLO</i>
lahar	<i>LA</i>
landslide	<i>LK</i>
lateral spread	<i>LS</i>
main scarp (also Microfeature)	<i>MAS</i>
mudflow	<i>MW</i>
rock glacier	<i>RO</i>
rock spread	<i>ROS</i>
rock topple	<i>ROT</i>
rockfall (also Microfeature)	<i>ROF</i>
rockfall avalanche	<i>RFA</i>

rotational debris slide	<i>RDS</i>
rotational earth slide	<i>RES</i>
rotational rock slide	<i>RRS</i>
rotational slide	<i>RTS</i>
sag (also Microfeature)	<i>SAG</i>
sag pond (water body; also Micro.)	<i>SGP</i>
sand flow	<i>RW</i>
scree slope	<i>SCS</i>
slide	<i>SJ</i>
slump block	<i>SN</i>
soil fall	<i>SOF</i>
talus cone	<i>TC</i>
talus slope	<i>TAS</i>
toe (also Microfeature)	<i>TOE</i>
topple	<i>TOP</i>
Toreva block	<i>TOR</i>
translational debris slide	<i>TDS</i>
translational earth slide	<i>TES</i>
translational rock slide	<i>TRS</i>
translational slide	<i>TS</i>

Microfeatures:

main scarp (also Landform)	<i>MAS</i>
minor scarp	<i>MIS</i>
rockfall (also Landform)	<i>ROF</i>
sag (also Landform)	<i>SAG</i>
sag pond (water body; also Landform)	<i>SP</i>
sand boil	<i>SB</i>
solifluction lobe	<i>SOL</i>
solifluction sheet	<i>SS</i>
solifluction terrace	<i>ST</i>
terracette	<i>TER</i>
toe (also Landform)	<i>TOE</i>

(9) VOLCANIC and HYDROTHERMAL

Landscapes:

caldera (also Landform)	<i>CD</i>
foothills	<i>FH</i>
hills	<i>HI</i>
lava field (also Landform)	<i>LF</i>
lava plain (also Landform)	<i>LV</i>
lava plateau (also Landform)	<i>LL</i>
mountains	<i>MO</i>
shield volcano (also Landform)	<i>SV</i>
volcanic field (also Landform)	<i>VF</i>

Landforms:

aa lava flow	<i>ALF</i>
ash field	<i>AQ</i>
ash flow	<i>AS</i>
block lava flow	<i>BLF</i>
caldera (also Landscape)	<i>CD</i>
cinder cone	<i>CI</i>
diatreme	<i>DT</i>
dike	<i>DK</i>
fissure vent	<i>FIV</i>
geyser	<i>GE</i>
geyser basin	<i>GEB</i>
geyser cone	<i>GEC</i>
hot spring	<i>HP</i>
kipuka	<i>KIP</i>
lahar	<i>LA</i>
<i>lava dome</i>	<i>LD</i>
lava field (also Landscape)	<i>LFI</i>
lava flow	<i>LC</i>
lava flow unit (also Microfeature)	<i>LFU</i>
lava plain (also Landscape)	<i>LN</i>
lava plateau (also Landscape)	<i>LL</i>
lava trench (also Microfeature)	<i>LTR</i>
lava tube	<i>LTU</i>
louderback	<i>LU</i>
maar	<i>MAA</i>
mawae	<i>MAW</i>
mud pot	<i>MP</i>
pahoehoe lava flow	<i>PAF</i>
pillow lava flow	<i>PIF</i>
plug dome	<i>PP</i>
pyroclastic flow	<i>PCF</i>
pyroclastic surge	<i>PCS</i>
shield volcano (also Landscape)	<i>SHV</i>
steptoe	<i>ST</i>
stratovolcano	<i>SV</i>
volcanic cone	<i>VC</i>
volcanic crater	<i>CR</i>
volcanic dome	<i>VD</i>
volcanic field (also Landscape)	<i>VOF</i>
volcanic neck	<i>VON</i>
volcanic pressure ridge (also Micro.)	<i>PU</i>
volcano	<i>VO</i>

Microfeatures:

corda	<i>CO</i>
lava flow unit (also Landform)	<i>LFU</i>
lava trench (also Landform)	<i>LT</i>
spatter cone	<i>SPC</i>
spiracle	<i>SPI</i>

tumulus (tumuli = plural)	<i>TU</i>
volcanic pressure ridge (also Landform)	<i>VPR</i>

- (10) TECTONIC and STRUCTURAL** (related to regional or local bedrock structures, or crustal movement. In soil survey information, tectonic and structural features are only recognized if they have some expression at or near the land surface).

Landscapes:

basin floor	<i>BC</i>
batholith	<i>BL</i>
bolson	<i>BO</i>
breached anticline (also Landform)	<i>BD</i>
dissected plateau	<i>DI</i>
fault-block mountains	<i>FM</i>
fold-thrust hills	<i>FTH</i>
foothills	<i>FH</i>
hills	<i>HI</i>
intermontane basin	<i>IB</i>
mountain range	<i>MR</i>
mountain system	<i>MS</i>
mountains	<i>MO</i>
piedmont slope	<i>PS</i>
plateau	<i>PT</i>
rift valley	<i>RF</i>
semibolson	<i>SB</i>
tableland	<i>TB</i>
valley	<i>VA</i>

Landforms:

anticline	<i>AN</i>
breached anticline (also Landscape)	<i>BRL</i>
canyon bench	<i>CYB</i>
cuesta	<i>CU</i>
cuesta valley	<i>CUV</i>
diapir	<i>DD</i>
dike	<i>DK</i>
dip slope	<i>DL</i>
dome	<i>DO</i>
fault block	<i>FAB</i>
fault zone	<i>FAZ</i>
fault-line scarp	<i>FK</i>
fold	<i>FQ</i>
graben	<i>GR</i>
half graben	<i>HG</i>
hogback	<i>HO</i>
homoclinal ridge	<i>HCR</i>
homocline	<i>HC</i>
horst	<i>HT</i>

louderback	<i>LU</i>
meteorite crater	<i>MEC</i>
monocline	<i>MJ</i>
rock pediment	<i>ROP</i>
scarp slope	<i>RS</i>
sill	<i>RT</i>
stock	<i>STK</i>
strike valley	<i>STV</i>
structural bench	<i>SB</i>
syncline	<i>SZ</i>
window	<i>WIN</i>

Microfeatures:

sand boil	<i>SB</i>
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- (11) **SLOPE** (generic terms or those that describe slope form, geometry, or arrangement of land features, rather than any particular genesis or process).

Landscapes:

badlands	<i>BA</i>
breached anticline (also Landform)	<i>BD</i>
breaklands	<i>BR</i>
breaks	<i>BK</i>
canyonlands	<i>CL</i>
dissected breaklands	<i>DB</i>
dissected plateau	<i>DI</i>
fault-block mountains	<i>FM</i>
foothills	<i>FH</i>
hills (singular = Landform)	<i>HI</i>
mountain range	<i>MR</i>
mountain system	<i>MS</i>
mountains	<i>MO</i>
piedmont	<i>PI</i>
piedmont slope	<i>PS</i>
plains (singular = Landform)	<i>PL</i>
plateau (also Landform)	<i>PT</i>
tableland	<i>TB</i>
upland	<i>UP</i>

Landforms:

beveled base	<i>BVB</i>
block stream	<i>BX</i>
bluff	<i>BN</i>
breached anticline (also Landscape)	<i>BRL</i>
broad interstream divide	<i>BID</i>
butte	<i>BU</i>
canyon bench	<i>CYB</i>

canyon wall	<i>CW</i>
cliff	<i>CJ</i>
colluvial apron	<i>COA</i>
cuesta	<i>CU</i>
dome	<i>DO</i>
escarpment	<i>ES</i>
faceted spur	<i>FS</i>
fault block	<i>FAB</i>
fault-line scarp	<i>FK</i>
free face (also Geom. Component – Hills, Mountains.)	<i>FW</i>
gap	<i>GA</i>
headwall	<i>HW</i>
high hill	<i>HH</i>
hill (plural = Landscape)	<i>HI</i>
hillslope	<i>HS</i>
hogback	<i>HO</i>
interfluve (also Geom. Component - Hills)	<i>IV</i>
knob	<i>KN</i>
knoll	<i>KL</i>
ledge	<i>LE</i>
low hill	<i>LH</i>
mesa	<i>ME</i>
mountain (plural = Landscape)	<i>MM</i>
mountain slope	<i>MN</i>
mountain valley	<i>MV</i>
notch	<i>NO</i>
paha	<i>PA</i>
peak	<i>PK</i>
pediment	<i>PE</i>
plain (plural = Landscape)	<i>PN</i>
plateau (also Landscape)	<i>PT</i>
ridge	<i>RI</i>
rim	<i>RJ</i>
rock pediment	<i>ROP</i>
scarp	<i>RY</i>
scarp slope	<i>RS</i>
scree slope	<i>SCS</i>
slickrock (also Microfeature)	<i>SLK</i>
spur	<i>SQ</i>
stack [geom.]	<i>SR</i>
structural bench	<i>SB</i>
talus cone	<i>TC</i>
talus slope	<i>TAS</i>
tor	<i>TQ</i>
valley	<i>VA</i>
valley-floor remnant	<i>VFR</i>
wind gap	<i>WG</i>

Microfeatures:

finger ridge	<i>FR</i>
mound	<i>MO</i>
rib	<i>RB</i>
rill	<i>RL</i>
slickrock (also Landform)	<i>SLK</i>

- (12) **EROSIONAL** (related dominantly to water erosion but excluding perennial, concentrated channel flow (i.e., fluvial, glaciofluvial) or eolian erosion).

Landscapes:

badlands	<i>BA</i>
breached anticline (also Landform)	<i>BD</i>
breaklands	<i>BR</i>
breaks	<i>BK</i>
canyonlands	<i>CL</i>
dissected breaklands	<i>DB</i>
dissected plateau	<i>DI</i>
foothills	<i>FH</i>
hills	<i>HI</i>
mountain range	<i>MR</i>
mountains	<i>MO</i>
piedmont	<i>PI</i>
piedmont slope	<i>PS</i>
plateau (also Landform)	<i>PT</i>
tableland	<i>TB</i>

Landforms:

ballena	<i>BL</i>
ballon	<i>BV</i>
basin-floor remnant	<i>BD</i>
beveled base	<i>BVB</i>
breached anticline (also Landscape)	<i>BRL</i>
canyon bench	<i>CYB</i>
canyon wall	<i>CW</i>
col	<i>CL</i>
colluvial apron	<i>COA</i>
cuesta	<i>CU</i>
cuesta valley	<i>CUV</i>
eroded fan remnant	<i>EFR</i>
eroded fan-remnant sideslope	<i>EFS</i>
erosion remnant	<i>ER</i>
free face (also Geom. Comp. – Hills, Mountains)	<i>FW</i>
gap	<i>GA</i>
hogback	<i>HO</i>
inselberg	<i>IN</i>
monadnock	<i>MD</i>
notch	<i>NO</i>

paha	<i>PA</i>
partial ballena	<i>PF</i>
peak	<i>PK</i>
pediment	<i>PE</i>
plateau (also Landscape)	<i>PT</i>
rock pediment	<i>ROP</i>
sabkha	<i>SAB</i>
saddle	<i>SA</i>
scarp slope	<i>RS</i>
slickrock (also Microfeature)	<i>SLK</i>
stack [geom.]	<i>SR</i>
strike valley	<i>STV</i>
structural bench	<i>SB</i>
terrace remnant	<i>TER</i>
tor	<i>TQ</i>
valley-border surfaces	<i>VBS</i>
valley-floor remnant	<i>VFR</i>
wind gap	<i>WG</i>
window	<i>WIN</i>

Microfeatures:

earth pillar	<i>EP</i>
finger ridge	<i>FR</i>
groove	<i>GR</i>
gully	<i>GU</i>
hoodoo	<i>HO</i>
pinnacle	<i>PI</i>
rib	<i>RB</i>
rill	<i>RL</i>
slickrock (also Landform)	<i>SLK</i>
swale	<i>SW</i>

(13) DEPRESSIONAL (low area or declivity features, excluding permanent water bodies).

Landscapes:

basin	<i>BS</i>
basin floor (also Landform)	<i>BC</i>
bolson	<i>BO</i>
breached anticline (also Landform)	<i>BD</i>
breaklands	<i>BR</i>
dissected breaklands	<i>DB</i>
semi-bolson	<i>SB</i>
valley	<i>VA</i>

Landforms:

alluvial flat	<i>AP</i>
basin floor (also Landscape)	<i>BC</i>

basin-floor remnant	<i>BD</i>
box canyon	<i>BOX</i>
breached anticline (also Landscape)	<i>BRL</i>
canyon	<i>CA</i>
Carolina Bay	<i>CB</i>
closed depression (also Microfeature)	<i>CLD</i>
col	<i>CL</i>
coulee	<i>CE</i>
cove	<i>CO</i>
cuesta valley	<i>CUV</i>
depression	<i>DP</i>
drainageway	<i>DQ</i>
drainhead complex	<i>DRC</i>
gap	<i>GA</i>
gorge	<i>GO</i>
gulch	<i>GT</i>
gut [valley]	<i>GV</i>
intermontane basin	<i>IB</i>
kettle	<i>KE</i>
mountain valley	<i>MV</i>
open depression (also Microfeature)	<i>ODE</i>
playa	<i>PL</i>
playa floor (also Microfeature)	<i>PFL</i>
playa rim (also Microfeature)	<i>PRI</i>
playa slope (also Microfeature)	<i>PSL</i>
playa step (also Microfeature)	<i>PST</i>
pothole (also Microfeature)	<i>PH</i>
pothole lake (intermittent water)	<i>WN</i>
ravine	<i>RV</i>
sabkha	<i>SAB</i>
saddle	<i>SA</i>
sag (also Microfeature)	<i>SAG</i>
semi-open depression	<i>SOD</i>
slot canyon	<i>SLC</i>
strike valley	<i>STV</i>
swale (also Microfeature)	<i>SC</i>
trough	<i>TR</i>
U-shaped valley	<i>UV</i>
valley	<i>VA</i>
valley floor	<i>VL</i>
V-shaped valley	<i>VV</i>

Microfeatures:

closed depression (also Landform)	<i>CD</i>
open depression (also Landform)	<i>OP</i>
playa floor (also Landform)	<i>PF</i>
playa rim (also Landform)	<i>PR</i>
playa slope (also Landform)	<i>PSL</i>
playa step (also Landform)	<i>PST</i>
playette	<i>PL</i>

pothole (also Landform)	<i>PH</i>
sag (also Landform)	<i>SAG</i>
swale (also Landform)	<i>SW</i>
tree-tip pit	<i>TTP</i>

- (14) **WETLANDS** (related to vegetated and/or shallow wet areas, and wet soils. (Provisional list: conventional, geologic definitions; not legalistic or regulatory usage)).

Landscapes:

estuary (also Landform)	<i>ES</i>
everglades	<i>EG</i>

(Generally, there is no appropriate Landscape term for wetlands; by default, choose the most appropriate Landscape term from another Process Environment or Other Grouping)

Landforms:

alas	<i>AA</i>
backswamp	<i>BS</i>
bog	<i>BO</i>
Carolina Bay	<i>CB</i>
dune slack (also Microfeature)	<i>DUS</i>
ephemeral stream (also Microfeature)	<i>EPS</i>
estuary (also Landscape)	<i>WD</i>
fen	<i>FN</i>
flood-plain playa	<i>FY</i>
fringe-tidal marsh	<i>FTM</i>
highmoor bog	<i>HB</i>
intermittent stream (also Microfeature)	<i>INT</i>
lowmoor bog	<i>LX</i>
mangrove swamp	<i>MAN</i>
marsh	<i>MA</i>
muskeg	<i>MX</i>
oxbow lake (intermittent water)	<i>WK</i>
peat plateau	<i>PJ</i>
playa (intermittent water)	<i>PL</i>
pocosin	<i>PO</i>
pothole (also Microfeature)	<i>PH</i>
pothole lake (intermittent water)	<i>WN</i>
raised bog	<i>RB</i>
ribbed fen	<i>RG</i>
sabkha	<i>SAB</i>
salt marsh	<i>SM</i>
slough (intermittent water)	<i>SL</i>
string bog	<i>SY</i>
swamp	<i>SW</i>
tidal flat	<i>TF</i>
tidal marsh	<i>TM</i>

Microfeatures:

dune slack (also Landform)	<i>DS</i>
ephemeral stream (also Landform)	<i>ES</i>
intermittent stream (also Landform)	<i>INT</i>
playette	<i>PL</i>
pothole (also Landform)	<i>PH</i>
vernal pool (seasonal water)	<i>VP</i>

- (15) WATER BODIES** (Discrete “surface water” features, primarily permanent open water, which in soil survey reports are commonly treated as the generic map unit “water” (e.g., lake), or as a spot or line symbol (e.g., perennial stream)). Several water body “landscape” and “landform” terms are obviously not terrestrial, but are Earth surface features (e.g., ocean).

Landscapes:

bay [coast] (also Landform)	<i>BY</i>
estuary (also Landform)	<i>ES</i>
gulf (also Landform)	<i>GU</i>
lagoon (also Landform)	<i>LG</i>
ocean	<i>OC</i>
sea (also Landform)	<i>SEA</i>
sound (also Landform)	<i>SO</i>
strait (also Landform)	<i>ST</i>

Landforms:

axial stream	<i>AX</i>
bay [coast] (also Landscape)	<i>BAY</i>
bayou	<i>WC</i>
cove [water]	<i>COW</i>
dune lake	<i>DUL</i>
estuary (also Landscape)	<i>WD</i>
fjord	<i>FJ</i>
glacial lake	<i>WE</i>
gulf (also Landscape)	<i>GU</i>
gut [channel] (also Microfeature)	<i>WH</i>
ice-marginal stream	<i>IMS</i>
inlet	<i>IL</i>
lagoon (also Landscape)	<i>WI</i>
lagoon channel	<i>LCH</i>
lake	<i>WJ</i>
lakebed	<i>LB</i>
marine lake	<i>ML</i>
nearshore zone	<i>NZ</i>
oxbow lake	<i>WK</i>
perennial stream (also Microfeature)	<i>PS</i>
playa lake	<i>WL</i>
pluvial lake	<i>PLL</i>
pothole lake	<i>WN</i>

proglacial lake	<i>WO</i>
river	<i>RIV</i>
sag pond (also Microfeature)	<i>SGP</i>
salt pond (also Microfeature)	<i>WQ</i>
sea (also Landscape)	<i>SEA</i>
shoal	<i>WR</i>
slackwater	<i>WS</i>
slough	<i>SL</i>
sound (also Landscape)	<i>SO</i>
strait (also Landscape)	<i>STT</i>
stream (permanent water)	<i>STR</i>
tarn (also Microfeature)	<i>TAR</i>
thermokarst lake	<i>WV</i>
tidal inlet	<i>TI</i>
tidal inlet [relict]	<i>TIR</i>
tunnel-valley lake	<i>TVL</i>

Microfeatures:

channel (permanent water)	<i>CH</i>
gut [channel] (also Landform)	<i>WH</i>
perennial stream (also Landform)	<i>PS</i>
pond	<i>PON</i>
pool	<i>POO</i>
sag pond (also Landform)	<i>SP</i>
salt pond (also Landform)	<i>WQ</i>
tank	<i>TA</i>
tarn (also Landform)	<i>TN</i>

- (16) SUBAQUEOUS FEATURES** (Discrete, relatively shallow underwater features that commonly can support rooted plants, and adjacent features, ordinarily found below permanent open water. Historically, in Soil Survey Reports these underwater features have been included in the generic map unit “water”). Subaqueous “landscape” terms are obviously not terrestrial, but are Earth surface features.

Landscapes:

bay [coast] (water body; also Landform)	<i>BY</i>
estuary (water body; also Landform)	<i>ES</i>
gulf (water body; also Landform)	<i>GU</i>
lagoon (water body; also Landform)	<i>LG</i>
ocean (water body)	<i>OC</i>
sea (water body; also Landform)	<i>SEA</i>
sound (water body; also Landform)	<i>SO</i>
strait (water body; also Landform)	<i>ST</i>

Landforms:

barrier cove	<i>BAC</i>
bay [coast] (water body; also Landscape)	<i>BAY</i>

bay bottom	<i>BOT</i>
cove [water] (water body)	<i>COW</i>
estuary (water body; also Landscape)	<i>WD</i>
flood-tidal delta	<i>FTD</i>
flood-tidal delta flat	<i>FTF</i>
flood-tidal delta slope	<i>FTS</i>
fluviomarine bottom	<i>FMB</i>
gulf (water body; also Landscape)	<i>GU</i>
inlet	<i>IL</i>
lagoon (water body; also Landscape)	<i>WI</i>
lagoon bottom	<i>LBO</i>
lagoon channel	<i>LCH</i>
lake	<i>WJ</i>
lakebed (water body)	<i>LB</i>
longshore bar	<i>LON</i>
mainland cove	<i>MAC</i>
marine lake	<i>ML</i>
nearshore zone	<i>NZ</i>
reef	<i>RF</i>
sea (water body; also Landscape)	<i>SEA</i>
shoal	<i>WR</i>
sound (water body; also Landscape)	<i>SO</i>
strait (water body; also Landscape)	<i>STT</i>
submerged back-barrier beach	<i>SBB</i>
submerged mainland beach	<i>SMB</i>
submerged point bar [coast]	<i>SPB</i>
submerged wave-built terrace	<i>SWT</i>
submerged wave-cut platform	<i>SWP</i>
tidal inlet	<i>TI</i>
tidal inlet [relict]	<i>TIR</i>
washover-fan flat	<i>WFF</i>
washover-fan slope	<i>WFS</i>

Microfeatures:

channel (permanent water)	<i>CH</i>
gut [channel] (water body)	<i>WH</i>

Anthropogenic Features:

dredged channel	<i>DC</i>
dredge-deposit shoal	<i>DDS</i>

629.11 List of Materials or Material-Related, Structure, or Morphological-Feature Terms Contained in the Glossary

(**NR** – terms that are NOT RECOMMENDED; **NP** – terms that are NOT PREFERRED)

aa lava
ablation till - NP
alluvium
andesitic lahar deposit
anticline
aquiclude
aquifer
aquitard
artifact
ash (volcanic)
ash flow - NP
backswamp deposit
basal till - NP
bauxite
beach sands
bed
bedded
bedding plane
bedrock
block lava
block field
block glide deposit
block stream
blue rock (volcanic)
boulder field - NR
bowl
breccia
buried soil
caliche
caprock
chert
chimney
cinders
clast
clastic
coastal marl
colluvium
complex landslide deposit
conglomerate
continuous permafrost
coprogenous earth
coprogenous material
country rock
craton
creep deposit
cross-bedding

cross-lamination
cross-stratification
cryptogamic crust
cryoturbate
cyclothem
dead-ice - NR
debris
debris avalanche deposit
debris fall deposit
debris flow deposit
debris slide deposit
debris spread deposit
debris topple deposit
deposit
desert pavement
desert varnish - NP
detritus (geology)
diamictite
diamicton
diatomaceous earth
diatomite
dike
dip
discontinuity
discontinuous permafrost
dropstone
dolomite (mineral)
dolomite (rock)
dolostone - NR
dome
dredge spoils
drift (glacial geology)
earthflow deposit
eolian deposit
epiclastic
erosional pavement
erratic
estuarine deposit
facies (stratigraphy)
fanglomerate
felsenmeer - NP
felsic rock
fill
fly ash
flow till
fluviomarine deposit
fold
formation (stratigraphy)
freshwater marl
glacial drift - NR
glacial outwash - NR

glacial till - NR
glaciofluvial deposits
glaciolacustrine deposits
glaciomarine deposits
glauconite pellets
graben
granitoid
greensands
ground soil
grus
gypsite
herbaceous peat
horst
human-transported material
ice-pushed ridge
ice wedge
ice wedge cast
igneous rock
interbedded
intrusive
lacustrine deposit
lagoonal deposit
lahar deposit
lamella
lamina
lamination - NR
lapilli
lateral spread deposit
lava
limestone
limonite
lithologic
lodgment till
loess
louderback
mafic rock
marine deposit
marl
mass movement deposit
melt-out till
metamorphic rock
metasediment
microbiotic crust
mine spoil, coal extraction
mine spoil, metal-ore extraction
mine spoil or earthy fill
moraine
moss peat
muck
mucky peat
mudstone

mudflow deposit
novaculite
nuée ardente
outcrop
outwash
overbank deposit
overburden
overthrust
paleosol
pahoehoe lava
parna
peat
pedisediment
permafrost
pillow lava
pitted outwash
plow pan
pluton
plutonic
porcellanite
puff
pumice
pyroclastic
pyroclastic flow
pyroclastic surge
regolith
relict soil
residuum
rhythmite
rockfall deposit
rockfall avalanche deposit
rock varnish
rotational debris slide deposit
rotational earth slide deposit
rotational rock slide deposit
rotational slide deposit
rubble
sand flow deposit
sand sheet
sandstone
saprolite
scoria
scree
sediment
sedimentary peat
sedimentary rock
shale
siltstone
sill
siltite
slide

slip face
slip surface
slope alluvium
sloughed till - NR
slump - NR
slump block
slump till- NR
soil fall deposit
solifluction deposit
solifluction sheet
spoil bank
spoil pile
sporadic permafrost
stagnant ice
stone line
strandline
subglacial flow till
subglacial melt-out till
subglacial till
supraglacial debris-flow sediment - NP
supraglacial flow till
supraglacial melt-out till
supraglacial till
syncline
talus
tephra
thaw-sensitive permafrost
thaw-stable permafrost
till (glacial)
tombolo
topple deposit
tor
translational debris slide deposit
translational earth slide deposit
translational rock slide deposit
translational slide deposit
tuff
valley fill
valley side alluvium
varve
ventifact
vitric
volcanic block
volcanic bomb
volcanic breccia
volcaniclastic
welded soil
welded tuff
woody peat

629.12 Genesis-Process Terms and Geologic Time Terms Contained in the Glossary

(**NR** – terms that are NOT RECOMMENDED; **NP** – terms that are NOT PREFERRED)

aeolian - NR
accretion
active layer
active slope - NR
aggradation
alluvial
angle of repose
avalanche
avulsion
backwearing
block glide
buried
bypassed
cat clay - NR
colluvial
competence
complex landslide
conformity
conglifraction - NP
congliturbation - NR
constructional (geomorphology)
corrosion
creep
cryoplanation
cryoturbation
cut and fill
debris avalanche
debris flow (mudflow)
debris slide
deflation
degradation
deposition
destructional (geomorphology)
dip (structural geology)
discontinuity
distal
earthflow
Eocene
eolian
erosion
erosional (geomorphology)
exfoliation
exhumed
extramorainic - NP
extramorainal
extrusive

fall
flow
fluvial
frost bursting - NR
frost churning - NR
frost riving - NR
frost shattering
frost splitting - NR
frost stirring - NR
frost weathering - NR
frost wedging - NR
geomorphology
gelifraction - NR
gelivation - NR
glacial
glacial epoch
glacial marine sedimentation
glacial outburst flood (see *jökulhlaup*)
glaciation
Holocene
ice age - NR
ice-rafting
ice segregation
intramorainal
joint
knickpoint
landslide
lateral spread
lithification
mass movement
mass wasting - NP
metastable slope - NR
Miocene
mudflow
nivation
Oligocene
Paleocene
pedoturbation
periglacial
Pleistocene
Pliocene
postglacial - NP
proximal
Quaternary
recent
relict
rockfall
rockfall avalanche
rotational landslide
sand flow
scour

scour and fill
slide
slope wash
slump - NP
soil creep - NP
soil fall
solifluction
strike (structural geology)
storm surge
stratified
stratigraphy
stream order
subaerial
subaqueous
subglacial
superglacial - NR
supraglacial
Tertiary
topple
translation slide
volcanic
weathering
welding

629.13 North American Glacial Episodes and General Geologic Time Scale ^{1, 2}

(Schoeneberger et al., 2012)

Era	Geologic Period		Geologic Epoch	Sub-Division	O Isotope Stage	Years (BP)		
CENOZOIC	QUATERNARY		Holocene		(1)	0 to 10-12 ka*		
			Late Pleistocene	Late Wisconsin	(2)	10-12 to 28 ka		
				Middle Wisconsin	(3, 4)	28 to 71 ka		
				Early Wisconsin	(5a - 5d)	71 to 115 ka		
				Late Sangamon				
				Sangamon	(5e)	115 to 128 ka		
				Late – Mid Pleistocene (Illinoian)	(6 - 8)	128 to 300 ka		
				Middle – Mid Pleistocene	(9 - 15)	300 to 620 ka		
				Early – Mid Pleistocene	(16 - 19)	620 to 770 ka		
			Early Pleistocene		770 ka to 2.6 Ma**			
			TERTIARY	Neo- gene	Pliocene	2.6 to 5.3 Ma		
					Miocene	5.3 to 23.0 Ma		
	Paleo- gene	Oligocene		23.0 to 33.9 Ma				
		Eocene		33.9 to 55.8Ma				
		Paleocene		55.8 to 65.5 Ma				
	MESOZOIC	CRETACEOUS		Late Cretaceous	65.5 to 99.6 Ma			
				Early Cretaceous	99.6 to 145.5 Ma			
JURASSIC				145.5 to 201.6 Ma				
TRIASSIC		201.6 to 251.0 Ma						
PERMIAN		251.0 to 299.0 Ma						
PENNSYLVANIAN		299.0 to 318.0 Ma						
PALEOZOIC	MISSISSIPPIAN		318.0 to 359.0 Ma					
	DEVONIAN		359.0 to 416.0 Ma					
	SILURIAN		416.0 to 444.0 Ma					
	ORDOVICIAN		444.0 to 488.0 Ma					
	CAMBRIAN		488.0 to ≈ 542.0 Ma					
	PRECAMBRIAN		> ≈ 542.0 Ma					

* ka = x 1,000; ** Ma = x 1,000,000

≈ = “approximately”

¹ Modified from Morrison, 1991; Sibrava et al., 1986; and Harland et al., 1990.² Modified from Walker and Geidman, 2009.**REFERENCES**

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629.14 Till Terms***TILL TERMS***

Genetic classification and relationships of till terms commonly used in soil survey. (Schoeneberger et al., 2012; adapted from Goldthwaite and Matsch, 1988)

Location (Facies of tills grouped by position at deposition)	Till Types	
	Terrestrial	Waterlaid
Proglacial Till (at the front of, or in front of a glacier)	proglacial flow till	waterlaid flow till
Supraglacial Till (on top of, or within upper part of a glacier)	supraglacial flow till ^{1, 3} supraglacial melt-out till ¹ (ablation till - NP) ¹ (lowered till - NP) ² (sublimation till - NP) ²	-----
Subglacial Till (within the lower part of, or beneath a glacier)	lodgment till ¹ subglacial melt-out till subglacial flow till (= “squeeze till” ^{2, 3}) (basal till - NP) ¹ (deformation till - NP) ² (gravity flow till - NP) ²	waterlaid melt-out till waterlaid flow till iceberg till (= “ice-rafted”)

¹ *Ablation till* and *basal till* are generic terms that only describe “relative position” of deposition and have been widely replaced by more specific terms that convey both relative position and process. *Ablation till* (any comparatively permeable debris deposited within or above stagnant ice) is replaced by *supraglacial melt-out till* and *supraglacial flow till*. *Basal till* (any dense, nonsorted subglacial till) is replaced by *lodgment till*, *subglacial melt-out till*, and *subglacial flow till*.

² Additional (proposed) till terms that have not gained wide acceptance, and are therefore considered to be *Not Preferred*, and should not be used (shown for completeness).

³ Also called *gravity flow till* (Not Preferred).

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Jackson, J.A. (ed.). 1997. Glossary of geology, 4th edition. American Geological Institute, Alexandria, VA.

Title 430 – National Soil Survey Handbook

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and Soil Survey Staff. 2012. Field book for describing and sampling soils, version 3.0. USDA Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

629.15 Pyroclastic Terms

PYROCLASTIC TERMS: Size and compositional relationships of pyroclastic terms commonly used in soil survey. (Schoeneberger et al., 2012; adapted from Fisher, 1989)

Pyroclasts and Pyroclastic Deposits (Unconsolidated)			
Size			
Scale:	0.062 mm ¹	2 mm	64 mm ¹
</			

¹ These size breaks are taken from geologic literature (Fisher, 1989) and based on the modified Wentworth scale. The 0.062 mm break is very close to the USDA's 0.05 mm break between *coarse silt* and *very fine sand* (Soil Survey Division Staff, 1993). The 64 mm "geologic" break is relatively close to the USDA's 75 mm break between *coarse gravel* and *cobbles*. (See the chart "Comparison of Particle Size Classes in Different Systems" in the "Profile / Pedon Description Section" under "Soil Texture" in the Field Book for Describing and Sampling Soils (Schoeneberger et al., 2012).)

² A minimum size limit of 2 mm is required for volcanic fragments (i.e., rock and pararock) in Soil Taxonomy (Soil Survey Staff, 1999), but is not required in geologic usage (Fisher, 1989). Soil Taxonomy also defines the term "pumicelike fragments" for vesicular pyroclastic materials other than pumice that have an apparent specific gravity (including vesicles) of less than 1.0 g/cm³.

³ The general descriptor for pumiceous pyroclasts smaller than 2 mm. Geologic usage is based solely upon composition and does not include any size restrictions.

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Part 630 – Benchmark Soils

Subpart A – General Information

630.0 Definition and Purpose

A. Definition

A benchmark soil is one of large extent within one or more major land resource areas (MLRAs), one that holds a key position in the soil classification system, one for which there is a large amount of data, one that has special importance to one or more significant land uses, or one that is of significant ecological importance.

B. Purpose

- (1) Benchmark soils, while being important soils in their own right, are also intended to serve as proxies for other similar soils. Their purpose is to focus data collection and the investigative effort on soils that have the greatest potential for extending collected data and resultant interpretations to other soils. This purpose is relevant both in making soil surveys and to soil survey customers in their goal to extend findings of their research. The cost of investigation and the large number of combinations of soil uses and management practices preclude laboratory and field studies of all soils; therefore, studies of benchmark soils are an essential component of developing nationwide soil databases and soil interpretations. Data obtained by studying benchmark soils can be used to help estimate important properties in similar soils. Benchmark soils can also be used to test new interpretations or to provide input to regional scale models. Knowledge of the properties and behavior of benchmark soils contributes to the understanding and interpretation of other soils with similar properties. This knowledge is important to soil technology and the use of soil surveys.
- (2) Lists of benchmark soils are useful in planning many kinds of soil studies. The designation of “benchmark” facilitates the selection of soils that meet research and other study objectives while also allowing for maximum extension of study data. Benchmark soils can be selected for their representativeness and included in studies of single soils or a suite of soils, such as those representing a gradient in temperature or moisture across a region. The list and accompanying information about the soil’s classification, land uses, land cover, and ecological significance are useful in the development of cross-site studies or networks, such as soil monitoring networks.
- (3) Some example uses for benchmark soils are—
 - (i) Extending estimated soil property data to similar soils.
 - (ii) Documenting soil properties for ecological site information.
 - (iii) Assessing conservation effects.
 - (iv) Evaluating soil interpretations.
 - (v) Studying macronutrients, micronutrients, and trace elements.
 - (vi) Lab characterization studies and special studies looking at soil carbon, heavy metals and other geochemistry analyses.
 - (vii) Monitoring change in soil quality and natural resource condition.
 - (viii) Measuring saturated hydraulic conductivity.
 - (ix) Dynamic soil property investigations.
 - (x) Verifying and testing soil erodibility factors.

- (xi) Collecting crop and range plant adaptation and yields.
- (xii) Assessing soil fertility.
- (xiii) Locating sources for training materials and onsite training activities.
- (xiv) Modeling crop, soil, and pesticide scenarios for surface water and groundwater assessments.
- (xv) Modeling pedotransfer functions.
- (xvi) Conducting cross-site research.

630.1 Policy and Responsibilities

A. Soil Survey Office (SSO).—The SSO is responsible for—

- (1) Evaluating the benchmark soils in their area of responsibility, for adherence to the benchmark soils definition and purpose, through cooperation and consultation with the members of the SSO technical team.
- (2) Proposing changes to the benchmark soils status of soil series, through the management team for the SSO and the soil survey regional office.
- (3) Identifying soil series that are considered similar to the benchmark soils for the extrapolation and transfer of data.
- (4) Ensuring pedon descriptions are entered in NASIS for benchmark soil sampling sites.
- (5) Including a focus on benchmark soils in long-range, project, and investigation plans.
- (6) Developing an inventory of existing data for benchmark soils within their area of responsibility.
- (7) Assessing the adequacy of the data and developing plans to fill identified data gaps.
- (8) Developing a narrative record for each benchmark soil within their area of responsibility.

B. Soil Survey Regional Office (SSR).—The SSR is responsible for—

- (1) Maintaining the benchmark status data element for soil series in the soil classification database.
- (2) Ensuring that benchmark soils are adequately addressed in SSO long-range, project, and investigation plans.
- (3) Ensuring the entire MLRA is adequately represented by an optimal number of benchmark soils by approving recommendations for changes to benchmark soil status.
- (4) Maintaining an inventory of existing data for benchmark soils, as supplied by each SSO, for their region.
- (5) Consulting with appropriate members of SSO management teams with regard to requests for revisions to benchmark status.
- (6) Focusing long-range soil survey investigation plans on benchmark soils and their characteristics.

A. C. State Soil Scientist.—The state soil scientist is responsible for—

- (1) Reviewing proposed changes, as a member of a management team for the SSO, to the benchmark status of soil series, and forwarding those that the management team concurs with to the SSR for approval.
- (2) Soliciting input from cooperators and interdisciplinary specialists in the selection of benchmark soils.
- (3) Ensuring that benchmark soils are considered in organizing and planning research, special studies, and investigations.

D. National Soil Survey Center (NSSC).—The National Soil Survey Center is responsible for—

- (1) Providing guidance in the selection of benchmark soils.

- (2) Providing customer support and ensuring that internet access and query routines for benchmark soils are available and functioning properly.
- (3) Communicating and consulting with the staff at the site hosting the electronic files needed to deliver benchmark soil information.
- (4) Through liaisons assigned to each SSR and SSO, assisting in the development of investigations plans.
- (5) Performing laboratory characterization.
- (6) Maintaining the laboratory database.
- (7) Developing web-based geospatial analysis tools through its Geospatial Research Unit (GRU) for use in analyzing and revising benchmark soils by major land resource area.
- (8) Developing web-based map display products.

630.2 Criteria for Selecting or Revising Benchmark Soils

A. Criteria

The soil series that are designated as benchmark soils within an MLRA should collectively reflect the major diversity of soils within the area. The criteria are as follows:

- (i) Extent.—The soil series that are selected as benchmark soils are commonly of large extent (>100,000 acres) in the land resource region (LRR), and of moderate or large extent (> 10,000 acres) in the MLRA. Not all series of moderate or large extent are benchmark soils. Generally, the combined total extent of all benchmark soils should comprise about 20 to 25 percent of the total soil area of the major land resource area. When combining the extent of the benchmark soils plus the extent of similar soils that they represent, collectively they are representative of 60 to 80 percent or more of all soils in the major land resource area. This kind of representation ensures that any collected data are widely applicable.
- (ii) Key Taxonomic Classes.—Soils that are representative of key positions in soil taxonomy within the MLRA (such as commonly occurring great groups, subgroups, or families) are considered for benchmark soil designation. Research on these can be easily applied to other soils in those classes. Typically, no more than one or two soils from the same family are designated as benchmark soils within an MLRA. See paragraph (iv) below for a reason to have more than one.
- (iii) Existing Data.—When similar soils are potential candidates for benchmark soil designation, soil series for which there are adequate amounts of data have preference over equally suitable series for which there are less data. Data-completeness of correlated pedon data must be evaluated concurrently with analyses of series extent, taxonomic significance, or unique importance. The National Cooperative Soil Survey (NCSS) soil characterization database (<http://ncsslabsdatamart.sc.egov.usda.gov>), maintained by the National Soil Survey Center, includes laboratory data for benchmark soils. In addition, soil survey investigations reports identify benchmark soils. This will optimize the identification of potential benchmark candidates.

Benchmark soils need to be well documented with complete characterization data. Ideally, there should be three to five pedons characterized. Each description must be accurately georeferenced. The data should include physical characterization (e.g., particle size, bulk density, moisture characteristics, Atterberg limits, etc.), chemical characterization (e.g., pH, base status, CEC, organic carbon, and calcium carbonate equivalent as applicable, etc.), and mineralogical characterization (e.g., clay minerals, optical grain counts). Additional data, such as cations extracted by ammonium oxalate,

cations extracted by dithionite citrate, electrical conductivity, COLE, phosphate retention, exchangeable sodium percentage, melanic index, and other properties, are important for some soils and should be considered when evaluating the completeness of existing data. Since there is not a single list of appropriate data for every soil, the assigned liaison from the NSSC Kellogg Soil Survey Laboratory, and where applicable, the local university NCSS cooperator, should be consulted to evaluate the adequacy of the existing data, identify data needs, and develop plans to expand the data available for benchmark soils in the region.

- (iv) Other Considerations.—The set of benchmark soils for a MLRA should include representatives from the major parent materials and landforms in the area. For example, coarse-loamy, mixed, active, mesic Typic Hapludalfs may be common on both extensive till plains and stream terraces in the MLRA. A single series from this family might not be adequate to represent these conditions if some key properties are significantly different between the two settings.

Certain soils are especially important because of their use or ecological importance in the landscape. If these soils are essential to the understanding of landscape processes or ecological functions within the MLRA, or interpretations for unique land uses or land management practices, they may be designated as benchmark soils, even if they are not extensive. The number of soils meeting this criterion alone is small, perhaps two or three per MLRA.

B. General Guidance

Using the criteria discussed above, select the fewest number of soils required to adequately represent the soils in the MLRA. By considering extent, taxonomic placement, ecological significance, major parent materials and landforms, uniquely important soils, and existing data, an optimal benchmark soil list can be developed.

630.3 Maintaining a Record of Benchmark Soil Data Needs

A. Maintenance

The benchmark status designation for soil series is recorded in the Soil Classification database. This database is managed by the SSR staffs. Soil surveys are dynamic; consequently, the adequacy of the current benchmark soils status needs to be evaluated periodically as soil survey information is updated. While changes can be made at any time, keep in mind that if changes are made too frequently, the effectiveness in fulfilling the intended purpose of the benchmark soils may be diminished. The benchmark soils designation is recorded for soil series within MLRAs.

B. Access to Benchmark Soil Lists

Use the online Soil Series Classification (SC) or Official Soil Series Descriptions (OSD) websites to view, query, and download benchmark soils lists. These data are on public-access, read-only web sites accessed by selecting “View OSDs by Query (with download option)” on the Official Soil Series Descriptions web page available at <http://soils.usda.gov/technical/classification/osd/index.html>. An option exists on the Soil Series Classification Query Facility web page (<https://soilseries.sc.egov.usda.gov/screports.aspx>) to download soil series data in a tab-delimited file format. These data may then be imported into spreadsheet and other programs for easier sorting and analysis.

C. Development of a Comprehensive Report

Each MLRA soil survey leader, in consultation with technical team members, the management team, and NCSS cooperators as appropriate, develops a comprehensive report summarizing the kinds of data and information currently available and data needed to predict the behavior of soils in each major land resource area. This report compares existing data and information on benchmark soils with needs to determine the adequacy of information for the MLRA. This comparison helps plan for studies of soil properties, qualities, and behavior.

D. Narrative Record of Each Benchmark Soil

Based on the comprehensive report, a narrative record of each benchmark soil is provided to State soil scientists for distribution. The record helps to facilitate long-range planning and to encourage cooperative ventures with research institutions. Discuss the kinds of special studies and soil properties needed. Include literature references of research studies on the benchmark soil. Refer to part 630, subpart B, section 630.10, for an example of a narrative record.

Part 630 – Benchmark Soils

Subpart B – Exhibits

630.10 Sample Narrative Record for Benchmark Soils

BETA SERIES – a member of the family of fine-loamy, mixed, superactive, frigid Typic Argiustolls. It dominantly occurs in the Rolling Soft Shale Plains, Major Land Resource Area (MLRA) 54, but it also extends into the Southern Dark Brown Glaciated Plains, MLRA 53C. The Beta series is about 105,000 acres in extent. Most areas of Beta soils are in privately managed grasslands used for grazing.

Beta soils are 100 to 150 centimeters deep to soft bedrock and formed in alluvium and residuum derived from sandstone, siltstone, and shale with thin surficial mantles of drift (e.g., till).

Other Series Represented: The Beta series is similar to the following series in MLRA 54.

Theta	Fine-loamy, mixed, superactive, frigid Typic Argiustolls
Gamma	Fine-loamy, mixed, active, frigid Typic Argiustolls
Delta	Fine-silty, mixed, superactive, frigid Typic Argiustolls

Data can potentially be used as a surrogate for these similar soils, but care should be taken when extending data for one soil series to another to ensure that the extension of data is reasonable for the particular case under consideration. These series, along with the Beta series, collectively are about 225,000 acres in extent.

The Beta series was selected as a benchmark soil primarily because it is an important soil occupying upland positions that have been impacted by glaciation in this otherwise unglaciated area. In addition, these soils support some of the most productive grasslands in the area.

Information needs: In MLRA 54, knowledge of the properties, qualities, and behavior of the Beta soils is useful in understanding: (1) the effect of changes in cropping systems and management practices on dynamic soil properties, (2) the penetration of roots and the movement of water into the soft bedrock, (3) pesticide and nutrient fate and transport for surface water and groundwater assessment, (4) the use of soils with soft bedrock for septic tank absorption fields, (5) the Silty rangeland ecological site, and (6) the use of soils with soft bedrock for building site development. The bedrock underlying Beta soils contains deposits of strippable coal, and the knowledge of soil properties, qualities, and behavior is important for the development of effective soil reclamation measures.

Data needs: The following dynamic properties and morphological attributes are needed across the common crop management systems: saturated hydraulic conductivity, soil bulk density, organic carbon, surface roughness, consistence, structure, and macropore characteristics (geometry, frequency, distribution, and continuity). The purpose is to integrate the macropore characteristic with structure, particle-size distribution, and mineralogy in order to develop a pedotransfer function that predicts saturated hydraulic conductivity.

Laboratory data:

National Cooperative Soil Survey (NCSS) Soil Characterization Database
(information available at this Web address: <http://ncsslabsdatamart.sc.egov.usda.gov/>)

User Pedon ID

82STATEFIPS031005

84STATEFIPS021002

87STATEFIPS005001

91STATEFIPS007007

97STATEFIPS013011

ANYSTATE University pedon data

(List sources and contacts where information can be acquired)

Part 631 – Soil Survey Investigations

Subpart A – General Information

631.0 Definition and Purpose

A. Soil survey investigations are activities that develop and provide reliable new information and understanding about soils, soil relationships, and soil survey methods.

B. Soil survey investigations—

- (1) Supplement field information with laboratory and analytical data on the properties and behavior of soil.
- (2) Develop field and laboratory methods.
- (3) Provide a database of soil information.
- (4) Provide concepts, methods, understanding, and predictions for soil survey interpretations and modeling.
- (5) Develop and provide theories and understanding to soil formation and the relationship of soils to genetic and landscape factors.

631.1 Policy and Responsibilities

A. Policy.— NRCS has authorization for research in support of soil survey activities. Soil survey researchers of the NRCS coordinate with field, State soils staffs, and State conservationists of NRCS and partners of the National Cooperative Soil Survey (NCSS). Investigations primarily focus on the soils of the United States, Puerto Rico, and Pacific Islands. Researchers working in other countries coordinate with the NRCS International Programs Division and the USDA Office of Capacity Building and Development of the Foreign Agricultural Service.

B. Responsibilities.—Investigations by the National Soil Survey Center (NSSC) respond to requests from NRCS soil survey, soil survey regional, or State offices, other branches of the NRCS, and other organizations. The NSSC initiates some projects to advance the NCSS program.

- (1) The NSSC is responsible for—
 - (i) Leadership in regional and national research projects for soil surveys.
 - (ii) Leadership in the Federal research program in pedology.
 - (iii) Manuals on laboratory procedures.
 - (iv) Training for field investigations.
 - (v) NCSS soil characterization and laboratory information management system (LIMS) databases.
- (2) The soil survey regional office (SSR) is responsible for—
 - (i) Approval of field soil survey investigations.
 - (ii) Identifying data voids.
 - (iii) Coordinating work plans with cooperators.
 - (iv) Requesting NSSC assistance.
 - (v) Ensuring complete pedon descriptions and accurate georeferenced locations for soil characterization samples.
 - (vi) Updating the classification of pedons in the national repository for laboratory data.

- (3) The soil survey office (SSO) is responsible for—
 - (i) Complete and accurate pedon descriptions and the classification of soils on sampling projects within the soil survey area.
 - (ii) Attribute data in the National Soil Information System.

631.2 Kinds of Projects

A. Laboratory Characterization Projects

- (1) Characterization projects define the morphological, chemical, physical, and mineralogical properties of soils within a major land resource area. The data are included in soil survey reports at the discretion of the MLRA soil survey office leader.
- (2) Characterization projects usually include suites of standard laboratory analyses, which are defined in section 631.3 A.
- (3) Laboratory characterization projects require work plans for the major land resource area. Section 631.12 provides an example of a characterization work plan. The work plan identifies pedons and laboratory data that may be published in the soil survey.

B. Research Projects

- (1) Research define soil data relationships, soil genetic processes, soil-landscape relationships, soil interpretive applications, or criteria for soil classification. Research projects normally combine field observations and laboratory or special field analyses. Some projects examine existing data to reveal new data relationships or applications.
- (2) An outline of the objectives, hypotheses, and methods of study for research projects reduces the complexity and helps report the results to other scientists.
- (3) Research projects require work plans. Section 631.10 gives an example of a research work plan checklist and Section 631-11 gives an example work plan.

C. Laboratory Reference Projects

- (1) Reference projects answer a single question or at most very few questions, directed at quick analyses such as on particle-size class, base saturation, or mineralogy.
- (2) Reference projects require basic documentation, including pedon descriptions, but do not require work plans.

D. Other Kinds of Projects

- (1) Other projects or services include landform and geomorphic studies, ground penetrating radar, other special measurements, extraction of information from the laboratory database, and literature searches.
- (2) Liaisons and others at the NSSC answer technical questions and help develop plans for a State, MLRA, or other land area.
- (3) The NSSC staff cooperates on various projects with visiting scientists, including NRCS soil scientists. Studies by MLRA, including soil survey updates, are an example.
- (4) Listings of existing data for the area of interest are available and should be obtained prior to requesting additional data-gathering projects.

631.3 Laboratory Investigation Methods

A. Standard Analysis.—Standard laboratory analyses include chemical, physical, and mineralogical analyses for classification of soils within soil taxonomy. Analyses also answer specific questions relating to soil survey interpretations and soil performance. The more routine analyses include

particle-size, cation exchange capacity, base saturation, organic carbon, pH, calcium carbonate equivalent, salt, bulk density, water retention, and clay mineralogy.

Laboratory analyses follow standards described in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 5.0, 2014, USDA, NRCS. Only the laboratory data from standard analyses enters the permanent NCSS Soil Characterization database. Method codes identify the analytical method for these analyses.

B. Special Analyses.—Some chemical, physical, and mineralogical analyses answer specific requests from States for conservation activities or to test new methods. Recurring requested analyses may become standard. Special analyses include published procedures used by other laboratories that have been developed or adapted by the NSSC Kellogg Soil Survey Laboratory.

C. Soil Sampling and Analysis

- (1) A soil horizon is the primary sampling unit. For all characterization projects and some reference projects, all horizons to 2 meters are sampled unless strongly cemented to indurated bedrock (i.e., lithic contact) is at a lesser depth. The project work plan identifies the pedons to be sampled and analyses to be made.
- (2) The soil survey office locates pedons for sampling that represent the soils and conditions of concern. Large excavations facilitate sampling. The sampling team records site data, including geomorphic information, vegetation, land use, and pedon description data before soil sampling begins.
- (3) Most laboratory analyses use air-dry bulk samples that are screened through a 2-mm sieve. Bulk samples need to be large enough to represent the proportion of rock fragments up to 20 mm (3/4 in.) in diameter and to provide at least one quart of material less than 2 mm in diameter. Proportions of rock fragments larger than 20 mm (3/4 in.) in diameter are estimated by volume or by a combination of weight and volume in the field. Bulk density, coefficient of linear extensibility (COLE), and moisture retention determinations require clod samples which preserve the field configuration of pore space. The NSSC Kellogg Soil Survey Laboratory has detailed information on pedon sampling.
- (4) The project objectives determine the analyses. The local and laboratory project coordinators jointly refine the objectives. Sampling protocol and standard laboratory analytical methods may be referenced in the Soil Survey Laboratory Methods Manual.
- (5) The NSSC Kellogg Soil Survey Laboratory, upon request, provides sampling equipment and supplies, such as bags, tags, shipping documents, saran for coating clods, clod boxes, etc., for sampling soils that are to be sent to the laboratory. The NSSC budgets costs for analyses and assistance for projects with NRCS and NCSS cooperators based on available funding and workload requests.

631.4 Field Investigation Methods

A. Landscape and Geomorphic Studies

- (1) Geomorphic studies use standard geologic methods and concepts of geomorphic surfaces to understand the relations among soils and the various parts of the landscape. Geomorphic surfaces can identify landscape elements that share a common geologic time component and can establish how different landforms and their materials relate to each other.
- (2) Field investigations of soil-geomorphic relations require detailed studies of the surficial geology and geomorphology of a small area. In the process, these patterns are related to the occurrence and distribution of soils.

- (3) The four phases of a field investigation are (1) determining the surficial geology, such as deposits and stratigraphy, (2) identifying the geomorphic surfaces to help establish the landscape and time frame, (3) establishing spatial relations through elevation and distance control, and (4) relating soil patterns to geomorphic units.
- (4) SSRs or States initiate field investigations with a request for technical assistance to the NSSC, as described in section 631.6. Obtain local assistance through national soil survey cooperators, State geological surveys, and universities.

B. Ground-Penetrating Radar and Electromagnetic Induction

- (1) Ground-penetrating radar (GPR) reveals differential transmission, reflectance, and attenuation of the radar signal within soil. It indicates the depth and horizontal continuity of objects, horizons, or layers below the soil surface. Observation depths range from less than 1 meter in clays to 30 meters in some sands.
- (2) Ground-penetrating radar helps to evaluate small-scale patterns of soil variability and estimate the composition of soil map units. It evaluates the continuity of root-restricting layers, and reveals other features and patterns that are important for soil mapping but are not clearly related to surface features.
- (3) The NSSC staff applies ground-penetrating radar to characterize soils and soil variability, determine the depths to diagnostic soil horizons, map bedrock surfaces and fractures, profile geomorphic and stratigraphic features, profile organic deposits and estimate peat reserves, and detect buried utilities, hazardous waste containers, and artifacts. The NSSC offers this service to the agency and cooperating groups.
- (4) Electromagnetic induction (EMI) estimates the electric conductivity of soil materials at variable depths below the soil surface. The electrical conductivity of soils is influenced by the type and concentration of ions in solution, the amount and type of clays in the soil matrix, the volumetric water content, and the temperature and phase of the soil water.
- (5) Electromagnetic induction uses electromagnetic energy to measure the apparent conductivity of earthen materials. Values of apparent conductivity are seldom diagnostic, but lateral and vertical variations in these measurements help to infer changes in soil types and soil properties, depths to contrasting layers and bedrock, and the locations of buried cultural features. Interpretations of the database on the identification of spatial patterns within data sets.
- (6) The NSSC staff applies electromagnetic induction technology to characterize soils and soil variability for many purposes. These purposes include precision farming and high intensity soil surveys, assess the distribution of saline and sodium affected soils, locate and map contaminant plumes emanating from waste-holding facilities, filter strips, mine tailing ponds or landfills, locate buried artifacts and areas of disturbed soils, and select sampling or monitoring sites. The center loans instruments and offers field assistance and training to the agency and cooperating groups.

C. Other Special Measurements and Instrumentation.—The NSSC offer other special equipment, such as electrical resistance blocks for water content and water suction, salinity meters, soil moisture and temperature sensors, and various permeameters for special investigations. Global positioning devices help document the locations of measurements. The center also provides simple, noncommercial methods to measure diverse properties, such as clod and crust rupture resistance, the near-surface bulk density of fragile soil materials, and roughness.

631.5 Investigations Planning

A. Objectives.—Work plans focus the question, identify the resources required, and schedule the necessary steps. Research and full characterization projects require a written work plan because of the complexity and duration of the project; the number and location of participants; the magnitude of time, funds, and other resources required; and the relationships of organizations.

B. Planning Process.—All investigations within NCSS should first be identified as a needed component of an approved initial soil survey or MLRA update project plan.

(1) Project Initiation

Anyone within the NCSS or even from outside the NCSS may recognize the need and initiate an investigations project. The memorandum of understanding for a project soil survey often initiates projects. The soil survey project office may identify an investigations need as a survey progresses. Review of the laboratory data within the major land resource area may show gaps in information and consequently lead to an investigation project. State, regional, national, or international initiatives may also generate a need for special projects.

(2) Project Definition

A cooperative effort by several investigators from more than one agency may provide project objectives and background information. If projects are within a survey area, the project soil scientist and staff draft the objectives, background, and needs of the project.

(3) Scheduling and Responsibilities

The person who initiated the investigations usually is responsible for scheduling and arranging for resources that are required to conduct the investigation. This information is outlined in the project work plan. For reference projects, the time and nature of information needed are in letter or oral agreements. For small projects with analyses, the letter of transmittal accompanying the samples includes the necessary information. Send copies of correspondence to appropriate administrators and interested technical people.

C. Work Plans.—Project work plans provide background information about the study area, survey project, scientific issues, resource relationships, or other concerns to identify the scope, objectives, and requirements. Work plans clearly specify the objectives, the needs, and the expected benefits. They assign responsibilities, estimate the resources needed, and outline how the results will be made available and used. Sections 631.10 and 631.11 show a checklist and example work plan for a research project. Section 631-12 gives an example work plan for a characterization project.

631.6 Requesting Assistance

A. Prior to the beginning of each fiscal year (usually by July 10), the NSSC requests SSOs, SSRs, and States to submit their needs for assistance for the following year. Responses to those requests allow the NSSC to allot resources and plan travel. The project work plan is to accompany the submission. Project work plans should be coordinated with cooperators prior to submission. The laboratory returns the work plan to the originator with comments and suggestions before work is begun on the project.

For reference projects, the request for assistance may accompany the samples and be confirmed orally or in writing through the liaisons.

B. All submissions of samples should include a list of the pedons and horizons sampled and pedon descriptions. It is desirable to have a statement of the problem and any time constraints that one may have.

C. Liaisons for the NSSC to the various SSRs and other staff members are available for the discussion, planning, and development of proposals for technical assistance on an informal basis at any time.

631.7 Laboratory Databases

A. National Cooperative Soil Survey Soil Characterization Database.—The database, located in Lincoln, NE, currently contains data for more than 64,000 pedons from analyses performed at the NSSC Kellogg Soil Survey Laboratory (KSSL) and from the three preexisting NRCS laboratories (at Riverside, CA; Beltsville, MD; and Lincoln, NE). The laboratory adds data from more than 600 pedons annually. Beginning in 2009, the characterization data from NCSS cooperating laboratories began to be added to the database. Customers may access the data through the National Cooperative Soil Survey Soil Characterization Data webpage at this web address: <https://ncsslabsdatamart.sc.egov.usda.gov/>. The data are also available on one CD-ROM disk. Access to the indexed data through the online database is by State and county, by MLRA, by classes of soil taxonomy, or by several other criteria.

B. Maintaining Data for Laboratory Pedons

- (1) Each laboratory pedon includes data for the taxonomic classification, latitude, longitude, map unit symbol, state, soil survey area, location of the sampled pedon, source of the data, kinds of analyses available, and other information. This information requires periodic maintenance to keep it current and accurate.
- (2) The soil survey regional office updates the data at any time by sending updated information to the staff of the Kellogg Soil Survey Laboratory. Contact the regional liaison for information on how the data may be submitted.

Part 631 – Soil Survey Investigations

Subpart B – Exhibits

631.10 Research Work Plan Checklist

1. Statement of Problem
 - concise summary
 - questions that illustrate problem and should be answered by the study
 - operational, such as “need to know in order to” rather than just need to know
2. Justification
 - local importance, such as for county
 - implications for wider application, such as at State and regional levels
 - benefit(s) to the soil survey program
3. Background
 - setting, such as climate, geology, landscapes, or soils.
 - soil series and their classification
 - persons familiar with the problem, such as those in NRCS or at a university.
 - specific background work pertaining to the problem, such as fieldwork, reviews, preliminary data gathering
4. Information Needed
 - geomorphic assistance
 - literature review
 - evaluation of existing data
 - information to be gathered in present study
5. Actions and Assignments
 - projected time table
 - project coordinators such as the person in the state whom the National Soil Survey Center staff should contact
 - Kellogg Soil Survey Laboratory assistance needed:
 - analyses suggested, such as specific questions to be answered for each soil and or horizon (complete analyses are not necessarily needed for limited, specific problems)
 - persons involved, including when and for what, and any necessary travel, etc.
 - report responsibility
 - report review responsibility
 - distribution and application of data, such as within state or in other states.
6. Illustrations
 - diagrams and illustrations that define study area location, soil-landscape, and stratigraphic relationships.

631.11 Example Research Work Plan

INVESTIGATION OF THE SOILS IN THE REGION OF GLACIAL LAKE KASKASKIA IN MLRAs 113, 114, AND 115

Sam J. Jones
MLRA Project Office
Belleville, IL

The Problem

(a) A significant portion of St. Clair County, and portions of Randolph, Monroe, Washington, Clinton, Bond, Fayette, and Marion Counties (Figure 1) are underlain by glaciofluvial and lacustrine deposits. These deposits can range in age from pre-Illinoian (formerly designated as Kansan or Nebraskan, and now grouped together as middle Pleistocene) to Woodfordian (mid to late Wisconsinan or late Pleistocene) or even to Holocene. The youngest of these deposits related to glacial activity is correlated with the Equality Formation (described by Willman and Frye, 1970). The fluvial deposits in the present flood plain area are correlated with the Cahokia Alluvium.

(b) The younger deposits in Glacial Lake Kaskaskia are part of the Equality Formation. Most of these areas are covered by Peoria Loess, except for the lowermost Woodfordian and possibly the early Holocene terrace level, which appears to have little or no loess cover (Figure 2). Extensive areas of Iva, Weir, Piasa, Herrick, Virden, and other similar soils were mapped on the other terraces along the Kaskaskia River. These soils typically formed in materials considered to be associated with upland positions.

(c) The original field sheets for the St. Clair County soil survey showed mapping units represented by tentative symbols, such as V308 (Alford), V453 (Muren), T16 (Rushville), V47 (Virden), T453B (Muren), and T454A (Iva). “V” was used for variant and “T” for terrace. These symbols were used to suggest differences in stratigraphy that do not traditionally occur in these upland soils. Documentation and correspondence during the survey also supported differences in stratigraphy. These differences were included in the “Formation of the Soils” section of the St. Clair County soil survey (Figure 3) (Wallace, 1978) but not included in the mapping and classification of the soils in the county. One of the main reasons for this exclusion was the emphasis in the 1978 survey on the description and classification of the soils to a depth of only 60 inches.

(d) More recently, the terrace/upland problem has been recognized in adjacent counties. During the recently completed Clinton County soil survey, soils formed in lacustrine deposits were mapped as T46 (Herrick), T47 (Virden), and 474 (Piasa). Soils mapped in mapping units T47 and 474 were eventually classified as a Montgomery taxajunct (a soil developed in lacustrine material), and a new soil series was developed in lieu of terraced-positioned Herrick soil mapped in map unit T46 to recognize the importance of the lacustrine parent material.

(e) Questions have arisen on the impact of these terrace soils and underlying materials on water availability for crops, crop yields, and water quality. The Iva (86 bu/ac), Herrick (89 bu/ac), and Virden (91 bu/ac) upland soils have relatively high corn yields listed in University of Illinois Circular 1156 (Fehrenbacher et al., 1978) compared to the listed yields of the traditional terrace soils, which include Okaw (47 bu/ac) and Hurst (52 bu/ac). Also, the yield on areas on the terrace mapped as Piasa is much higher than that listed for the Piasa (52 bu/ac) that is traditionally mapped as an upland soil. These discrepancies have been brought to light in recent tax appeals to the State Board of Review. Differences in observed yields suggest differences in soils and available moisture for crop growth. These differences

also suggest that the clayey substratum of the terrace soils influence the available water and the movement of the water through the soil.

(f) The problem involves not only accurately mapping and classifying the surface soils but also accurately identifying and mapping the underlying materials, which influence the genesis, classification, and management of these soils. The objective of this study is to accurately identify soils, parent materials, and stratigraphy in the Glacial Lake Kaskaskia area. The hypothesis is that soils in the Glacial Lake Kaskaskia area differ from the upland soils, and that this difference is reflected in stratigraphy, physical and chemical soil properties, water status, and crop yields. Studying these soils in detail will provide more accurate interpretations for agricultural and urban uses in the Glacial Lake area and the adjoining upland areas.

Justification

The Kaskaskia River glaciofluvial and lacustrine deposits occur in eight counties. The drainage basin of the Kaskaskia River covers 3,712,640 acres. The importance of the surficial and subsurficial materials in the Kaskaskia River Basin to agriculture and to the ground-water quality of the area is evident. Rapid urban growth is occurring in St. Clair, Randolph, and Monroe Counties, and therefore, more urban and agricultural demands are being made on water that is supplied by the Kaskaskia River Basin. St. Clair County is currently being updated as part of the Major Land Resource Area Soil Survey Update program in Illinois. Not only will the update in St. Clair County benefit from this study, all updates of the other counties within MLRAs 113, 114, and 115 that have glaciofluvial and lacustrine deposits will also benefit. The information gained in this study will improve the credibility of the soil survey by supplying the survey users with more accurate and precise soil maps and interpretations. We will also be gathering soils and geology information at greater depths.

Background

(a) Most of the soils in the study area are the types that occur on uplands. The uplands consist mainly of the Illinoian glacial till plain or glacial outwash plain that is covered by loess. The total thickness of the Peoria Loess and Roxana Silt ranges from 100 feet in the western part of the area to 4 or 5 feet in the eastern part. Soils on the terraces formed in loess less than 60 inches thick overlying clayey material or in the clayey material. There are also extensive areas of alluvial lands and bottomlands that drain to the Kaskaskia River, which drains into the Mississippi River.

(b) The focus of this study is to determine the boundary between the upland areas, represented primarily by soils formed in loess over glacial till, and the areas represented primarily by soils formed in glaciofluvial and lacustrine deposits. The difficulty in determining this boundary was well documented by the former soil survey leader of the 1978 St. Clair County soil survey and his primary survey members. Historical correspondence between the soil survey party, the Illinois State Geological Survey, and the MLRA staff shows the difficulty and importance of making this determination. Unfortunately, the separations made by the soil survey party were dropped during correlation and final publication. This action was due to the emphasis on studying the soil to a depth of only 60 inches and to the emphasis on the taxonomic placement of pedons. The MLRA update surveys will include more detailed descriptions at greater depths in order to meet the demands of modern agriculture and urbanization.

Information Needed

A soil-geomorphic/soil-stratigraphy study would be appropriate to determine the characteristics and extent of the glacial lake and to examine the relationship of these deposits to the distribution of soils across the landscape. From this study we could expand our knowledge of geomorphology and pedogenesis and gain a greater understanding of the geologic history of the Kaskaskia River Basin.

Action and Assignments

(a) The MLRA update office requests the assistance of the staff at the National Soil Survey Center in Lincoln, NE. The Illinois Soil Survey Laboratory liaison is familiar with the area. He has expressed interest in working on this problem and would be of great assistance in determining the soil-geomorphic/soil-stratigraphy relationships.

(b) The coordinators for the study will be the MLRA project coordinator, the area soil scientist at Carbondale, IL, and the Illinois State soil scientist. I will be the contact person. Other participants will be personnel from the Illinois State University and soil scientists in MLRAs 113, 114, and 115.

(c) Deep cores taken with a hydraulic probe and pits will be used to describe soils and sediments and to collect samples for appropriate chemical, physical, and mineralogical analyses.

(d) The study will be carried out in stages. The first stage will begin in November in St. Clair County. Transects will be made across three major valleys in St. Clair County: the Kaskaskia, Silver Creek, and Richland Creek valleys. Deep cores (at depths > 20 feet) will be taken in transects perpendicular to each valley. A minimum of four cores will be taken in each transect; and each transect will begin in the upland and continue down an interfluvium to the predicted terrace level, across the river channel to the terrace level on the other side, and again up an interfluvium to the upland. Transect and core locations will be determined from topographic data and existing core data. We will determine the geomorphic and stratigraphic relationships with emphasis on identifying the presence or absence of the Sangamon Geosol. The Sangamon Geosol is a key marker in identifying upland positions.

(e) Tracing the Sangamon towards the streams will reveal where the Sangamon has been eroded out of the valley. At the erosional boundary we expect the surface to be covered by Wisconsinan deposits, and in places it may be lacustrine (slack water deposits). Therefore, we need to examine the water regime characteristics at this geologic boundary to determine its influence on the distribution of modern soils (especially “problem” soils, such as Natraqualfs).

(f) In places the development of the present soils in loess over the Pearl Formation with a Sangamon Geosol is different than that of the soils in loess over the Sangamon Geosol in till. The soils in the Pearl Formation are commonly developed to a greater depth and in places are better agronomic soils. This relationship may, in part, explain the higher yields of the Piasa mapped on the terrace as compared to the yields for the Piasa mapped on the upland.

(g) The results from the first stage of this study will be used to guide the investigations in other counties that contain Kaskaskia glaciofluvial and lacustrine sediments. After determining the soil geomorphic and soil stratigraphic relationships in St. Clair County, the next portion of the study will take place downstream in Monroe and Randolph Counties and upstream in Washington, Clinton, Fayette, Bond, and Marion Counties. We hope to begin this portion of the study in the spring of 1992. The goal is to map the areal distribution of glaciofluvial and lacustrine sediments in the eight-county study area and eventually throughout Southern Illinois and to determine the influence of these sediments on the genesis, morphology, classification, and management of the modern soils. The results of this study will be published and distributed to states that have extensive glaciofluvial and lacustrine sediments.

Summary of Plan of Action

(a) The MLRA project coordinator in conjunction with the Illinois State Geological Survey (ISGS) will perform a literature review. (Completed 11/91).

(b) The details of the experimental design and laboratory needs will be determined by the MLRA project coordinator, the area soil scientist, the liaison for the National Soil Survey Center, and the Illinois State Geological Survey. At this time we will determine what water table, hydraulic conductivity, and yield data are needed for the study. (Completed 11/91).

(c) The fieldwork for the study will begin with 1 or 2 weeks of fieldwork in 11/91 and with cooperation between the Illinois NRCS, ISGS, and the National Soil Survey Center.

(d) Information gathered from the first three steps will guide the direction of the next portion of the fieldwork that is to be carried out in 3/92.

(e) It is envisioned that the study will take 3 to 4 years to ensure sufficient collection of soils, yield, and water table data.

References

Fehrenbacher, J.B., R.A. Pope, I.J. Jansen, J.D. Alexander, and B.W. Ray. 1978. Soil productivity in Illinois. University of Illinois at Urbana-Champaign, College of Agriculture, Cooperative Extension Service, Circular 1156.

Wallace, D.L. 1978. Soil Survey of St. Clair County, Illinois. U.S. Government Printing Office, Washington, D.C.

Willmam, H.B., and J.C. Frye. 1970. Pleistocene stratigraphy of Illinois. Illinois State Geological Survey Bulletin 94.

631.12 Example of a Soil Characterization Work Plan

SOIL CHARACTERIZATION WORK PLAN

Identification:

State: *Kansas* Date: *September 15, 1990*
Investigation project name: *Brown County Study*
County (Counties): *Brown*
MLRA:
Plan prepared by: Name *Jim Jones*
In-state contact(s): Name *Jim Jones*
Actively cooperating agencies: *Kansas Agricultural Exp. Sta.*

Give the area or region of sampling, if appropriate, or the name(s) of soil survey area(s) if they are different from the county (counties) identified above.

Reason for Investigations Project:

Underscore the number for the primary reason(s) for the project.

1. Needs of initial soil survey
2. Survey update or modernization
3. Interpretations problem
4. Regional recorrelation or redefinition of series.
5. Study of genetic factors, processes, relationships
6. Support of other activity (such as an agronomic study)
7. Other (specify)

Intended Use of Project Information:

Underscore the number for the primary uses.

1. Characterize series or phase
2. Document experimental or study site(s)
3. Determine classification
4. Support correlation
5. Test Soil Taxonomy
6. Study soil relationships
7. Included in the published soil survey report
8. Other (specify)

For items 4, 5, 6, or 7, list questions to be answered.

Title 430 – National Soil Survey Handbook

Assistance Requested:

Which year(s): *1990*

Lab analyses from: KSSL Only *x* KSSL and:

If data needed in less than one year, when needed?

Consultation before sampling? yes no

Field study before sampling? yes no

Reference samples to guide site selection? yes no

Help with sampling? yes no

Sampling equipment from KSSL? yes no

Number of pedons: *5-7*

Approximate number of samples: *50-55*

Ship to: *Name*

Natural Resources Conservation Service

Address

Town, State ZIP

Proposed date for sampling: *May 7-11, 1990*

Alternative date(s):

Status of Site Selection:

1. Sample sites have been identified
 - a. specific pedons? yes no
 - b. specific area (within 500 feet)? yes no
 - c. general area (within a mile or two)? yes no
2. Transect information available yes no
3. If 1a is no, when will pedons be selected?

Persons or Agencies Responsible:

Site selection: *Project office*

Excavation of pits: *Local NRCS*

Tools, equipment, materials: *KSSL*

Descriptions and classification: *State Personnel*

Sample shipment: *Kansas State Office*

Analyses, other than KSSL: *none*

Other:

Other Pertinent Information:

(may be supplied by attachments, such as official series descriptions, if applicable)

*Pedon 5: Amego soil does not have free carbonates in the solum.
The soils mapped in Brown County do.*

Complete Table 1 for all projects; list alternatives if purpose is to check classification. Complete other tables insofar as information is readily available.

Table 1 Classification of Pedons to be Sampled.

Pedon Number	Classification to Family	Series (and phase, if important)
1	<i>Typic Hapludolls</i> <i>fine-silty, mixed, superactive, mesic</i>	<i>Marshall*</i>
2	<i>Aquertic Argiudolls,</i> <i>fine, smectitic, mesic</i>	<i>Mayberry</i>
3	<i>Aquertic Argiudolls</i> <i>fine, smectitic, mesic</i>	<i>Chase</i>
4	<i>Typic Hapludolls,</i> <i>loamy, mixed, superactive, mesic, shallow</i>	<i>Vinland</i>
5	<i>Typic Argiudolls</i> <i>fine, mixed, superactive, mesic</i>	<i>Wamego*</i>

* Pedons to be sampled may not be representative of the named series but may become new series.

Table 2 Extent of Series or Other Class Represented.

Pedon Number	Estimated Extent, acres		
	This Survey Area	State	Total
1		173,000	1,600,000
2		2,000	111,000
3		97,000	97,000
4		132,000	132,000
5		39,000	39,000

Table 3 Genetic Factors of Soils.

(Attach block diagrams, geologic cross section, etc., if available)

Pedon Number	Parent Material	Landscape Position	Drainage Class	Vegetation (Site)	Other
1	<i>Loess</i>	<i>Upland ridge</i>	<i>W</i>	<i>Corn</i>	
2	<i>Till</i>	<i>Convex summit</i>	<i>MW</i>	<i>Wheat</i>	
3	<i>Alluvium</i>	<i>Low terrace</i>	<i>SP</i>	<i>Soybeans</i>	
4	<i>Shale</i>	<i>Steep upland</i>	<i>E</i>	<i>Pasture</i>	
5	<i>Shale, ss</i>	<i>Narrow ridge</i>	<i>W</i>	<i>Native grass</i>	

Table 4 Useful Data Available for These or Similar Soils.

(Use lines as needed for each pedon to be sampled)

Pedon Number	Year & State	Similar Pedons Previously Analyzed			
		County	NRCS Lab or other	Same Series Family	Other Similar
3	KS1983	Morris	KSSL	Series	
5	KS1987	Wabaunsee	KSSL	Series	

(430-631-H, 1st Ed., Amend. 34, Jan. 2018)

Part 638 – Soil Data Systems

638.0 Definition and Purpose

- A. The National Cooperative Soil Survey (NCSS) collects, manages, interprets, and disseminates soil survey information using a dynamic soil information system from which many different products can be produced.
- B. Soil data systems consist of multiple automated soil applications or modules that interact with each other to provide information. Soil data systems aid the collection, storage, manipulation, and dissemination of soil information. These applications include attribute and spatial databases and are collectively referred to as the “National Soil Information System.”
- C. The acronym “NASIS” is used to identify the transactional attribute database and user application of the National Soil Information System. Refer to part 639 of this handbook for more information on NASIS.
- D. Validation and certification routines add assurance about the quality of soil survey information. Validation routines also help ensure that the data populated is correct and complete. Certification guidelines provide verification that the data has been reviewed prior to publication.

638.1 Procedures and Responsibilities

- A. Procedures.—Soil survey information is maintained in the National Soil Information System. This system is used by NCSS members for data collection through information publication. Users of automated soil applications who are members of NCSS are provided support and training on the use and management of all automated soil applications.
- B. Responsibilities
- (1) Primary responsibility for various aspects of the National Soil Information System is with soil survey offices, State offices, soil survey regional offices (SSRs), the National Soil Survey Center (NSSC), and, on some Federal lands, such NCSS partner agencies as the U.S. Department of the Interior (USDI) Bureau of Land Management, USDA Forest Service, USDI National Park Service, and others. State offices are responsible for downloading and making available soils information for NRCS field offices FOTG and Web Soil Survey for customers.
 - (2) Roles and responsibilities of offices within NRCS include the following:
 - (i) Soil survey offices (SSOs)—
 - Collect and populate soil profile descriptions, field notes, and other point data.
 - Originate or maintain official series descriptions for the MLRA.
 - Compile, analyze, and aggregate point data to identify component-level ranges.
 - Populate component data to identify the component level and horizon level property ranges.
 - Develop the map unit concept for the soil survey.
 - Populate map unit name based on soil survey map unit concept.

- Analyze spatial map unit boundaries to verify proper line placement, map unit concept, and landscape concept.
 - Ensure the quality of data entered into the NASIS database.
 - Ensure security of NASIS data by not sharing NASIS logins.
 - Notify NASIS site dataset managers in the soil survey regional office (SSR) when membership for specific individuals in a NASIS group is no longer needed.
 - Provide quality control of all populated data.
- (ii) State offices—
- Distribute soil survey information to users.
 - Assist users of soil survey information.
 - Develop soil interpretation criteria in conjunction with other discipline experts and cooperators as needed to meet local interpretation needs.
 - Supplement the system by developing soil interpretive group assignments and forwarding them to the SSR for inclusion.
 - Certify and export NASIS database dataset to the staging server.
 - Certify spatial dataset at the staging server.
 - Validate and commit NASIS dataset and spatial datasets to the Soil Data Warehouse and Web Soil Survey as the official information for public use.
 - Coordinate in-State training on the use of automated soil applications.
 - Notify the appropriate area and field offices and affected partner agencies of significant revisions to the database.
- (iii) Soil survey regional offices—
- Provide the quality assurance and completeness checks of the information in the NASIS database.
 - Provide quality assurance for official soils descriptions within the region.
 - Maintain the soil classification database for the official soil descriptions within the region.
 - Sponsor user training for automated soil applications.
 - Provide continuing user support for all automated soil applications.
 - Evaluate proposals for new applications and for enhancements to existing applications.
 - Recommend development priorities to the chair of the Soil Business Area Analysis Group (SBAAG).
 - Verify that users requesting NASIS accounts are NCSS members or persons working on behalf of NCSS.
 - Obtain the completed security forms from the user and submit them to the Soils Hotline when requesting a NASIS user account.
 - Manage members in NASIS groups.
 - Remove users from NASIS groups as necessary.
 - Notify the Soils Hotline when a user no longer needs a NASIS account or when a NASIS account needs modification (e.g., name change by submitting Form NRCS-IRM-02, “Request for User Access to ITS Resources”).
- (iv) The National Soil Survey Center—
- Sponsors NCSS members at National Headquarters, centers, and institutes who request accounts for accessing soil applications.
 - Develops and implements guidelines for data administration and management, including quality control procedures.
 - Provides application analysis to support system development.

- Manages the NCSS soil data dictionary as a subset of the NRCS corporate data dictionary.
- Provides training to SSRs and assists SSR staff in providing training to the soil survey office and project office staffs.
- Assists in system building tasks, such as developing documentation, testing, and data conversion.
- Coordinates with the Information Technology Center to develop software for soil data systems.
- Creates and maintains NASIS accounts.
- Adds and removes users from roles in eAuthentication system.
- Moderates and supports various discussion and user group questions and issues using GovDelivery, Soil Taxonomy Forum, and similar venues.

638.2 Components of the National Soil Information System

A. Transactional Databases

- (1) NASIS.—The acronym “NASIS” is used to identify the transactional attribute database and user application for NCSS. The NASIS application and database stores the observations, measurements, and estimated soil properties and qualities collected and developed as part of the soils inventory. The NASIS database is national in scope and is populated and managed by means of the NASIS software application.
 - (i) NASIS encompasses major data categories of the National Soil Information System, such as—
 - Point data records including soil profile descriptions, laboratory data, field measurements, transect observations, and other site-specific information.
 - Geographic area records including symbols, names, acreages of soil survey areas, and map unit legends of soil survey areas.
 - Map unit records, including national map unit symbols, map unit names, and the physical, chemical, and morphological properties and interpretations for map unit components.
 - Standards, criteria, interpretation criteria, and other data and documents used to establish concepts, assist aggregation, and communicate policy.
 - (ii) Additional information specific to the NASIS database is located in part 639 of this handbook.
 - (iii) Detailed information on population of the tabular database is located in part 618 of this handbook.
- (2) Staging Server.—The staging server is the convergent step of the pathway where final validation of tabular and spatial data is performed before archiving to the Soil Data Warehouse and publishing to the Web Soil Survey. The two principal points for the collection and editing of data are NASIS (for the attribute data on soil properties and interpretations) and the spatial data showing location and extent of soils and related features. When the state soil scientists certify that these data are accurate and complete for release to the public, they authorize a survey area to be sent to the Soil Data Warehouse and Soil Data Mart via the staging server. This may be a new release or an update of an earlier release, both of which are retained in the warehouse.
- (3) Official Series Descriptions (OSD).—The USDA-NRCS official soil series descriptions contain the taxonomic description of each soil series identified in the United States, territories, commonwealths, and island nations served by USDA-NRCS.

- (i) “Official soil series description” is a term applied to the description approved by NRCS that defines a specific soil series. These official soil series descriptions document the taxa in the series category of the national system of taxonomic classification. They serve as specifications for identifying and classifying soils. Official series descriptions are maintained in a file storage system (“file share”) that is accessed by the staff in the SSR. Official series descriptions are updated and processed with a software application named the “SC/OSD Maintenance Tool.” As the SSR staff add or revise series for which they have responsibility, they transmit these series to the OSD file share where all series are stored.
 - (ii) The OSD file share is both a transactional database maintained by the SSRs as well as a publication database available to the public. The read-only web access to official series descriptions provides the public the capability to view the individual series records, to query the database and produce a report with the selected soils, to produce national reports with all soils in the database, or to view maps identifying the distribution of series within the nation using the series extent mapping tool.
 - (iii) More detailed information on official soil series descriptions is available in part 614 of this handbook.
- (4) Soil Classification Database (SC).—The USDA-NRCS soil classification database contains the taxonomic classification of each soil series identified in the United States, territories, commonwealths, and island nations served by USDA-NRCS. Along with the taxonomic classification, the database contains other information about the soil series, such as office of responsibility, series status, dates of origin and establishment, benchmark soil status, and geographic areas of usage.
 - (i) The SC database is maintained by the NRCS soil SSR staff. As series are added to the official series description file, the soil classification file needs to be updated accordingly. The classification of a soil series listed on the official series description and that listed in the soil classification file are kept in agreement by the SSR staff. Additions and changes are continually being made as a result of ongoing soil survey work and refinement of the soil classification system. As the database is updated, the changes are immediately available to the user, so the data retrieved is always the most current.
 - (ii) The SC database is both a transactional database maintained by the SSRs as well as a publication database available to the public. The read-only web access to this soil classification database provides the capability to view the contents of individual series records, to query the database on any data element and produce a report with the selected soils, or to produce national reports with all soils in the database. The standard reports available allow the user to display the soils by series name or by taxonomic classification.
- (5) Pedon Description Applications.—Soil descriptions can be entered into the National Soil Information System by using the NASIS software or the PedonPC software. Older software, such as PedonCE and Windows Pedon, can also be used for the collection of point data. Pedon descriptions are stored in the NASIS database and made available to all NCSS soil scientists.
 - (i) PedonPC.—The PedonPC description program is software used to populate pedon descriptions into a database. The data collected in the PedonPC database is imported into NASIS. Detailed information on the use of PedonPC and the import of pedon data into NASIS is available at this web address:
<http://soils.usda.gov/technical/nasis/downloads/index.html#PedonPC>.
 - (ii) AnalysisPC.—AnalysisPC is the complementary database and user application for analyzing pedon data. The database can be used to sort, select, aggregate, and compare data. It can also produce a written copy of the pedon description. Integration with a geographic information system (GIS) software program allows for spatial display of the locations of pedon data. Detailed information on the use of AnalysisPC and the export of

pedon data from NASIS is available at this web address:

<http://soils.usda.gov/technical/nasis/downloads/index.html#AnalysisPC>.

- (6) Laboratory Information Management System (LIMS).—The National Soil Survey Center's Kellogg Soil Survey Laboratory (KSSL) manages the internal Laboratory Information Management System. This system is designed to support the collection and analysis of soil samples, provide interpretation, manage and enhance the data, and disburse soil information in support of the NRCS Soil Survey Program. LIMS is a client-server system that allows the laboratory instruments and lab station computers to send analysis results to the central server.
 - (i) As samples are sent to the Kellogg Soil Survey Laboratory, they are assigned a unique sample number, labeled, and logged into LIMS. Information pertaining to the sample, pedon, site, and project associated with each sample is collected and stored. Each laboratory analysis request can be customized to use a particular preparation, along with other analysis-specific instructions. After the data entry, a project is prioritized and organized for work throughout the laboratory.
 - (ii) LIMS provides an interface to communicate which preparations need to be performed on each sample and to collect weights and other data associated with the preparation of the sample. After dispositions are assigned to the prepared samples, the horizon samples appear on the work list within the laboratory. The raw data is then used to calculate results that are validated by the technicians for accuracy and reliability. LIMS has many reports written for custom application within the laboratory to assist technicians in completing their work.

B. Publication Components

- (1) Soil Data Warehouse (SDW).—The Soil Data Warehouse is a central repository for the current and previous versions of official soil survey data that have periodically been certified and exported from NASIS by state soil scientists since 2003. The data comes to the SDW via the staging server. The most recent versions of the attribute data and of the spatial data are forwarded to the Soil Data Mart, along with a metadata file, for delivery to soil survey users and other user applications through the Web Soil Survey. The metadata file conforms to the standard format of the Federal Geographic Data Committee (FGDC).
- (2) Soil Data Mart (SDM).—The Soil Data Mart is an internal (nonpublic) national central repository of the current version of soil data, both spatial and tabular. It serves as the single point of delivery to the Web Soil Survey of official data which is intended for public use.
- (3) Web Soil Survey (WSS).—The Web Soil Survey (accessible at <http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>) is a web application that allows various customers to access official soil survey maps and manuscript reports in an interactive mode. Created from the SDM data, customers can display soil maps, generate soil property or interpretive thematic maps, generate manuscript soil reports, and either print or save these products to their local computer. The Web Soil Survey allows customers to build a free custom soil survey manuscript through their selection of various maps and reports.
 - (i) Data distributed from the Web Soil Survey is in the Soil Survey Geographic database (SSURGO) format. For the tabular data, this format dictates which soil attributes are included, how those attributes are defined, how those attributes are grouped, and how those groups are related. For the spatial component, this format dictates which spatial layers are defined, which spatial layers are mandatory, and the standards to which that spatial data conforms. A metadata file in standard FGDC format is included with each dataset.
 - (ii) Manuscript style reports are provided on Web Soil Survey for the public to retrieve basic soil property, quality, and interpretation information. Datasets can be downloaded that include the attribute and spatial databases for individual soil surveys. Customers can

import the data into MS Access databases and into a GIS program for creation of thematic maps.

- (4) **Soil Data Access.**—The Soil Data Access (accessed at <http://sdmdataaccess.nrcs.usda.gov/https://sdmdataaccess.nrcs.usda.gov/>) is a web application that provides a suite of web services whose purpose is to meet requirements for requesting and delivering soil survey data from SDM in both a spatial and a tabular data format. The web application allows the user to create ad hoc queries to retrieve attribute data by a user-defined structured query. This application also allows the user to query the spatial data by an area of interest or retrieve specific soil attributes outside the normal delivery database.
- (5) **SSURGO Template Database.**—Detailed data from the Web Soil Survey is distributed in what is referred to as “SSURGO” format. SSURGO is the acronym for Soil SURvey GeOgraphic database. It is the most detailed level of mapping completed and is designed for use by landowners and for city and county general landuse planning purposes. For the tabular component, this format dictates which soil attributes are included, how those attributes are defined, how those attributes are grouped, and how those groups are related. For the spatial component, this format dictates which spatial layers are defined, which spatial layers are mandatory, and the standards to which that spatial data conforms.
 - (i) The tabular component is distributed for use in Microsoft Access database software. This MS Access “SSURGO template database” is a soil survey publication consisting of the tabular data, table relationships, and a series of manuscript-style reports providing soil properties, qualities, and interpretations. The default SSURGO template is the national template (e.g., `soildb_US_2002.mdb`). States have the ability to customize a template database and provide publication reports for their needs (e.g., `soildb_PA_2003.mdb`).
 - (ii) The spatial component is imported for use into a GIS program. Spatial data is available in several formats based on standards of the Environmental Systems Research Institute, Inc. (ESRI). These formats are ArcView shapefiles, ArcInfo coverages, or ArcInfo Interchange formats. Spatial layers include the soil survey area polygon and the map unit boundary polygons and can include the line map units, point map units, spot features, or a combination of these. Map unit boundary polygons in the digital map data are map unit delineations. The minimum delineation size ranges from 1.43 acres (0.57 hectare) to 5.7 acres (2.3 hectares). Themes for thematic maps are based on map units. Many map unit polygons can be labeled the same, but all point to the same record in the tabular map unit table.
- (6) **Soil Data Viewer (SDV).**—The Soil Data Viewer is a tool built as an extension to the ArcMap module of the ESRI ArcGIS system that uses the SSURGO template database and allows a user to create soil-based thematic maps. The application can be run independent of ArcMap, but output is limited to a tabular report. SDV integrates the spatial shapefile and attribute SSURGO template database and provides users access to soil interpretations and soil properties while shielding them from the complexity of the databases. SDV makes it easy to compute a single value for a map unit and display results, relieving the user from the burden of querying the database, processing the data, and linking to the spatial map. SDV contains processing rules to enforce appropriate use of the data. It provides the user with a tool for quick geospatial analysis of soil data for use in resource assessment and management. Additional information is available at this web address:
https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/home/?cid=nrcs142p2_053620.
- (7) **National Cooperative Soil Survey (NCSS) Soil Characterization Database.**—The NCSS soil characterization database is a Web application designed to allow users to generate, print, and download reports containing soil characterization data stored and maintained by the National Soil Survey Center’s Kellogg Soil Survey Laboratory (KSSL). The KSSL maintains the soil characterization database as a data mart of laboratory data. This data mart holds the entire set of both legacy and current KSSL data exported from LIMS. Beginning in 2009,

characterization data from NCSS cooperating laboratories began to be added to the database. The system uses the same general reporting model as LIMS, with an enhanced Web-based query interface. The database is available at this web address:

<http://ncsslabsdatamart.sc.egov.usda.gov>.

- (8) U.S. General Soil Map Database (STATSGO2).—The U.S. general soil map database contains generalized soil associations designed for State or regional land use planning. It consists of a broad-based inventory of soils and miscellaneous areas that occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped. The tabular and spatial components of the STATSGO2 database are available for download from the Web Soil Survey at this web address:

<http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>. STATSGO2 data are available for the United States, Puerto Rico, and the U.S. Virgin Islands, but missing for American Samoa, Guam, Marshall Islands, Micronesia, Northern Mariana Islands, and Palau.

- (i) The tabular component is distributed in standard SSURGO data format that can be imported into a Microsoft Access database software using the SSURGO template database. This MS Access “SSURGO template database” is a soil survey publication consisting of the tabular data, table relationships, and a series of manuscript reports providing soil properties, qualities, and interpretations. There is a potential for 21 components in each STATSGO2 map unit.
- (ii) The spatial data is available in an ArcView shapefile, ArcInfo coverage, or ArcInfo Interchange formats. Spatial layers include the soil survey area polygon and the map unit boundary polygons. Approximate minimum delineation size is 625 hectares (1,544 acres) as represented at a scale of 1:250,000 or, in Alaska, 10,000 hectares (25,000 acres) at a scale of 1:1,000,000. Linear delineations in the lower 48 continental States should be not less than 0.5 cm (0.2 inches) in width. The number of delineations per 1:250,000 quadrangle generally ranges from 100 to 200 but may range up to about 400. Map unit boundary polygons in the digital map data are map unit delineations. Therefore, themes for thematic maps are based on map units. Many map polygons can be labeled the same, but all point to the same record in the map unit table.

638.3 Managing Soil Spatial and Tabular Databases

A. Spatial and Attribute Data.—Soil survey attribute data and, to the extent possible, all other soil survey information (maps, interpretations, and metadata) are maintained in a central, sole-source repository (Soil Data Warehouse). These data are accessible to customers electronically through the Web Soil Survey, which is a dynamic soil survey information delivery system. SSURGO spatial, tabular, and metadata can also be obtained from the Geospatial Data Gateway. New and updated soil survey information, when placed into the Soil Data Warehouse, provides customers with the latest soil survey information. Procedures to enhance the information in the Soil Data Warehouse are part of the normal update of soil survey information.

B. Managing Tabular Data

- (1) Incorrect entries, obsolete terms, and null data are common deficiencies in the Soil Data Warehouse. Data searches of these errors satisfy the need for an evaluation and subsequent change over the extent of the map unit, and additional evaluation is not needed. New data entries or corrections to existing data entries, including taxonomic classification, may be made any time that errors are discovered. Changes that affect the legend, such as component names used in the map unit name, are proposed by the SSO and approved by the SSR. Correlation decisions must be recorded in NASIS or, if not yet SSURGO-certified, with an amendment to the correlation document, as appropriate.

- (2) The SSR ensures the quality of all new and revised soil survey data in the region, conducts a quality assurance review of the revised spatial data, manages the assignment of editing permissions in NASIS, assures that individuals with editing privileges are properly trained, and approves changes to the legend that are proposed by the SSO. The SSR coordinates with the States to develop a plan that addresses the population of new data or correction of existing NASIS datasets. The purpose of the plan is to minimize the risk of data being included that does not meet NCSS standards, is inconsistent with data in adjoining areas of the same soils, or is of unknown origin. The plan builds quality control and quality assurance into the editing process. The plan may include such information as—
 - (i) A list of individuals who have permissions to edit the data.
 - (ii) Actions to obtain needed training.
 - (iii) A list of map units, data mapunits, and data elements expected to be addressed.
 - (iv) Guidance documents, algorithms, and other aids to be used.
 - (v) A schedule of when work will be done.
- (3) At least annually (more frequently if needed to meet NRCS or cooperator needs), NASIS data is exported to the Soil Data Warehouse for all soil survey areas. Publication of soil databases is managed by the individual non-MLRA soil survey areas currently defined within NASIS.

638.4 Soil Survey Goals and Progress

Soil survey goals and progress are maintained in NASIS. The “Project Object” (refer to sections 608.7 and 639.3 of this handbook) is used to track the goals and progress of soil survey projects. The tables within the Project Object provide information to track the progress of soil survey projects at the national level. The MLRA soil survey leader populates the “Project Mapunit” table with those map units designated in the annual plan of operations. The “Milestone” table provides the MLRA soil survey leader the ability to track certain events of each update project.

638.5 Distribution of Soils Data

- A. NASIS data are distributed using the National Soil Information System and the web portals created for publication of soils information.
- B. Internal Publication
 - (1) Soil database information in the Customer Service Toolkit (CST) is provided from web applications through the National Soil Information System. The State soil scientist is responsible for providing the current official soil database to the CST.
 - (2) The State soil scientist certifies data downloaded to the CST. Soil data is not downloaded to the CST until it has been certified. Soil data elements are edited and certified for each CST application, such as the Revised Universal Soil Loss Equation (RUSLE), before they are downloaded.
- C. External Publication
 - (1) Soil database information is distributed to cooperators and the public through the Web Soil Survey and the publication web outlets detailed in section 638.2B of this handbook.
 - (2) The State soil scientist should maintain a file of users who have requested and received digital map unit record data sets from the state office staff. At a minimum, document the requester’s name, the date, and a brief description of data provided.
 - (3) User documentation or a user guide is provided with each data set that is distributed. As a minimum, include the following information:

Title 430 – National Soil Survey Handbook

- (i) The definition of data elements (data dictionary)
- (ii) Description of the data format
- (iii) Disclaimer on the use of the data
- (iv) Request that NRCS be acknowledged as the source of the data

Part 639 – National Soil Information System (NASIS)

Subpart A – General Information

639.0 Definition and Purpose

A. Definition.—The National Soil Information System (NASIS) application and database is one component of the overall National Soil Information System of the National Cooperative Soil Survey (NCSS). The application is used for the entry, storage, maintenance, interpretation, and publication of data pertaining to all aspects of the soil survey program.

B. Purpose.—NASIS is designed as a client-server software application that accesses a national database to retrieve and build a local database. Edits are made to the local copy of the data and then uploaded back to the servers that store the national database. A soil scientist collects documentation during the course of a soil survey, and this documentation is compiled, analyzed, and aggregated to build information on soil properties, qualities, and interpretations for components within a map unit.

C. Database Structure.—NASIS organizes soil survey data into major categories which are further defined by database objects and their underlying parent tables and child tables. The following are the major categories of the NASIS application:

- (1) Database security system
- (2) Point data records
- (3) Geographic area records
- (4) Map unit records
- (5) Standards, criteria, and guidelines
- (6) Spatial database

639.1 Policy and Responsibilities

A. Policy.—NASIS is the transactional database containing all soil survey attribute information. The data is maintained by the soil survey office staff following the guidelines set forth in this handbook, the NASIS online help feature, and other guidance documentation. The technical review and quality assurance of this information is completed by the soil survey regional offices (SSRs) as listed below. Distribution and public release of information is completed by the State soil scientist. The NASIS database is housed at the USDA Enterprise Data Center in Kansas City, MO.

B. Responsibilities

- (1) The soil survey office (SSO) is responsible for the following:
 - (i) Collecting soil pedon descriptions used to document the soil properties for a map unit component and entering the pedon data into NASIS.
 - (ii) Collecting samples to be analyzed for soil physical and chemical properties.
 - (iii) Aggregating or summarizing the pedon descriptive information and laboratory characterization data to build the soil component property ranges and representative values.
 - (iv) Creating and maintaining map unit information and component properties used to generate manuscript reports for soil surveys in its assigned area.
 - (v) Developing the accompanying spatial databases.

- (vi) Ensuring the quality control of all data entered into NASIS within its area of responsibility.
- (2) The SSR is responsible for the following:
 - (i) Creating and managing NASIS ownership groups and assigning members to each group as needed to manage edit permissions of the data.
 - (ii) Ensuring that soil property data conform to NCSS standards
 - (iii) Providing support, training, and leadership to SSO in describing soil properties and in making estimations of map unit component data.
 - (iv) Recommending actions needed to correct errors and inconsistencies in NASIS.
 - (v) Populating and maintaining general soil map data in the NASIS database and submitting it to the national coordinator for the U.S. General Soil Map.
 - (vi) Monitoring soil survey update projects in NASIS and assisting the soil survey offices in keeping the soil survey projects on schedule.
 - (vii) Completing the technical review and the quality assurance of the data entered into NASIS for its area of responsibility.
 - (viii) Ensuring that all soil survey office staff in their area of responsibility receive proper and adequate training in the use of NASIS software.
- (3) The State office (SO) is responsible for the following:
 - (i) Managing the legends and publication map unit symbols within its State of responsibility.
 - (ii) Certifying and exporting correlated NASIS data to the Soil Data Warehouse and Web Soil Survey for geographic areas within its State.
 - (iii) Developing criteria for local or State interpretations in NASIS, as needed.
- (4) The National Soil Survey Center (NSSC) is responsible for the following:
 - (i) Coordinating with the Information Technology Center to ensure that NASIS-related software is developed and operational.
 - (ii) Developing and implementing NASIS software training materials.
 - (iii) Developing national standards and procedures for population and management of soil data in NASIS.
 - (iv) Developing national interpretations using detailed and general soil survey information.
 - (v) Managing certain data tables (e.g., “Area” and “Geomorphologic Feature” tables) in NASIS that serve as lookup lists.
 - (vi) Maintaining the general soil information data set.
 - (vii) Creating and maintaining NASIS user accounts.
 - (viii) Granting and revoking access through eAuthentication.

639.2 Soil Survey Application Security Policy

A. NASIS Accounts.—The NRCS is the lead agency for the NCSS (7 CFR Sec. 2.61). In its leadership role, NRCS maintains NASIS for the collection, management, and distribution of NCSS information. Access to NASIS is granted to NCSS partners and authorized agents for the purpose of creating, maintaining, or interpreting NCSS information. NASIS is a U.S. Government computing system. Only official NCSS activities are authorized on this system.

B. Requests for a NASIS User Account.—Requests to become a NASIS user are submitted to SoilsHotline@lin.usda.gov. They must include the user’s full name, eAuthentication identification (not the password, just the user name), phone number, city, and State.

C. NASIS User Requirements.—The NASIS user must obtain a level-2 eAuthentication account through the eAuthentication website at the following address: <https://www.eauth.usda.gov>.

639.3 NASIS Organization and Database Objects

A. NASIS Organization.—The NASIS database is organized into separate database business objects that each contain data of a particular type.

- (1) Each record in the tables of a business object is owned by a specific NASIS site and group. Authority to edit a particular object is limited to users who are members of the responsible group and have the edit privileges for that object. Items within an object are owned by the creating group.
- (2) The user who creates or last edits a data record is recorded in each table along with the date and time of the edit. In addition, the user who last edited any data record in any table in the data object is listed in the object root table as the last person to edit the object along with the date of that edit.
- (3) Users who do not belong to a group are read-only users and cannot edit any data.
- (4) Frequently asked questions on NASIS and contact information is available at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/tools/?cid=nrcs142p2_053551 for NASIS assistance if a user record needs to be created, deleted, or modified in a way that cannot be accomplished by the individual user.

B. Database Objects.—Detailed descriptions of each data business object and data element in NASIS are available in the NASIS online help system. Some data elements are restricted to specific entries, while others allow any appropriate entry. Detailed metadata reports for NASIS are accessible through the following address:

https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/survey/tools/?cid=nrcs142p2_053548. Follow the link to the “NASIS Version 7.x” index web site.

C. Database Security System.—The security and communication of soil survey data housed in business objects in NASIS is maintained through the tables contained within the NASIS “Site” object and the NASIS “User” object. The tables constitute parts of the database security system.

- (1) NASIS “Site” Object.—This business object contains the “NASIS Site” table, “NASIS Group” table, and “NASIS Group Member” table.
 - (i) The “NASIS Site” table contains all of the NASIS sites in the database. Parts of this table can be edited, but only by a user with NASIS administration privileges (i.e., the DSM flag is set to “yes”).
 - (ii) The “NASIS Group” table lists the groups established for the NASIS site shown in the “NASIS Site” table. For example, a NASIS database at an SSR may have one group for the SSR staff and another group for the SSO staff working on the same data. The table can be edited, but only by a user with NASIS administration privileges.
 - (iii) The “NASIS Group Member” table lists the users who are members of the group shown in the “NASIS Group” table. Users in the “NASIS Group Member” table can edit data owned by the group. The table can be edited but only by a user who has NASIS administration privileges.
- (2) NASIS “User” Object.—This business object contains the “NASIS User” table. The “NASIS User” table lists the users authorized to use NASIS. This table can be edited by users for applicable data such as email address, phone number, and description. Users with NASIS administration privileges can also edit this table.

D. Point Data Records.—Point data records include soil profile descriptions, laboratory characterization data, field measurements, transect observations, site associations, and other soil survey data collected at individual sites. Point data records concern the composition, physical, chemical, morphological, and interpretation properties and performance for a specific point on the landscape at which data is collected. These data records are recorded in the NASIS database in the

“Site” object, “Pedon” object, “Transect” object, “Site Association” object, and “Vegetation Data” object, which are defined below. These objects are created as needed and retained as part of the historical records. Guidance on population of the various data tables and data elements is available in the NASIS Pedon Data Entry Guide, which is available on the NASIS downloads web site. (https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053329.pdf).

(1) “Site” Object

- (i) This business object contains a set of data tables designed to identify a specific geographic location and its characteristics. The spatial area of a particular site record may be a specific point where a pedon is described or may be a determined spatial area. The “Site” object allows for recording various kinds of data including soil profile descriptions, laboratory data, vegetative data, or specific soil property studies. Descriptions for the “Site” object tables and their data elements are available in the NASIS online help. The parent table in the “Site” object is the “Site” table. The “Site” table has several underlying child tables that contain detailed information on various features of a specific site. Sites are identified in the field labeled “User Site ID.” This field records a unique concatenated number assigned to identify a specific record. Historically, it has been assigned a 10- to 15-character field using the protocol shown here:

- A letter identifying the type of sample or description
- The four-digit calendar year (previously a two-digit year)
- The two-character FIPS State code
- The three-digit FIPS county code
- A three- or four-digit consecutive pedon number for the calendar year (e.g., S2010NE097001).

- (ii) Further guidance on the population of this field can be found in section 1.1.3 of Soil Survey Investigations Report No. 45, Soil Survey Laboratory Information Manual, Version 2.0, February 2011, USDA, NRCS. Specific sampling projects (e.g., the Rapid Carbon Assessment project) may provide specialized guidance for populating data.

- (2) “Pedon” Object.—This business object is designed to record the morphology, field measured properties, estimated or observed features, and taxonomic classification of a pedon. Each record in the “Pedon” object is linked to a corresponding record in the “Site” object using the “User Site ID” and the “Site Observation Date” columns. The parent table in the “Pedon” object is the “Pedon” table. The “Pedon” table has many underlying child tables that contain detailed information on various morphological features of a specific pedon. Within the “Pedon” table is the field labeled “User Pedon ID.” This field is a duplicate of the User Site ID, unless multiple pedons are linked to one site. It is a unique concatenated number assigned to identify the specific record. It is historically a 10- to 15-character field beginning with the type of sample, the four-digit (or older two-digit) calendar year, the two-character FIPS State code, the three-digit FIPS county code, a three- or four-digit consecutive pedon number for the calendar year (e.g., S2010NE097001-1), and if necessary a dash and number is allowed to identify multiple pedons linked to one site. Further guidance on the population of this field can be found in the Soil Survey Laboratory Information Manual, as cited above. Specific sampling projects (e.g., the Rapid Carbon Assessment project) may provide specialized guidance for populating data.

(3) “Transect” Object

- (i) This business object is designed to group individual pedons that are the stops along a specific transect. The object table in the “Transect” object is the “Transect” table. The “Transect” table records the “User Transect ID” that is used in the “Pedon” table to link pedons to the appropriate transect. The “User Transect ID” is a unique set of characters

used to identify the transect name. A suggested naming convention is the concatenation of the following:

- The letter “T”
 - The calendar year (e.g., “2010”)
 - The MLRA symbol (e.g., “74”)
 - The map unit symbol (e.g., “AbA”)
 - A sequential transect number for that survey for the given year (e.g., “001”)
- (ii) An example of this identifier is “T201074AbA001.” The “Transect Estimated Composition” table is a child table beneath the “Transect” table that stores the transect composition percentage by component name and local phase.
- (4) “Site Association” Object.—This business object is designed to record and manage groups of sites. The parent table in the “Site Association” object is the “Site Association” table. A record is created in this table to group various site records for a specific sampling study or for a particular update project.
- (5) “Vegetation Plot” Object.—This business object is designed to group and summarize vegetation data and analysis from plots and transects. It records metadata associated with vegetative plots and transects including inventory protocols, data summaries, and analysis details and observations regarding disturbances and grazing. The “Vegetation Plot” object includes data drawn from the “Plant” and the “Site Observation” parent tables.

E. Geographic Area Records.—Geographic area records include symbols, names, and acreages for soil survey areas as well other political and physiographic areas. Geographic area records are maintained in the Area Type object.

- (1) “Area Type” Object.—This business object provides a means to organize the various types of geographic areas and to provide a complete list of approved soil survey areas and standard acreages for official soil survey areas, States, counties, and MLRAs used in soil survey operations management. Other types of areas are also recorded. The “Area Type” object includes the “Area Type,” “Area,” and “Area Text” tables.
- (i) The “Area Type” table lists the types of areas and the owners of each area. In NASIS, different kinds of areas are organized by area type. For example, traditional soil survey areas are listed in the “Area” table under the “Non-MLRA Soil Survey Area” type. Users may create their own area types.
- (ii) A record in the “Area Type” table is created as necessary and retained as part of the historical records for a soil survey area.
- (iii) Records recorded in the “Area Type” and “Area” tables serve as lookup tables for other data elements in NASIS.
- (iv) Nationally coordinated area type objects owned by NSSC Pangaea must not be duplicated.
- (v) The “Non-MLRA Soil Survey Area” and “MLRA Soil Survey Area” are the official area types for soil survey areas. Record maintenance for these official area types is the responsibility of the National Soil Survey Center.
- (vi) The “area symbol” is a unique label within a particular area type that is used to identify the soil survey area. Typically, symbols for political areas such as States and counties use Federal Information Processing Standards (FIPS) codes (e.g., Lancaster County, Nebraska = NE109). A survey area and a county may have the same area symbol because each is recorded under a different area type.
- (vii) The “area name” is the name given to the specific area. Although a soil survey area may be named for a county, the soil survey area name is recorded under the “soil survey area” area type and the county name is recorded under the “county” area type, even if the names are the same.

- (viii) The “area acres” are the total acreage of all land and water areas in a specified geographic area as identified by the 1992 National Resources Inventory (NRI) data. For example, the total acreage of a multicounty soil survey area is recorded in this table, as well as the total acreage for each of the counties. Parts of the soil survey area that occur in each county are recorded in the “Legend Area Overlap” table. Acreages are not recorded for some area types.

F. Map Unit Records.—Map unit records include soil survey area legends, map units, and the soil properties and interpretations for map units and their components. Map unit records are maintained in the “Legend” object, “Mapunit” object, “Data Mapunit” object, and “Project” object.

- (1) “Legend” Object.—This business object is designed for publishing soil survey information. The “Project” object, discussed later, was added with NASIS version 6.0 for the management of soil surveys. The “Legend” object links the survey area to its associated set of map units. These records are used to create the map unit identification legend, conversion legends, and correlation status reports for the survey area. The “Legend” object is created at the beginning of the survey, maintained throughout the course of the survey, and retained as part of the historical records. The “Legend” object includes several tables including the main “Legend” table. Generally, the legend in an initial survey is the responsibility of the soil survey office during the course of the initial soil survey. Responsibility is transferred to the SSR at completion of the survey.
 - (i) In the “Legend” table, some columns are available for viewing but are restricted for editing. For example, the “survey status” column (which identifies the archived entries as belonging to nonproject, initial, published, update needed, update, out-of-date, or extensive revision surveys) and “correlation date” column (which records the historical correlation date for the survey) cannot be edited. Other data columns are not restricted for editing and allow any appropriate entry (e.g., “Legend Text”).
 - (ii) In the “Legend Mapunit” a link is recorded between the “Legend” table and individual map unit records in the “Mapunit” table. The “Legend Mapunit” table identifies the publication map unit symbol, map unit status, and map unit acres for map units in the given survey area. The publication map unit symbol is assigned by the State soil scientist.
 - (iii) The combination of map unit symbols and their status in the survey area legend are unique.
 - (iv) The “Legend Area Overlap” table is required to contain at least the appropriate valid “State or Territory” area type overlap record, the appropriate “MLRA” area type, and the valid “County or Parish” area type overlap record within the legend survey area.
 - (v) Each “County or Parish” area type listed in the “Legend Area Overlap” table has its corresponding “State or Territory” area type overlap.
 - (vi) Project scale in the “Legend” table must be populated.
 - (vii) Each map unit within the “Legend Mapunit” table has a unique publication symbol, name, and status combination (see part 627, section 627.5, of this handbook for guidance). The map unit name is maintained in the “Mapunit” object, defined below.
 - (viii) Once created, map unit records are never deleted. During the correlation process, the status of map units migrates from “provisional” to “approved” to “correlated.” If a map unit is correlated to a new symbol, its status is changed to “additional.”
- (2) “Mapunit” Object.—This independent object is designed to facilitate sharing map units across soil survey area and political boundaries. The “Mapunit” object maintains the map unit name, its national map unit symbol, and the link to its associated data mapunits. It documents a continuous record of map unit development and correlation decisions made for the map unit, independent of the legend to which it is linked. These records are used to create the map unit identification legend, conversion legends, and correlation status reports for the

- survey area where the map unit is linked. A map unit is related to a geographic area when linked to a soil survey area legend by the “Legend Mapunit” table. The Mapunit object includes several tables, including the “Mapunit,” “Correlation,” “Mapunit History,” and “Mapunit Text” tables.
- (i) The “Mapunit” table lists mapunit name, kind, national mapunit symbol, and linear and point feature characteristics. This information is relative to the specific map unit and must be considered when the map unit is linked to multiple legends.
 - (ii) The “Correlation” table records all instances of data mapunits used to support correlation of the map unit. The “Mapunit History” table is populated when a new map unit is created and populated at each correlation event that affects the map unit.
 - (iii) The “National Mapunit Symbol” is a computer-assigned conversion of the internal map unit record identification number to a base-31 alphanumeric character. This field is generated as new rows are created in the “Mapunit” table, and it is protected from editing. It was designed to facilitate the concept of soil survey update on an MLRA basis by providing a unique symbol to a map unit regardless of the soil survey areas to which the map unit is linked.
 - (iv) Responsibility and ownership of a specific map unit is indicated by the “Mapunit NASIS Site” and “NASIS Group” columns in the “Mapunit” table. Map unit management in an ongoing survey or update project is the responsibility of the soil survey office.
- (3) “Data Mapunit” Object.—This business object is a record or a collection of records identifying percentage of its components (i.e., composition), physical and chemical properties, morphological attributes, interpretations, and performance for a map unit. A “Data Mapunit” object is a set of data records and as such is not related to any geographic area or map unit delineation unless linked to a specific map unit. These records are used to document map unit concept characteristics and create reports of soil properties and interpretations. “Data Mapunit” objects are created as needed and retained as part of the historical records. The “Data Mapunit” object includes the parent “Data Mapunit” table and many other tables. The underlying “Component” and “Horizon” tables are child tables of the “Data Mapunit” table. The “Component” and “Horizon” tables each have many underlying child tables.
- (i) “Data Mapunit” Table.—The “Data Mapunit” table lists data mapunits by using the “DMU Description” field as well as the “DMU NASIS Site,” and “NASIS Group” fields to identify ownership. It also contains information such as the order of survey for which the data mapunit was developed and State-specific soil potential and interpretive class ratings.
 - (ii) “Component” Table.—The “Component” table lists the named soils, miscellaneous areas, or both for each map unit. Soils and miscellaneous areas populated in the “Component” table are the components identified in the map unit name along with those components that are strongly contrasting to the named components. Components are designated as either “major” or “minor” components depending on their percentage in the composition of the map unit. This table provides information pertinent to the component as a whole (e.g., slope, drainage class, taxonomic classification, etc.).
 - (iii) Important Guidance on Populating Component Data
 - If the component percentage is greater than zero (e.g., Low=65, RV=75, High=90) for a component, that component exists in every delineation of that map unit. If the component percentage includes zero (e.g., Low=0, RV=50, High=90), the component may exist in some delineations but not in others.
 - Total representative component percentage should equal 100 percent; it cannot exceed 100 percent.

- The component name field must be populated using sentence case with a series name or an appropriate higher taxon name (e.g., Udorthents). Phase criteria, commas, spaces, or extraneous soil criteria information is not allowed in the component name field. Extra information is recorded in the “Local Phase” column.
 - The entry in the “Taxon Kind” column must agree with the component name. For example, if the name “Rock Outcrop,” is used then “miscellaneous area” must be selected as the taxon kind.
 - If the component kind is designated as a miscellaneous area, then the component name must exactly match one of the approved types that are defined in part 627 of this handbook.
 - Major components must be designated as such. Major components are generally those that are identified in the map unit name.
 - The “Hydric Rating” column must be populated for each component.
 - Pedons used to support development of the component must be identified with a record (i.e., row) in the “Component Pedon” table. This record links the “Data Mapunit” and “Pedon” objects. Only one pedon record is assigned as the “representative” pedon.
 - If a soil floods, or ponds, or contains moisture, then all 12 months are populated in the “Component Month” table and the months in which the annual event most commonly occurs are populated. Remaining months are left NULL.
 - In the “Component Crop Yield” table, only one unit of measure (UOM) is assigned for the unique crop name (e.g., a data entry showing two records of alfalfa, one with tons and one with AUM, is incorrect).
 - All root-limiting layers must be populated in the “Component Restriction” table. Depth to the restrictive layer matches the depth to the corresponding horizon in the “Component Horizon” table.
- (iv) “Horizon” Table.—The “Horizon” table presents the various horizons that have been aggregated from the genetic soil horizons described in the various documented pedons. These horizon data are aggregated for ease in generating interpretations and presenting soil survey information to users. Each horizon recorded in this table identifies the range of properties and interpretations for the given horizon. The horizons and their range of properties are aggregated from the observed population of point descriptions collected for the given component within the given map unit. Horizon properties are assigned three values: Low (L), Representative (RV), and High (H).
- (v) Important Guidance on Populating Horizon Data
- Refer to part 618 of this handbook for detailed information on soil properties.
 - If the horizon thickness is greater than zero (e.g., Low=5, RV=8, High=12), the horizon exists everywhere this component occurs in this map unit. If the horizon thickness includes zero (e.g., Low=0, RV=1, High=3), the horizon may exist in some places where this component occurs but may not exist in other places.
 - “Top (Low, RV, High)” is the distance from the top of the soil to the upper boundary of the soil horizon. “Bottom Depth (Low, RV, High)” is the distance from the top of the soil to the lower boundary of the soil horizon.
 - No gaps or overlaps are allowed in horizon depths. Depths must join exactly between adjacent horizons.
 - “Master” is one of three kinds of symbols that, when concatenated, are used to distinguish different kinds of layers in soils. Master horizons and layers are the base symbols to which other characters are added to complete the designations. Capital letters, carets (^), and virgules (/) are the symbols used to choose the “Master”

designation. The word “and” is also part of the designation of some combination horizons (e.g., E and B).

- Master horizons “O” and “R” must have the “Master” and “Designation” columns properly populated.
 - Combination horizons, such as “E/Bt” or “E and Bt,” are recorded twice: once for the characteristics of the first part and again on another row for the characteristics of the second part. The RV depths for each characteristic horizon should reflect the best estimate of depths for the recorded part. The RV values assigned for horizon top and bottom depths must be continuous (e.g., 20 to 35 cm for one record and 35 to 50 cm for the other record) and should not be duplicated or overlapping. The range of depths should be populated in the “Low” and “High” columns to identify the overlapping nature of the horizon.
 - “Designation” is the concatenation of five kinds of symbols that are separate data elements in NASIS and must be populated individually. These symbols are discontinuities (“Disc”), master horizons and layers (“Master”), prime symbols (“Prime”), suffix symbols (“Suffix”), and vertical subdivisions (“Sub”). These symbols are used in various combinations to designate layers within the soil. The full horizon designation, such as “Btk2” or “2^Cg1,” is shown in the “Designation” column. Default designations were set as generic “H” horizons, such as H1, H2, etc., during conversion from a prior database into NASIS. These generic designations may continue to be used. The “Designation” column may be calculated, based on data in other columns. The status indicator in the rightmost part of the “Designation” column indicates whether a value in this column has been manually entered (M), calculated (C), or neither (a null entry in the status block).
 - All “Low,” “Representative,” and “High” value fields are populated for soil properties.
 - Tenth-bar, third-bar, and 15-bar water contents are populated with values less than 100.
 - Populate CEC-7 if pH is greater than or equal to 5.5; otherwise populate ECEC.
 - Only one “Representative” texture is assigned for each horizon in the “Horizon Texture Group” table.
 - Avoid the use of stratified textures (e.g., SR-S-L) if possible by separating and populating horizons based on different soil properties.
 - Horizon structure must be populated.
 - Populate all fields in the “Horizon Fragments” table for soils with fragments.
 - The sum of the values in the “Vol % RV” column of the Horizon Fragments table should match the value in the “Total Fragment Volume RV” column in the “Horizon” table.
 - The sum of fragment volumes must agree with the texture modifier chosen for the RV texture modifier and class in the “Horizon Texture Group” table.
- (4) “Project” Object.—This business object is the soil survey program management tool designed for the management of all soil survey operations, including planning, managing, and tracking the status, milestone events, and progress of NCSS. The “Project” object is used to record staff, goals, progress, and survey management considerations. A record in the “Project” object is created as needed and retained as part of the historical records. The “Project” object includes the parent “Project” table and several other tables. Generally, responsibility for project data is created by the soil survey office.
- (i) For outmoded surveys, the project name will use the non-MLRA soil survey area name identified in the MOU (e.g., Saline County, Kansas – Published).

- (ii) For updating soil surveys, the project name will use the MLRA symbol and the project name (e.g., MLRA 73 – Harney Silt Loam Ksat Study). The “Non-MLRA soil survey area” fields are not populated for update surveys.
- (iii) For the Soil Data Join Recorrelation projects, the project name will use the “SDJR” prefix, followed by the MLRA symbol and the project name (e.g. SDJR – MLRA 133B – Bowie fine sandy loam, 1 to 3 percent slopes)
- (iv) The “Soil Survey Office Area Symbol” and “Name” data elements must be populated.

G. Standards, Criteria, and Guidelines.—Standards, criteria, and guidelines include taxonomic class limits, series ranges in characteristics, interpretation criteria, and other data and documents used to establish concepts, assist aggregation, and communicate policy in soil survey. Most standards, criteria, and guidelines, such as this handbook and the Soil Survey Manual, are managed as online documents. Some standards, criteria, and guidelines, such as queries, reports, and interpretation criteria, are managed as data in NASIS. These NASIS data records are recorded in the “Query” object, “Report” object, and business objects described for “Properties, Evaluations, and Rules,” defined below.

- (1) “Query” Object.—This business object is designed to maintain the name, selection criteria, description, and default target table developed for individual queries. The “Query” object contains the “Query” table and “Query Text” table. Queries are created as needed and retained at the discretion of the owner of the query. Ownership of a specific query is indicated by the site and group fields on the “General” tab for the particular query in NASIS. Authority to edit the “Query” object is limited to users who are members of the group that owns the query. Descriptions for data elements in the “Query” object and instructions for use of the editor are in the NASIS online documentation.

Queries.—Specific naming convention is requested to facilitate consistency and avoid duplication of queries within the NASIS application. Queries are used to retrieve specific soil data records from the national NASIS database to populate the local NASIS database and also to bring soil data from the local database into a current NASIS session (selected set) for viewing, editing, or reporting. Note the following guidance on queries:

- The query name should begin with a key word that either targets the table or data being queried (e.g., Component or Area/Mapunit/Component).
 - The key word is followed by concise terms that specify the criteria and parameters by which the query selects the data. The suggested syntax is: “[keyword] by [criteria] where [parameters].” Examples include:
 - “Area/Mapunit/Datamapunit by Area ID”
 - “Area/Mapunit/Component by component name, SSA symbol where major = yes”
 - “Pedon/Site/Transect by Soil Name As Sampled”
 - The “Query Description” must be populated by describing the appropriate target tables, the purpose of the query, the query author, and the date the query was created.
 - User names, numbers, and office locations are not acceptable for query names.
 - Key words are not to be prefixed with numbers or symbols with the intent to override sorting.
 - Duplicate queries among the various NASIS sites are avoided. A list of “Favorites” is a feature of NASIS that is available to manage the individual user’s queries.
 - The “Query Text” table is used to document edits made to each query.
 - Further details describing the process of writing queries can be found in the in the NASIS online documentation.
- (2) “Report” Object.—This business object is designed to maintain the style, format, content, and layout specifications developed for individual reports. Reports are created as needed and

retained at the discretion of the owner of the report. Ownership of a specific record in the “Report” object is indicated by the site and group fields on the “General” tab for the particular report in NASIS. The “Report” object contains the “Report” and “Report Text” tables. Authority to edit the “Report” object is limited to users who are members of the group that owns the report. Descriptions for data elements in the “Report” object and instructions for creating reports are in the NASIS online documentation.

Reports.—A specific naming convention is necessary to facilitate consistency and avoid duplication of reports within the NASIS application. Reports are used to view data and generate output and can be run against the national NASIS database or against the local database. Note the following guidance on queries:

- The report name should begin with a key word, in uppercase, that groups the report for a specific use. Examples include the following:
 - “CORR” for correlation reports
 - “MANU” for manuscript reports
 - “PEDON” for pedon reports
 - “SSS” for soil survey schedule reports
 - The key word is followed by a space, en dash, space. This is followed by concise terms that specify the purpose of the report. For example, the syntax should be “[keyword] – [criteria].” Examples include:
 - “CORR – Legend Field Review”
 - “MANU – Soil Features”
 - The “Report Description” field must be populated, and it must describe the purpose of the report, the report author, and the date the report was created.
 - Do not use user names or locations for report names.
 - Key words are not prefixed with numbers or symbols with the intent of overriding the default sorting.
 - Avoid duplicating reports, since reports are available on all NASIS sites.
 - Notes are entered into the “Report Text” table to document edits made to each report.
 - Further details describing the process of writing reports can be found in the NASIS online documentation.
- (3) **Properties, Evaluations, and Rules.**—The criteria for soil interpretations are comprised of “properties,” “evaluations,” and “rules.” These three elements are designed to maintain a list of soil properties, class limits, ranking terms, and restriction terms for each soil survey interpretation. The data for these elements is recorded in the “Property” object, “Evaluation” object, and “Rule” object. Records in each object are used to predict behavior from the physical, chemical, and morphological properties of individual components of map units. Interpretive results are reported and maintained independently from the criteria.

Interpretation Criteria.—Interpretation criteria include official criteria as well as regionally or locally developed criteria. They are created as needed and retained as part of the historical records. Interpretation criteria are housed in several tables in the NASIS application. Further details describing the process of writing interpretations can be found in part 617 of this handbook and in the NASIS online documentation. Detailed guidance on developing interpretations is available from the NSSC soil survey interpretations staff.

H. Spatial Database.—The spatial database is not yet integrated into the NASIS application. It is maintained as a separate standalone database.

639.4 Guidelines for Changing, Adding, or Deleting Soil Property Data Elements

- A. Data Dictionary.—The NRCS Soil Science Division maintains a soil data dictionary, which contains the national list of approved soil attributes and the standards for naming, defining, and implementing attributes in soil databases.
- B. Maintenance.—NSSC is responsible for maintaining the soil data dictionary and for integrating soil data within soil information systems as well as within other NRCS information systems.
- C. Modification.—Changes, additions, or deletions to the soil data dictionary are proposed by any participant in the National Cooperative Soil Survey. Those suggestions are transmitted to the NSSC.
- D. Definition.—Changes, additions, or deletions to the soil data dictionary are defined as—
- (1) Adding or removing attributes from the approved list of soil attributes.
 - (2) Changing the definition of an existing attribute, including adding to, removing from, or redefining abbreviations or codes used to describe soil properties.
 - (3) Adding to, removing from, changing, or redefining the methods used to obtain data for an attribute or changing the methods used for the derivation of data values for the attribute.
- E. Proposal Process.—The following steps are used to propose or revise soil property data elements for the NASIS application:
- (1) Formulate the need for a new element or a revision of an existing data element.
 - (2) Record the necessary descriptive information for the data element using the exhibit found in part 639, subpart B, section 639.10, of this handbook.
 - (3) Solicit comments from other soil scientists to refine proposals. Standing committees of regional NCSS conferences are appropriate venues. Refer to part 602 of this handbook for information.
 - (4) Forward proposals for changes, additions, or deletions of data elements to the director of the NSSC for coordination of review and update of the soil data dictionary.

Part 639 – National Soil Information System (NASIS)

Subpart B – Exhibits

639.10 Proposed Amendment to Soil Data Dictionary

Attribute Name (proposed or modified):

Data Type (choose one of the following four data type choices):

☐ Text <256 characters

length of text field _____

☐ Text >256 characters

☐ Number

lowest value _____ highest value _____

units of measure _____

integer? (yes or no) _____ float? (yes or no) _____

number of decimal places if “float” is chosen _____

☐ Choice List

_____ choices (attach) choice definitions (attach)

Definition of Attribute:

Purpose of Attribute (why it is necessary, how it is used):

Relationship to Other Data, Validations, Calculations:

Part 644 – Delivering Soil Survey Information

Subpart A – General Information

644.0 Definition and Purpose

A. Definition.—Soil survey information is the analysis and summary of records gathered either during the initial inventory or added later to enhance the data assembled during the initial investigation and mapping. Soil survey information is distributed in a variety of forms and always includes a geographic component identifying either the spatial or point location of the information. Soil survey information describes, defines, and classifies the soils and interprets them for various uses. It documents the kinds, extent, location, and quality of the soils in the survey area. It contains soil interpretations appropriate for the intended uses of the soils. The memorandum of understanding for the soil survey area describes these uses.

B. Purpose.—The purpose of soil survey information is to transfer knowledge to those who make decisions about soil use. Soil survey information may utilize several delivery systems and is represented by different soil survey products.

C. Authority.—According to the authority outlined in 7 CFR Section 611.10(a) (October 8, 2004), NRCS conducts soil surveys under national standards and guidelines for naming, classifying, and interpreting soils and for disseminating soil survey information. This part of the National Soil Survey Handbook provides standards on dissemination of soil survey information.

644.1 Types of Soil Survey Delivery

Soil survey information is delivered primarily through three online systems: Web Soil Survey, the National Cooperative Soil Survey (NCSS) Soil Characterization Database web application, and the Soil Geochemical Spatial Database web application.

- (1) Web Soil Survey.—The Web Soil Survey is the primary delivery mechanism for detailed soil survey information. This web application has several delivery functions. It includes web-based soil surveys with user-determined text and maps of areas of interest. The Web Soil Survey allows the user to interactively select an area of interest on the map, to view and print the soils map for the area-of-interest, to access soil data for the area, and to obtain information on the suitability of the soils for selected uses. The Web Soil Survey is a dynamic system; any corrections and enhancements made to the spatial and tabular data as a result of soil survey maintenance can be uploaded to the intermediate databases which provide informational services to the Web Soil Survey. Although the information in the current version is detailed soil survey information, plans are to include general soil information and point data. The tabular data, spatial data, template database, and FGDC metadata for the U.S. General Soil Map (STATSGO2) are available for download from the Web Soil Survey.
- (2) National Soil Characterization Database.—The National Soil Characterization Database offers a web application that provides analytical data for pedons of U.S. and foreign soils from both the National Soil Survey Center's Kellogg Soil Survey Laboratory (KSSL) and NCSS cooperating laboratories. Standard morphological pedon descriptions are available for

- most of these pedons. The data are available online at <http://ncsslabsdatamart.sc.egov.usda.gov>. They are point data.
- (3) Soil Geochemical Spatial Database Web Application.—The Soil Geochemical Spatial Database web application is an ArcView-driven web application. The geographic display consists of two major sets of geochemistry data:
- (i) Current geochemical data.—These data are displayed in four geographic layers: “Site Info,” “Major Elements,” “Trace Elements,” and “Selected Characterization Data.”
 - (ii) Holmgren Dataset.—These data were produced by the SCS Soil Survey Laboratory during the 1970s and 1980s for a project documenting the content of selected trace elements in agricultural soils of the United States (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/tx/home/?cid=nrcs142p2_053632).

644.2 Policy and Responsibilities

A. 7 CFR Section 611.11 directs the NRCS to disseminate soil survey information to the public through electronically accessible maps and reports, electronic access to data files, or printed documents. To the extent limited by commonly accepted technology, soil survey information is disseminated in electronic form. NRCS is to make soil survey information available as soon as is practical following fieldwork or other soil survey activity that provides new soil survey information. Sensitive or personally identifiable information, such as landowner names, must not be attached to point data accessible in NRCS products. Policy on media protection (access, storage, transport, sanitization, and disposal) is available in Title 270, General Manual, Part 418, at <http://directives.sc.egov.usda.gov/viewerFS.aspx?hid=28735>.

B. Official Soil Survey Information

The official source of soil information is the Web Soil Survey, a part of the National Soil Information System.

- (i) This system provides for the collection, storage, manipulation, and dissemination of detailed and general soil survey information.
- (ii) The system includes certified tabular and spatial data at various scales.
- (iii) The goal is to distribute and maintain accurate and complete information on the current condition of the soils of the United States in a seamless sequence of spatial and tabular data.
 - Soil survey information is published and issued to users soon after the completion of the fieldwork.
 - Initial detailed soil survey information is to be posted when the spatial data is certified, the NASIS data is certified and both databases are ready to send to the Soil Data Warehouse; this occurs within 1 year after mapping is complete.

C. Interpretations

- (1) Interpretations are generated from soil property data and approved interpretation criteria.
- (2) Interpretations used in disseminating soil survey information are extracted directly from information hosted on the Web Soil Survey.
- (3) The interpretation results are not modified or adjusted individually in any way. They are the results generated by the criteria.

D. Responsibilities

- (1) The Soil Survey Office (SSO) is responsible for—

- (i) Creation and maintenance of fully populated soil survey databases in the National Soil Information System with the properties to generate tables of soil survey information and interpretations for all soil surveys in their assigned area.
 - (ii) Detailed soil mapping for digitized and certified detailed soil spatial data.
 - (iii) Primary authorship and preparation of soil survey manuscripts for complete soil survey publications.
 - (iv) Developing technically correct, consistent, complete, current, organized, clear, and concise soil survey manuscripts.
 - (v) Responding to the customer needs and expectations defined in the memorandum of understanding.
 - (vi) Meeting NCSS standards.
 - (vii) Preparing illustrations and photographs.
 - (viii) Requesting the assistance of staff specialists for soils and other disciplines, as needed.
 - (ix) Developing schedules and meeting established dates.
- (2) The Soil Survey Regional Office (SSR) is responsible for—
- (i) Ensuring that detailed and general soil survey products and information conform to NCSS standards.
 - (ii) Providing support and leadership to the SSO in describing soil properties and making estimations used as data elements.
 - (iii) Providing support and leadership to the SSO in preparing soil survey manuscripts and maps and the processes involved, such as map compilation and digitizing.
 - (iv) Ensuring that soil survey products and information are technically correct, consistent, complete, current, and organized in a clear and concise manner.
 - (v) Ensuring that soil survey information reflects current local conditions and needs.
 - (vi) Providing training to authors.
 - (vii) Recommending the action needed to correct an error in a database.
 - (viii) Monitoring key project dates in NASIS and assisting the project office in keeping the soil survey on schedule.
 - (ix) Ensuring multidiscipline and cooperator input when soil survey information is prepared and reviewed.
 - (x) Editing, formatting, proofreading, and preparing text and tables for soil survey manuscripts. and
 - (xi) Ensuring conformity of publications to the Government Printing Office Style Manual.
- (3) The State office is responsible for—
- (i) Certifying and posting official detailed soil survey information in the Web Soil Survey.
 - (ii) Developing criteria for local or State interpretations, as needed.
 - (iii) Selecting the appropriate tables of detailed soil information for use within the Web Soil Survey.
 - (iv) Developing a program that ensures equitable distribution of soil survey information and products.
 - (v) Populating the electronic field office technical guide (eFOTG) with soil survey information from the Web Soil Survey.
 - (vi) Ensuring that any directive included in the MOU or other working agreement directing the restriction of information sensitive to national security is complied with (see section 606.1 of this handbook).
- (4) The National Soil Survey Center is responsible for—
- (i) Developing national standards and procedures for disseminating soil survey information.
 - (ii) Developing national interpretations using detailed and general soil survey information.
 - (iii) Maintaining the general soil information data set.
 - (iv) Maintaining a national list of published soil surveys, including out-of-print surveys.
 - (v) Providing for the delivery of soil survey information on web delivery tools.

644.3 Soil Survey Products

Soil survey information is assembled at various scales to meet the needs of various customers. The product types are as follows:

- (1) Point Soil Data.—These are data that are sampled in one location.
 - (i) Point data include pedon description data and lab characterization data that are georeferenced. Some of this information is currently delivered through the laboratory characterization database or within printed publications, such as soil survey reports and soil survey investigation reports.
 - (ii) Most point data gathered as field documentation for soil survey are now captured within the National Soil Information System but are not made available elsewhere.
- (2) Detailed Soil Survey Information
 - (i) This information consists of soil survey spatial data (soil maps or digital data) and reports, such as the standard product of detailed soil surveys, and generally is at a scale of either 1:12,000 or 1:24,000.
 - (ii) This information is delivered by the Web Soil Survey.
- (3) Complete Soil Survey Publication.—The complete soil survey publication includes materials and sections identified in section 644.10. The complete soil survey publication—
 - (i) Includes detailed soil survey information and other explanatory information.
 - (ii) Is delivered as standardized PDF files of text, tables, and maps both by CD-ROM and in the Web Soil Survey as a soil survey manuscript.
 - (iii) New or old, whether published in printed form, on CD-ROM, or on the web, is listed on the national list of published soil surveys, which is maintained by the National Soil Survey Center at http://soils.usda.gov/survey/printed_surveys/. This site includes the list of completed soil survey publications, information on ordering printed copies or CD-ROMs, and information about online soil survey publications.
- (4) U.S. General Soil Map. This dataset includes both spatial and tabular data.
 - (i) The level of mapping is designed for maps to be used for broad planning and management covering State, regional, and multistate areas.
 - (ii) Soil maps for the U.S. General Soil Map database are produced by generalizing the detailed soil survey data.
 - (iii) The mapping scale for the general soil map is 1:250,000 (with the exception of Alaska, which is 1:1,000,000).
 - (iv) Web access to the U.S. General Soil Map is provided, with the capability to download data, within the Web Soil Survey.
 - (v) Future plans call for online viewing and analysis of the U.S. General Soil Map to be available on Web Soil Survey.
- (5) Major Land Resource Areas of the United States.—The map of the major land resource areas of the United States is a generalization of the map units in the U.S. General Soil Map. Some line work is also taken from U.S. Forest Service and U.S. Environmental Protection Agency ecoregion maps.
 - (i) Delineations are compiled to a base map of 1:250,000 and displayed at scales of 1:3.5 million to 1:7.5 million. Currently, no tabular database has been developed for this data layer.
 - (ii) All connected soil data are in text fields, except for National Resource Inventory data. However, the MLRA map is linked to a companion dataset, called “Common Resource Areas,” that has linkages to short narratives and the Conservation Systems Guides (CSGs) database, used by the field office technical guide.

644.4 Development of Point Data

Point data become a product of soil survey when they are incorporated into the database. These data include soil profile descriptions, soil water or temperature measurements, transects, field notes, and data derived from characterization or engineering test laboratories.

644.5 Development of Detailed Soil Survey Information

Detailed soil survey information becomes a product of soil survey when it is entered into the Soil Data Warehouse. It includes all soil map unit and component information and spatial information.

644.6 Development of a Complete Soil Survey Publication

A. Planning

- (1) The memorandum of understanding for the soil survey area is the guidance document for soil surveys from design to delivery. It must be specific, and signers must commit to its contents.
- (2) The workload analysis identifies the tasks and the timeframe to complete each task. Part 608, section 608.4, of this handbook, provides more information. Part 608, section 608.8, provides information on scheduling.
- (3) During the initial field review, the SSO and the SSR assign each section of the manuscript to an author. They also identify dates for completion.
- (4) The layout and design of a “complete soil survey publications” are standardized so that the publications have a consistent corporate look and meet Government standards. Flexibility is available to authors in the presentation of this soil survey information, as outlined in section 644.8, which indicates required and optional sections. The content should meet the needs of the intended users. These needs are identified in the memorandum of understanding.

B. Quality Control and Assurance

- (1) Progressive correlation and certification help to resolve soil survey problems and meet soil survey needs throughout the course of the soil survey project. The SSR assists the SSO during the project activities, including manuscript preparation, to ensure the timely completion of the manuscript and database and conformance to standards.
- (2) The authors and the SSO staff control the technical quality of a soil survey manuscript. Technical specialists in such fields as range, forestland, wildlife, and engineering provide assistance. Quality control occurs during each stage in the project.
- (3) The SSR and technical specialists review the soil survey manuscript and database for technical accuracy and adherence to standards. The soil scientists on the SSR staff provide quality assurance of the text and maps. The SSR certifies the soil survey legend, descriptions, database, mapping, and manuscript during progressive reviews.
- (4) The National Geospatial Center of Excellence controls the quality of printing the CD-ROMS.

C. Ordering Copies (Previous Procedure)

- (1) The State conservationist submits a consolidated State order for CD-ROMs or print copies of surveys and map copies on Form NRCS-SOI-7 to the National Geospatial Center of Excellence about 3 months before manuscript completion. Section 644.11 contains an example of the form. Include the shipping addresses of those locations receiving copies.

- (i) The State conservationist coordinates with the cooperating agencies and libraries, institutions, and officials of interested agencies. Up to 1000 CD-ROMs and 500 sets of maps can be ordered.
 - (ii) Each cooperating agency is entitled to 50 copies of the published soil survey on CD-ROM at no cost.
 - (iii) In special situations, where printed and bound copies are required, approval by the Soil Science Division director is required. The State conservationist will indicate on the NRCS-SOI-7 the number of copies to be printed on paper and the number to be published on CD-ROMs.
 - (iv) Prior to final publication, the State conservationist checks the submitted Form NRCS-SOI-7 to ensure that it still is current. The State conservationist notifies the National Geospatial Center of Excellence of any change in the number of copies ordered. The revised Form NRCS-SOI-7 must be received before the survey is sent for the production of CD-ROMs.
- (2) Members of Congress are informed of the availability of the publication. Refer to section 644.12 for a sample.

D. Printing Requirements and Options for Soil Surveys

- (1) Although soil survey publications are issued only as electronic copies of text and maps on CD-ROMs, on the web, or both, maps may be available as flat maps where printing from electronic media is not feasible. Printing of paper copies of the text requires special approval by the Soil Science Division director.
- (2) All surveys must be sent to the National Geospatial Center of Excellence for the production of original CD-ROMs and electronic files. States and cooperators can produce copies of issued CD-ROMs as needed.
- (3) The National Geospatial Center of Excellence maintains the printing materials for maps. States ensure that other printing materials, such as photographs, are stored for future use.
- (4) Electronic files can be provided to cooperators and others, who can then produce additional copies of the survey for distribution or sale to the public.

E. Detecting and Correcting Errors in Printed Copies of Published Soil Surveys

Printing and binding errors include blank pages, duplicate or missing pages, poor binding, misplaced pages, and blurred print. Some errors may occur in every copy of the survey. They include missing paragraphs, misplaced captions, wrong entries in tables, and defective maps. Determine the extent of the error before selecting a corrective action. The National Geospatial Center of Excellence can provide assistance to the State soil scientist in determining the corrective action to be taken.

F. Distributing a Published Soil Survey

- (1) When the soil survey publication of an area is printed on a CD-ROM or other electronically readable media, the National Geospatial Center of Excellence notifies the State conservationist to expect delivery of the publication. The State conservationist and the cooperating agencies implement their marketing plan and distribute the soil survey to maximize its utilization.
- (2) The distribution ensures that each published soil survey is available to all people. The U.S. Department of Agriculture (USDA) prohibits discrimination on the basis of race, color, national origin, age, disability, and where applicable, sex (including gender identity and expression), marital status, familial status, parental status, religion, sexual orientation, political beliefs, genetic information, reprisal, or because all or a part of an individual's income is derived from any public assistance program (not all prohibited bases apply to all

- programs). Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotope, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). The distribution may entail printing paper copies from the CD-ROM or downloaded from the web.
- (3) Prior to distribution, check all copies. Be sure all sections of the PDF files open properly. Also, check maps if they are printed separately. Report errors to the State soil scientist, who in turn notifies the National Geospatial Center of Excellence.

644.7 Development of the U.S. General Soil Map

A. Digital General Soil Map of the United States

- (1) The basis for the Digital General Soil Map of the U.S., or STATSGO2, is the former State Soil Survey Geographic (STATSGO) dataset. This database includes spatial and tabular data.
- (2) It uses the Geographic Coordinate System with North American Datum (NAD) 1983.
- (3) This database is established and managed as one data set.
- (4) Data is refreshed annually. The database uses a standard State boundary vector and the National Atlas Coastline.
- (5) The Web Soil Survey (WSS) is the public distribution site.

B. This dataset provides—

- (1) A nationally consistent soil geographic database.
- (2) Soil data compatible with other data digitized from 1:250,000-scale maps, such as land use and land cover, political boundaries, and federally owned land.
- (3) Soil information at a level of detail for a State or broader geographic information system.
- (4) A set of consistent, joined county general soil maps of the same scale used for a State or broader geographic information system.
- (5) Maps for interim general soil data for areas where digital detailed soil survey maps are not complete.
- (6) General soil data to determine optimal locations for various uses.
- (7) General soil maps for publications in soil survey and watershed reports.
- (8) A tool for use with other resource information for the State, region, or nation in a geographic information system.

C. Components of the U.S. General Soil Map

- (1) In general, map units are a combination of associated phases of soil series that enable the most precise interpretations. Where soil series are not established or are not adequately described, some map units contain soil components which are associated higher taxonomic categories such as subgroups or families. Components may also be miscellaneous areas (i.e., nonsoil bodies) such as playas, rock outcrop, or water. Water bodies not large enough to be delineated, but of sufficient extent, are added as components of general soil map units.
- (2) Map units have a maximum of 21 soil components. The percentages of the components of a map unit add up to 100 percent. Highly contrasting components are kept separate, even though they are of minor extent. For instance, 1 percent rock outcrop is significant and should be identified in the composition.
- (3) Not all components are in all delineations of a general soil map unit, and the composition percentage may vary by delineation.
- (4) The information about map units includes reliable estimates of the components and their composition percentages. The methods by which the composition was determined is included. Composition is determined by using transects, measuring components, or

calculating in a geographic information system from digital Soil Survey Geographic (SSURGO) data. Transects are commonly located and examined on soil survey field sheets.

Part 644 – Delivering Soil Survey Information

Subpart B – Exhibits

644.10 Sections of a Soil Survey Publication

Accessibility statement

Cover

“How To Use This Soil Survey”

“Box” information and EEO statement

Contents

Foreword (or Preface)

“General Nature of the Survey Area”

 Introductory information and locator map

 Climate tables and “Climate” section

 Other sections, such as “History,” “Natural Resources,” and “Transportation Facilities”

 “How This Survey Was Made”

 “Survey Procedures”

 “General Soil Map Units”

 Detailed soil map unit descriptions

 “Use and Management of the Soils” and interpretive tables

 (Cropland, pasture, woodland, rangeland, wildlife habitat, recreation, and engineering uses are all optional, depending on relevancy.)

 “Land Capability Classification”

 “Prime Farmland”

“Soil Properties” and properties tables

 “Engineering Index Properties”

 “Physical Properties”

 “Chemical Properties”

 “Soil Features”

 “Water Features”

 “Physical and Chemical Analyses of Selected Soils”

 “Engineering Index Test Data”

“Classification of the Soils” and classification table

Series descriptions¹

“Formation of the Soils”

References

Glossary

General soil map

Detailed soil maps

 Detailed map sheets

 “Index to Map Sheets”

¹ As we have progressed to automated development and delivery of soil survey information, taxonomic descriptions (series or higher taxa) are not required for a manuscript to meet minimum standards. Please note that you are not prohibited from publishing these descriptions, including the option to use the OSD. The soil survey regional director may have additional insight and suggestions about this.

“Conventional and Special Symbols Legend”

“Soil Legend”

Photographs

Block diagrams and other drawings

GENERAL INTRODUCTION

Soil Survey Manuscript Format

Soil survey publications on CD-ROM include the soil descriptions, interpretations, and maps published on one disk. Flexibility is available for offices that desire to have additional maps printed.

Editing Prewritten Material

Authors should use the latest version of the prewritten material that is available. This material introduces major sections and describes the tables used in soil surveys. It should be edited only as needed. Authors need to ensure that table letters are changed to the appropriate numbers and that statements that misrepresent the survey area are changed or deleted. They should not, however, delete rating factors when these factors are not limitations in the survey area. The factors were considered when the soils were rated. Deleting references to them implies that they were not considered.

A. COVER

This is prewritten material. The names of cooperating agencies are to match the “Classification and Correlation Document.”

B. HOW TO USE THE SURVEY

A page entitled “How To Use This Soil Survey” is inserted into the text by the editorial staff prior to sending the manuscript for publication. This page is included as part of the electronically generated prewritten material.

C. CREDITS

This page is referred to by the editorial staff as the “box.” It is prewritten material. Dates and cooperators are to match the “Classification and Correlation Document.” Credit for financial or other assistance by agencies other than cooperators can be given at the end of the second paragraph on this page. Insert the caption for the cover photo.

D. CONTENTS

This is prewritten material with addition or deletion of headings as needed. Series names are to match the correlation document. The table of contents must accurately represent the actual contents of the survey. Do not list page numbers.

E. FOREWORD

This is prewritten material with insertion of the name of the survey area and the State conservationist’s name. (Note: If the State conservationist’s name is not used, change “Foreword” to “Preface”; be sure also to change the listing in the table of contents.)

F. TITLE PAGE

This is prewritten material. Fill in the name of the survey area, the author’s name, and the names of soil survey project members. Fill in the names of the cooperating agencies as they appear in the correlation document.

G. INTRODUCTION TO THE SURVEY AREA

This part of the survey is not assigned a heading. A few short paragraphs describe the location of the survey area, the size of the area, and some important facts about the area. If a soil survey of the area or part of the area has been previously published, it is pointed out that this survey supersedes the older one. Make sure that the older published survey is cited in the list of references.

H. GENERAL NATURE OF THE SURVEY AREA

This section highlights the natural and cultural features in the survey area that affect the use and management of the soils. Brief discussions of the history and development of the area, climate, physiography, drainage, natural resources, farming, etc., can be included. If history and development are described, the emphasis should be on land use. Significant trends in population and in soil use can be described. A discussion of the trends in land use is especially appropriate for survey areas that have been subject to recent extensive changes. Data from census or other sources should be supported by appropriate references. This section should give the reader a general impression of the area.

Information given in the introduction to the survey area is not repeated. Technical material does not belong in this section. If general enough for the lay reader, a brief discussion of the geology of the survey area can be included here. A highly technical discussion belongs in the section on “Formation of the Soils.”

The climate section is required as either a link to the Climate Data Access Facility or as a section. If possible, use the prewritten material. Authors are encouraged to use the automated climate tables from the Climate Data Access Facility located in Portland, OR. The standard “normal” period of 1971 to 2000 is used, but long term or climates of other periods can supplement this required period.

I. HOW THIS SURVEY WAS MADE

This is prewritten material with the following additions. Explain all locations that are not exactly joined briefly at the end of this section. Explain a blank or unmapped area on the map within the boundaries of the survey. Is the area unmapped because it is a restricted military installation or because access was denied?

The purpose of the survey procedures section is to describe and document specific procedures used to make or update the soil survey.

J. GENERAL SOIL MAP UNITS

The general soil map, if used, is a subset of the Digital General Soil Map of the U.S. This section consists of prewritten material, general soil map unit descriptions, and a discussion of broad land use considerations. The broad land use considerations part is optional. Three-dimensional block diagrams and cross-sectional diagrams that show the location of the major soils of a general soil map unit on a landscape and their relationship to underlying material is optional.

K. DETAILED SOIL MAP UNITS

Map unit descriptions, if used, provide users in nontechnical terms the typical profile of the named soil or soils, information about the basic soil interpretations and management concerns that could reasonably be expected for the common land uses. Map unit descriptions are written in a way that will help the reader understand the behavior of the soils within a survey area. If detailed soil map units are used they must add value to the information provided in the tables. The descriptions sequence is:

- (1) Map symbol and map unit name
- (2) Major features, setting, and composition
- (3) Brief soil profile
- (4) Included areas

- (5) Soil properties and qualities
- (6) Use and management
- (7) Interpretive groups

The information in the use and management section of the map unit description is intended to alert the user to significant problems or qualities of the soil. The discussion should be brief, concise, and informative. The description of the major hazards and management concerns must be consistent with the assigned interpretive groups.

L. USE AND MANAGEMENT OF THE SOILS

This section gives, mainly in tables, information applicable to the use and management of the soils. It discusses yields and suitability or potential and limitations of the soils for major land uses. There is a prewritten explanation for each table. In addition, there are discussions of general management concerns and practices applicable to all soils that are used for a particular purpose, such as crops and pasture.

M. SOIL PROPERTIES

Data about soil properties are listed in tables in this section. All tables are generated from certified data. Information includes estimates of engineering index properties, physical and chemical properties, and soil and water features. Also, available field and laboratory data are given in this section.

N. CLASSIFICATION OF THE SOILS

This section consists of a brief description of the system of soil classification and tables. Taxonomic unit descriptions define the range in characteristics of a soil series as mapped within the major land resource area or utilize or link to the official soil series descriptions. The description is written for those individuals who need a detailed technical description of the soil and the associated range in characteristics.

O. FORMATION OF THE SOILS

This section allows soil scientists to record their concepts of the soil genesis in the survey area. The formation of the soils section can be an important part of the manuscript because it describes the models used by soil scientists in making the soil survey, however, the section is optional. This information is useful to soil scientists as well as other users of the soil survey.

P. REFERENCES

References are to be shown in the reference section only. List only the references cited in the text. Previously published soil surveys of the area should always be cited.

Q. GLOSSARY

A glossary is required. The glossary defines terms, words, and phrases in the manuscript that are likely to be unfamiliar to most readers.

R. TABLES

All tables are exact replicas of the tables extracted from the certified data source. No adjustments are made to these reports.

S. ILLUSTRATIONS

Illustrations help convey important facts to readers. They relate specifically to the soils shown on the map and to places within the survey area. Each illustration must be referred to in the text. Photographs and drawings, such as maps, diagrams, and charts, are useful types of illustrations.

644.11 Record Sheet for Collating State Orders for Published Soil SurveysU.S. DEPARTMENT OF AGRICULTURE
Natural Resources Conservation ServiceNRCS-SOI-7
7-96**RECORD SHEET FOR COLLATING STATE ORDERS
FOR PUBLISHED SOIL SURVEYS**

Soil Survey of		COPIES
I. NRCS ORDER		
A. FREE COPIES TO COOPERATING AGENCIES. AGENCY	SHIPPING ADDRESS	
B. COPIES TO BE BOUGHT BY COOPERATING AGENCIES (Attach a signed copy of the purchase agreement) AGENCY		
C. COPIES FOR STATE NRCS OFFICES, STATE OFFICE		
AREA OFFICE		
FIELD OFFICE		
OTHER (specify)		
D. COPIES FOR USE BY NRCS NATIONAL OFFICE		21
E. TOTAL NRCS ORDER. ADD ITEMS I A-D.		21
II. EXTRA SOIL MAP (unbound and printed front only) FOR NRCS.		
A. SETS OF COMPLETE SOIL MAP AS IN PUBLISHED SOIL SURVEY.	SHIPPING ADDRESS	COPIES
B. SETS OF COMPLETE SOIL MAP WITHOUT AERIAL PHOTO BACKGROUND.		
C. SETS OF AERIAL PHOTO BACKGROUND ONLY.		
D. COPIES OF GENERAL SOIL MAP WITH COLOR TINTS.		
E. COPIES OF GENERAL SOIL MAP WITHOUT COLOR TINTS.		
DO NOT WRITE IN THIS BOX TOTAL NRCS (USDA) ORDER FOR GPO: =	SIGNED: STATE CONSERVATIONIST	DATE:
SIGNED AND DATE: _____		

This form was electronically produced by National Production Services Staff

644.12 Example of Letter to Senator – Notification of Availability of Soil Survey

Honorable _____
United States Senate
Washington, DC

Dear Senator _____:

The National Cooperative Soil Survey (NCSS) is a nationwide partnership of federal, regional, State, and local agencies and institutions. Partners in NCSS work together to inventory, document, and interpret the soils of the United States and territories and to disseminate information about the soils.

The Natural Resources Conservation Service (NRCS), an agency of the U.S. Department of Agriculture, is responsible for leadership of the National Cooperative Soil Survey. We have completed a soil survey titled _____. This soil survey is now available at the State office of NRCS in _____ and on the web at <http://soils.usda.gov/survey/>.

Sincerely,

State Conservationist

cc:

_____, Chairperson, _____ Conservation District

Part 647 – Soil Map Development

Subpart A – General Information

647.0 Definition and Purpose

A. Soil map development includes activities related to the preparation and completion of maps for soil survey. The purpose is to provide current and accurate soil maps (digital and analog) and related products to users. Three functional areas describe the major cartographic procedures: imagery acquisition, digital data capture, and digital map finishing. A glossary of terms used in soil map development is present in part 647, subpart B, section 647.15.

B. Imagery Acquisition.—Field mapping for soil survey is performed on an imagery base. Digital soil survey development and publication products utilize digital imagery. A memorandum of understanding (MOU) or long range soil survey plan initiates the acquisition of imagery for mapping and publication. Aerial photography can still be used in completing initial soil survey projects. Hardcopy imagery can also be used as a tool in association with digital imagery.

C. Digital Data Capture.—Field mapping is performed using electronic media and heads-up (on-screen) digitizing. In rare instances mapping on hardcopy aerial photography, which is subsequently compiled to orthophotography, may be allowed when digital imagery is inadequate or when field digitizing tools are not available. This part establishes the standards and specifications for the soil survey map component of the Soil Survey Geographic (SSURGO) database.

D. Digital Map Finishing and Print-on-Demand Maps.—Digital map finishing is the addition of data layers (i.e., transportation, hydrography, and cadastral) to the soils data to generate a print-ready file.

647.1 Procedures and Responsibilities

A. Procedures

- (1) According to NRCS policy (Title 430, General Manual, Part 402, subpart A, section 402.2) National Cooperative Soil Survey activities are guided by cooperative arrangements, such as memoranda of understanding among partners, long range plans for each soil survey office and project plans.
- (2) Soil survey products from new and updated soil surveys are based on soil mapping designed to be used at a 1:24,000 or 1:12,000 scale. Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.
- (3) Soil surveys use the definitions and applications of soil survey features on Form NRCS-SOI-37A from part 627, section 627.14, of this handbook. Definitions of ad hoc features are the responsibility of the soil survey regional office (SSR).
- (4) All new soil surveys must be digitally captured, certified, and maintained in the Soil Data Warehouse. All updated soil surveys will be maintained in the Soil Data Warehouse.
- (5) New and updated soil survey publications utilize digital map finishing. The digital publication format is a 3.75- or 7.5-minute quadrangle.

B. Responsibilities

- (1) The Federal Geographic Data Committee (FGDC) and the Office of Management and Budget (OMB) are formally assigned the responsibility for national coordination of digital soils data

- to NRCS. See the OMB Circular A-16 for more information:
https://www.whitehouse.gov/omb/circulars_a016_rev/.
- (2) NRCS Federal Responsibilities
 - (i) NRCS has the Federal responsibility for the National Cooperative Soil Survey and Federal leadership for collecting, storing, maintaining, and distributing soil information on tribal and privately owned lands in the United States. These activities include—
 - Acquiring base imagery for soil survey mapping.
 - Performing the quality assurance of soil survey maps.
 - Preparing data for publication.
 - (ii) NRCS also has the lead Federal responsibility in collecting, archiving, and distributing the SSURGO database.
 - (3) National Headquarters provides overall direction, policy, guidance, and leadership for the National Cooperative Soil Survey within NRCS. See part 608, subpart A, section 608.1, of this handbook for more detailed information on the responsibilities of National Headquarters and the other NRCS offices mentioned in this section.
 - (4) The National Soil Survey Center is responsible for national standards, databases, training, research, and analysis.
 - (5) The SSR is responsible for providing leadership in the production and quality assurance of soil survey information.
 - (6) The State office is responsible for certifying and posting official detailed soil survey information in the Soil Data Mart.
 - (7) The soil survey office is responsible for conducting quality control of all soil survey activities in the assigned portions of the MLRA soil survey area.
 - (8) The National Geospatial Center of Excellence (NGCE) is responsible for helping coordinate NRCS aerial imagery and LIDAR acquisitions.
 - (9) The digitizing units are responsible for—
 - (i) Coordinating data capture and soil business activities with SSRs to ensure an orderly flow of work for all soil surveys which are to be processed by the unit.
 - (ii) Performing certification review of submitted materials.
 - (iii) Notifying the SSR of any problems discovered during certification review that require action by the SSR prior to certification.
 - (iv) Digitally capturing compiled map materials, including scanning soil lines, labeling, edge matching, and digitizing linear and point features.
 - (v) Performing quality control of final digital data, including spatial and metadata.
 - (vi) Exporting the spatial data to the staging server.
 - (10) The digital map finishing sites (housed under the SSRs) are responsible for—
 - (i) Coordinating digital map finishing activities with SSRs to ensure the orderly flow of work for all digital map finishing projects.
 - (ii) Performing quality control with 100-percent edit.

647.2 Imagery

A. Imagery should be the best available for the soil survey project that meets the National Standard for Spatial Data Accuracy.

B. Initiation of Imagery Acquisition

- (1) Acquisition of imagery for mapping and publication of soil surveys begins before the fieldwork. It starts with a long range plan or an MOU between NRCS and cooperating entities. For more information about the MOU, see part 606 of this handbook. Responsibilities and intentions towards data capture and map finishing are part of a soil survey area MOU or an amendment to an MOU.

- (2) To acquire imagery, use the Geospatial Data Gateway (<https://datagateway.nrcs.usda.gov/>).

C. Imagery Acquisition Assistance. The NGCE is available to assist SSRs in acquiring aerial photography and orthophotography. The NGCE will—

- (1) Provide information on imagery availability.
- (2) Inspect imagery to ensure quality and coverage.

647.3 SSURGO Characteristics

The database consists of—

- (1) Soils mapping using mobile devices, digital orthoimagery, and heads-up (on-screen) digitizing as much as possible to promote efficiency of data capture.
- (2) Mapping on 3.75-minute or 7.5-minute digital orthoimagery quadrangles or compiling onto one of these bases before or during digitizing if the techniques described in paragraph (1) above are not possible.
- (3) Mapping at a 1:12,000 or 1:24,000 scale.
- (4) An approved and signed classification and correlation document and amendments or an approved legend in the National Soil Information System (NASIS) for a progressive soil survey.
- (5) Captured or converted data in a geographic coordinate reference system, decimal degrees map units, and a North American Datum of 1983 (NAD 83) with a Geodetic Reference System of 1980 (GRS 80) spheroid.
- (6) Georeferenced digital spatial data, tabular data, and metadata.
- (7) Spatial data stored in a vector data structure.
- (8) Archiving in a survey area format.
- (9) Maintenance of the digitizing standards and specifications of NRCS.

647.4 Data Capture Specifications

A. Base Map Characteristics

- (1) Maps to be Used.—Imagery should be the best available for the soil survey project that meets the National Standard for Spatial Data Accuracy.
- (2) Scale.—The primary standard is a 1:12,000 or 1:24,000 scale base.
- (3) Reference System.—The horizontal control is the NAD 83 or World Geodetic System 1984 (WGS 84) and is determined by the imagery base.

B. Features to be Captured.—Area soil survey features and linear and point soil survey features are digitized as three separate layers.

(1) Layer 1

Examples of area features are soil and water areas. These features are composed of soil boundary lines or other boundary lines, such as a double line stream or limit of soil survey, that form polygons and occupy area.

(2) Layer 2

- (i) Examples of soil line segments are narrow elongated riparian areas.
- (ii) Examples of soil point features are small circular riparian areas.

(3) Layer 3

- (i) Examples of special linear features are escarpments and gullies.

- (ii) Examples of special point features are landform features, miscellaneous surface features, and ad hoc features (sometimes known as spot symbols). Wet spots, pits, and sinkholes are specific examples of these features.
- (iii) Both linear and point special features represent areas that are too small to be digitized as polygons (area features smaller than 0.5 cm in diameter).

C. Data Capture.—The following standards and specifications apply to soil surveys at scales of 1:12,000 to 1:24,000:

- (1) Data Capture by Heads-Up (On-Screen) Digitizing.—Data capture of all soil survey features (i.e., soil and water boundaries and linear and point features) is performed by heads-up digitizing. Heads-up digitizing uses a data capture device, such as a mouse or stylus, to trace or draw on digital imagery.
- (2) Data Capture by Manual Digitizing
 - (i) Each soil survey feature (i.e., soil and water boundaries and linear and point features) is digitized within a 0.01-inch (0.254-mm) line width of the source document and the centerline of the boundary must be followed.
 - (ii) Geographic control is established using the four corner coordinate values of the 7.5-minute quadrangle or 3.75-minute quadrangle.
- (3) Collective Data Capture Specifications.—The following specifications apply to both heads-up and manual data capture:
 - (i) All beginning and ending points of each digitized line at a common intersecting point (node) must be connected with another soil boundary, water boundary, or limit-of-soil-survey boundary.
 - (ii) Average vertex density (distance between vertices) for soil and water boundaries should be greater than 15 meters.
 - (iii) Straight segments of soil and water boundaries (i.e., survey area boundaries and urban map units) should be represented by no more than two vertices, one at each end of the segment.
 - (iv) All “islands” must be digitized as a continuous line segment with only a beginning and ending node.
 - (v) Each boundary must be represented with no greater number of coordinate pair vertices than is necessary to record the boundaries.
 - (vi) In areas of dense soil and water boundaries, each boundary must have a minimum separation of 1/16 inch (19 ground meters at 1:12,000 or 38 ground meters at 1:24,000) or more at output scale for clarity.
 - (vii) For soil and water boundary editing, zoom in no farther than about twice the publication scale:
 - 1:12,000 for a 1:24,000 scale survey area.
 - 1:6,000 for a 1:12,000 scale survey area.
 - The practical limit of zooming in to edit boundaries is a 1:3,000 scale.
- (4) Spatial Reference
 - (i) The coordinate reference system required for all coordinate data includes—
 - A ground-based system and projection.
 - Horizontal datum, either the NAD 83 that is based upon the GRS 80 spheroid or the WGS 84 that is based on the WGS 84 spheroid.
 - (ii) No x_ or y_ coordinate shifts (offsets) are permitted.
- (5) Spatial Format.—The format is:
 - (i) A geodatabase
 - (ii) Vector structures (i.e., location of lines, points, and area boundaries) that are represented as x, y coordinate pairs

D. Legends

(1) Area Features

- (i) Use the soil map symbols in the legend in the classification and correlation document and amendments.
 - (ii) Permanent water and miscellaneous water will conform to soil map unit labels (i.e., alpha, numeric, or alphanumeric). The use of symbols W and M-W is not required.
- (2) Figure 647-A1 below shows a hypothetical example of an approved correlation legend that uses connotative, alphabetic map unit labels as the publication symbols. Connotative map unit labels are optional regardless of what kind of symbol is chosen.

Figure 647-A1

Publication Symbol	Approved Map Unit Name
ApB	Alpha silt loam, 1 to 3 percent slopes
Ba	Barney loam, very stony
Be	Beta silt loam
Go	Gomer clay, frequently flooded
Md	Madras loamy fine sand
W	Water
We	Wehadkee fine sandy loam

- (3) Linear and Point Soil Map Unit Features.—Use the soil map symbols in the legend in the classification and correlation documents and amendments.
- (4) Linear and Point Special Features.—Digitize the soil survey standard and features identified in this handbook in Part 627, subpart B, section 627.14, Feature and Symbol Legend for Soil Survey, NRCS–SOI–37A, if they are identified in the classification and correlation document and amendments. Ad hoc features follow standard landform and miscellaneous surface features on the legend.
- (4) Figure 647-A2 below shows an example of approved features with the descriptive labels.

Figure 647-A2

Feature Label	Feature Name
CLA	Clay spot
GPI	Gravel pit
ROC	Rock outcrop
SLP	Short, steep slope
STV	Very stony spot

WET	Wet spot
BOG	Areas of acid organics

E. Labeling

- (1) Descriptive Labels.—Label each feature with a descriptive label. The descriptive labels are identical to the map unit symbols in the approved soil classification and correlation document and amendments. They include symbols for map unit delineations, special features, and ad hoc features.
- (2) Label Position.—For area features, position the coordinate point for the map unit label at or near the centroid (i.e., geometric center) of the polygon. Move the coordinate point into the area if the centroid falls outside of the polygon. Centrally locate the coordinate point on the feature.
- (3) Special Labels.—Special labels are listed in the map unit table in NASIS so that a map unit key (mukey) can be generated for them. As such, they will be included in the map unit legend.
 - (i) Label areas not yet mapped or digitized as part of a progressive survey NOTCOM, for not completed.
 - (ii) Label large concrete or riprap-covered dams DAM and large levees LEVEE when unassigned.
 - (iii) Label water areas (ponds and lakes) with an appropriate map unit symbol. They should not be unlabeled.
 - (iv) Label areas that are unmapped because access was denied with any appropriate symbol. See part 608, subpart A, section 608.3, of this handbook for more information on the recommended map unit name for such areas.
 - (v) If the assigned map unit symbols are numeric, then only areas not yet completed (i.e., labeled NOTCOM) would lack a numeric symbol.

F. Spatial Data Files Naming Convention.—These file names are internal. They are utilized by ArcGIS and ArcInfo quality assurance processes. They are not the file names that are distributed by the Soil Data Mart that meet the Standard for Geospatial Dataset File Naming.

The naming convention for SSURGO spatial files is the two-letter State FIPS code followed by a three-digit soil survey area number. An example of the soil polygon coverage name for Henry County, VA, is VA089_a. Each geospatial layer has its own designation:

- (i) a – soil polygon
- (ii) b – soil survey boundary
- (iii) c – linear soil map unit
- (iv) d – point soil map unit
- (v) l – linear special feature
- (vi) p – point special feature
- (vii) q – quadrangle

G. Tabular Attribute Data

- (1) Current and accurate tabular data are present in the soil classification and correlation document and amendments, and they are identical to the data downloaded for use in the Field Office Technical Guide. The reliability of the individual data elements and tables are to be addressed in the metadata file if necessary.
- (2) The exportcertdate column in the distlegendmd “Map Unit Record” table is defined as the mm/dd/yyyy that the data for the soil survey area was certified by the SSR as edited and

available for public use. This column must be populated when submitting the tabular data. This is essential for dating the tabular data, which are periodically updated.

- (i) Map Unit Record Database.—Each map unit symbol contained in the spatial data must have a matching symbol in NASIS. It is acceptable for extra symbols to be in the NASIS data that are not in the spatial data.
- (ii) Special Features.—Prepare and archive a soil survey features file for the SSURGO database. The name of the file will be “feature.” The format is a variable record length ASCII text file. The first row contains the name of each column, feat_label, feat_name, and feat_desc. The second row contains at least one dash underneath each column name. Tabs separate the column names and dashes. A return character is at the end of each of these rows. Delimit each subsequent row by a return character and form a record in the table. A row consists of tab-delimited columns. Each row has the same number of columns as the file header (first two rows). The file contains a descriptive label, feature name, and definition for each linear and point soil survey feature and ad hoc feature in the legend.

H. Metadata

- (1) The SSURGO product is a combination of both spatial and tabular data. FGDC-compliant metadata exists for the spatial and tabular data. Both static and dynamic metadata exist for the tabular component.
- (2) Metadata provide information about the content, quality, condition, and related characteristics of data; information about the SSURGO database holdings to data catalogues, clearinghouses, and brokerages; and information needed to process and interpret SSURGO data received through a transfer either by media or the Internet.
- (3) Submit metadata with the SSURGO spatial data for archiving in the Soil Data Warehouse. The template in part 647, subpart B, section 647.16, is used to create metadata. The name of the metadata file in the SSURGO database is the area symbol for the soil survey area to which the dataset applies. The extension will be “met.” For example, va089.met is the name of the metadata file for Henry County, VA.

I. Quality Control

- (1) Quality control of soil surveys and their digital products is the responsibility of the office doing the work. The SSR provides quality assurance for the soil survey process.
- (2) The digitizing units perform quality control on the digital survey.

J. Quality Assurance

- (1) The SSR is responsible for the overall technical accuracy of soil surveys.
- (2) The NGCE provides assistance to the SSR on quality assurance review of digital soil surveys.

647.5 Archiving

The certified or updated soil survey information is permanently archived in the Soil Data Warehouse and then utilized by a variety of applications. The following conditions must be met for data to be uploaded to the staging server and then committed by the State soil scientist to the Soil Data Warehouse:

- (1) The digitizing units must have a signed certification letter for surveys that have not previously been archived in the Soil Data Warehouse.
- (2) The data must be converted to an ArcInfo coverage format.
- (3) The reference system must be projected to (if needed) the geographic coordinate system, NAD 83 datum, GRS 80 spheroid, and decimal degree map units.

- (4) A soil map unit polygon coverage and the soil survey boundary coverage must be present and correctly named.
- (5) A metadata file, correctly named, must be present.
- (6) The data must be zipped.

647.6 Digital Map Finishing and Print-on-Demand Maps

A. General

- (1) The Digital Map Finishing and Print-on-Demand Maps (DMF–PODM) process replaces the previous digital map finishing method. The new DMF–PODM process uses ArcMap Version 9.3.1 (or later) and Maplex for ArcGIS. The Digital Map Finishing and Print-on-Demand Maps User Guide provides instruction for the new process.
 - (i) Users should adhere to all specifications cited in Part 647, subpart B, section 647.12, “Digital Map Finishing and Print-On-Demand Maps Specifications,” and the user guide.
 - (ii) Contact the NGCE for a copy of the user guide.
 - (iii) See the overview of the Digital Map Finishing and Print-on-Demand Maps process in Part 647, subpart B, section 647.11, “Digital Map Finishing and Print-on-Demand Maps Flowchart.”
- (2) SSRs are responsible for performing digital map finishing. The NGCE provides technical assistance for digital map finishing. The NGCE performs a limited number of digital map finishing projects upon request from the State soil survey office.
- (3) Form NRCS–SOI–37A (see part 627, subpart B, section 627.14, of this handbook) in the classification and correlation document identifies the features that will appear in the soil survey publication. Only map finish the items indicated on this approved form.

B. Quality Control and Quality Assurance.—The SSR are responsible for digital map finishing and its quality control and assurance (data accuracy and DMF–PODM specifications are in Part 647, subpart B, section 647.12). State offices may agree to share this role. The NGCE provides DMF technical assistance to the SSRs. The NGCE also ensures adherence to the DMF–PODM specifications.

- (1) The SSR is responsible for developing DMF–PODM products and ensuring a 100 percent quality control edit before the PDFs are created. A digital map finishing checklist is provided in part 647, subpart B, section 647.13.
- (2) The SSR will provide three PDFs (one sheet should include the limit of soil survey) to the NGCE to ensure adherence to the DMF–PODM specifications. The NGCE will notify the State and SSR of their findings.
- (3) The PDFs created receive a 100-percent quality assurance review. When the corrections are made, the final PDFs are returned to the SSR for certification. See Part 647, Subpart B, Section 647.14, “Digital Map Finishing Certification.”
- (4) The SSR director signs the digital map finishing certification letter and ships the digital data files (file geodatabase, .mxd, .eps, and .pdf files) to the NGCE for archiving.

C. How Data Are Obtained

DMF–PODM data can be obtained by downloading digital files from the Geospatial Data Gateway. The Digital Map Finishing and Print-on-Demand Maps User Guide contains additional information for attaining data.

D. Data Themes

- (1) Data themes available for the DMF–PODM process are SSURGO, Dynamap (TeleAtlas), National Hydro Dataset, Quad Index, Public Land Survey System (PLSS), Geographic

- Names, and Digital Raster Graphics (DRG). The National Agricultural Imagery Program (NAIP) imagery and ShadedRelief (Hillshade) imagery are captured from the NGCE Image Server. Other digital imagery may be used if FGDC standards are met.
- (2) Files provided by the NGCE (administrative privileges will be required to load fonts).
- (i) Fonts
- NRCS-adhoc.TTF
 - NRCSP____.TTF
 - NRCSS____.TTF
 - The DMF–PODM specifications (see Part 647, subpart B, section 647.12) prescribe font style and sizes for specific map elements in order to maintain uniformity for all soil survey maps. Specific fonts (arial and times new roman) are used for soil labels, place names, culture and hydrographic feature names, margin information, etc.
- (ii) Style Sheet (NRCS SSURGO.style)

To maintain consistency for map elements across map sheets undergoing digital map finishing, a style sheet is used. Stored in the ArcMap DMF tools folder, the style sheet employed in the DMF–PODM method for soil surveys is named NRCS SSURGO.style. The style sheet ensures that cultural and hydrographic point and line features are rendered the same way on different soil surveys.

- (iii) Templates.—NGCE templates include the `dmf_template_12k.mxt` (quadrangle template), `dmf_template_24k.mxt` (quadrangle template), and `dmf_template_63.mxt` (1:63,360 quadrangle template). To minimize user input and create a consistent map finishing product, the templates must be used for the DMF–PODM process. The digital map finishing templates include the following information:

Note: All measurements cited are approximate. Do not adjust these elements on the templates.

- Agency Name.—The agency name is located in the upper left corner of each map, 0.5 inch below the map margin. Indicate as—
UNITED STATES
DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
- Soil Survey Area Name.—The soil survey area name is located in the upper right corner of each map, 0.7 inch above the map neat line and 0.5 inch below the map margin. The soil survey area name is also located in the lower right corner of each map, 0.5 inch below the map neat line and 2.1 inches above the map margin.
- Quadrangle Name.—The U.S. Geological Survey (USGS) quadrangle name is located in the upper right corner of the map, 0.5 inch above the map neat line and 0.7 inch below the map margin.
- Quadrangle Sheet Number.—The map sheet number is located in the upper right corner of the map, 1 inch below the map neat line and 1.7 inches above the map margin.
- Bar Scale Information.—Three separate bar scales are located in the lower center of each map. The first bar scale represents the mile increment, about 1 inch below the map neat line. The second bar scale represents the kilometer increment, 0.5 inch below the first scale. The third bar scale represents the foot increment, 0.5 inch below the second scale.
- Map Scale Information.—The map scale is located in the lower center of the map below the bar scales. Most scales are 1:12,000 and 1:24,000.

- Source Note Information.—Each map requires a source note in the lower left corner of the map, 0.2 inch below the map neat line. The lower limit must not exceed 2.2 inches below the map neat line (0.5 inch above the map margin). The note references contributors to the soil survey program and identifies the imagery date.
 - This soil survey map was compiled by the Natural Resources Conservation Service, U.S. Department of Agriculture.
 - Aerial imagery from the National Agriculture Imagery Program (NAIP), 2008 to present.
 - National Hydrography Dataset (NHD) and cultural features derived from data provided by the Department of the Interior-USGS.
 - North American Datum of 1983 (NAD 83), Universal Transverse Mercator (UTM) coordinate system.
- Adjoining Sheet Names.—The “Joins Sheet” notes are used to identify adjacent quadrangle names. Eight adjoining sheet names are prepositioned at the appropriate locations on the template.
- State Coordinate Ticks and Values (optional).—Position the tick values in 1,000-meter increments. Orient the values horizontally.
- Geographic Coordinate Ticks and Values.—The geographic coordinate values are indicated as latitude and longitude in the degree, minute, second format in each map corner. The coordinate values are 15-minute, 7.5-minute, and 3.75-minute.
- North Arrow.—A north arrow is displayed between the source note and scale bar, 5.5 inches from the left side of the map neat line.
- Soil Survey Area Information.—The State and county information is located in the lower right corner of each map below the map neat line. The State and county information is also located in the upper right corner of the map.
- Map Projection Information.—All map projection information is indicated in the source note. The map projection includes the UTM coordinate system, zone, and datum. The datum is the same for all maps within a survey area.
- Index Map-Quadrangle Index.—Position the index map-quadrangle index at the bottom of the map and center between the scale bar and the soil survey area name.

E. Digital Map Finishing and Print-on-Demand Maps Specifications

- (1) Base map requirements for digital map finishing are the same as those for SSURGO digitizing. See section 647.4 for these requirements. The SSR reviews and certifies all digital map finishing.
- (2) Acquire digital data layers from the Geospatial Data Gateway and other Federal geospatial data portals as needed. Create a file geodatabase and import all digital data themes needed for digital map finishing.
- (3) All digital map finishing work must meet the proper density, line widths, symbol, font styles, and sizes as stated in the Digital Map Finishing and Print-on-Demand Maps User Guide and in Part 647, subpart B, section 647.12 “Digital Map Finishing and Print-on-Demand Maps Specifications.”

F. Data Files

- (1) Culture.—Cultural information including political and administrative boundaries, transportation, buildings, structures, and public land survey are displayed in black on the publication maps.
- (2) Priority.—When two or more boundaries fall in the same location, figure 647-A3 shows the priority for symbolizing these features.

Figure 647-A3

Priority	Feature
1	Road
2	National
3	State
4	County or parish
5	Reservation (national, State forest, or park)
6	Limit of soil survey
7	Minor civil division
8	Public land survey system
9	Neat line

- (3) Soils.—Soil information includes the soil delineations, soil labels, and standard landform and miscellaneous surface features certified as SSURGO.

- (i) Soil Polygons.—Soil delineations include all linear and point soil delineations as well as soil and miscellaneous areas, such as gravel pit areas; water areas; miscellaneous water areas, which are further identified as sewage lagoons and filtration ponds; and double line streams and canals.

Note: Use the same color (RGB) for all polygons and labels throughout the survey area.

- (ii) Soil Labels.—The digital map finishing application places one soil label in each soil polygon, horizontally and near the geometric center of the soil delineation. Additional labels can be added as needed.

- Ensure soil labels do not touch or extend across soil boundaries or other map features.
- Soil labels that do not fit horizontally within the soil delineation will require rotating or leading.
- Where the soil polygon is too small to contain a label, place the label outside of the delineation and use a leader extending into the polygon.
 - A leader normally should not cross more than one soil line except where unavoidable.
 - The ends of the leader must not touch the soil label or any other map element within the soil area.
- Soil polygons longer than approximately 3 inches in any direction may require more than one soil label.
- In elongated or narrow areas, place soil labels as needed to maximize clarity.
- If using a hydro layer with blue line symbols, it is permissible for the soil label to overlap the line feature to avoid using a leader.

- (4) Hydrography.—Hydrographic information includes water bodies, streams, ditches, flood pool boundaries, springs, and wells. Streams less than 0.5 inch in length are not shown except where connected to map neat lines that extend onto the adjacent map.

Hydrographic Features:

- Streams.—Label stream names. Place double line stream names between shores where overprinting will not occur. Place type for linear features on the upper side aligned with the general direction of the feature. Place names on the same side and align to fit the feature. Some features may require more than one label or different sized labels. Place word components in uncluttered areas wherever possible.
 - Other Hydrographic Features.—Label other hydrographic features, if needed; for example, ponds, lakes, and reservoirs.
- (5) Annotation.—Annotation includes soil labels and the proper names of cultural, hydrographic, and hypsographic features. The USGS digital raster graphics files (DRGs) are used for guidance in determining the names and locations of all annotation, excluding the placement of soil labels. Position annotation to read from left to right or from bottom to top (except where a feature is at an angle of more than 90 degrees, causing annotation to appear upside down). Align with the general shape of the feature it represents, unless specified to be placed horizontally. Where letter spacing is preferred for effective presentation of feature names, space the letters proportionately across the feature area. Avoid placing annotation over other features wherever possible.
- (i) Public Land Survey System (PLSS).—Label township and range identifications along the soil survey area boundary or outside the map neat line. Identify all land division sections within the interior of all maps. Adjust the section numbers to avoid overprinting other map elements.
- (ii) Boundary Identifications
- Soil Survey Boundaries.—Identify all national, State, county or parish, and limit-of-soil-survey boundaries, and place the labels parallel to the boundary line. The soil survey area boundary options are county or parish boundary, State or national boundary, and limit of soil survey.
 - Identify limit-of-soil-survey boundaries only when they do not correspond with national, State, or county or parish boundaries. Label them “LIMIT OF SOIL SURVEY.”
 - If the proper name of a reservation, forest, or national or State park does not appear in the interior of the map, identify the boundary with its proper name, such as “ROSEBUD INDIAN RESERVATION.”
 - For surveys that coincide with counties, parishes, or MLRAs, label names of adjacent counties and parishes along the outside edge of the soil survey boundary parallel to the boundary. Where the survey joins another State, label the adjacent State name along with the adjacent county and parish names.
 - Where the survey adjoins another nation, label the national name and its provincial name along the national boundary.
 - For survey areas that contain more than one county or parish or portions of counties or parishes and have county or parish (or State) boundaries within a survey area, label counties, parishes, and States as they occur on each side of the State boundaries. Label more than once where boundaries are meandering or difficult to follow.
 - Political and Administrative Boundaries.—Label text for national or State parks, forests, and reservations parallel to the boundary line symbol.
- (iii) Transportation
- Road Emblems.—Identify interstate, Federal, State, and other roads by placing route emblems as needed on the map. Place emblems horizontally. Place the emblem directly on the feature. Where roads continue on adjoining maps, place the emblems close to the map neat line. Identify county highways and other roads as needed.
 - Railroads.—Place the name directly on the feature. Abbreviate the names as needed.

- (iv) Geographic Names Information System (GNIS) – Populated Places.—Label cities, towns, and other populated areas horizontally. Annotation sizes should be used to distinguish priorities.
 - (v) GNIS – Nonpopulated Places
 - Airports and Schools.—Label airports and schools horizontally.
 - Churches and Cemeteries.—Label churches and cemeteries horizontally.
 - (vi) Hypsographic Features.—These include mountain ranges, ridges, peaks, knobs, buttes, hills, canyons, bluffs, plateaus, sinks, summits, gaps, mesas, plains, prairies, passes, reefs, valleys, hollows, meadows, gulches, deserts, washes, faults, escarpments, islands, peninsulas, arroyos, capes, points, landings, beaches, and basins.
- G. Spatial Data Format.—The format is:
- (1) A geodatabase
 - (2) Vector structures (i.e., location of lines, points, and area boundaries) that are represented as x, y coordinate pairs
- H. Encapsulated Postscript Files
- The encapsulated postscript files will serve as master files for each of the map sheets. The average file size for a 3.75-minute quarter quadrangle is 100 megabytes. A 7.5-minute full quadrangle will average about 300 megabytes in size. Adobe Acrobat PDFs will be generated from this file for web delivery, CD production, or printing.
- I. Delivery Formats
- (1) Zip the primary DMF folder (State soil survey area id – STSSAID). This folder should include the .mxd, .eps, and .pdf files and the file geodatabase.
 - (2) The DMF–PODM files will be retrieved from the incoming site and stored on DVDs for long-term storage.

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Note: Adobe and Acrobat are either registered trademarks or trademarks of Adobe Systems Incorporated in the United States, other countries, or both.

Title 430 – National Soil Survey Handbook
Part 647 – Soil Map Development
Subpart B – Exhibits

647.10 Soil Survey Geographic Data Certification

EXAMPLE – Modify to fit the survey.

SPATIAL DATA

1. Digitizing meets NRCS standards and specifications as described in Section 647.4 of the National Soil Survey Handbook (NSSH).
2. Quality control included a _____ (100% edit by MLRA soil survey office, for example).
3. Quality assurance included _____
_____[Edits by the MLRA regional office], for example].
4. Soil and survey boundaries are digitized within a _____ [0.01-inch (0.254-mm), for example] line width of the published or revised soil survey.
5. Where a soil area boundary line intersects a quadrangle boundary, the line matches the line in the adjoining quadrangle within 0.01 inch (0.254 mm) measured centerline to centerline.
6. Map data are stored in a _____ (vector, for example) format.
7. Map data have been uploaded to the Soil Data Warehouse for archiving.

ATTRIBUTE DATA

1. Database tables are current and accurate.
2. .

METADATA

The metadata template has been completed and uploaded to the Soil Data Warehouse for archiving.

I certify that the data have passed a 100 percent edit.

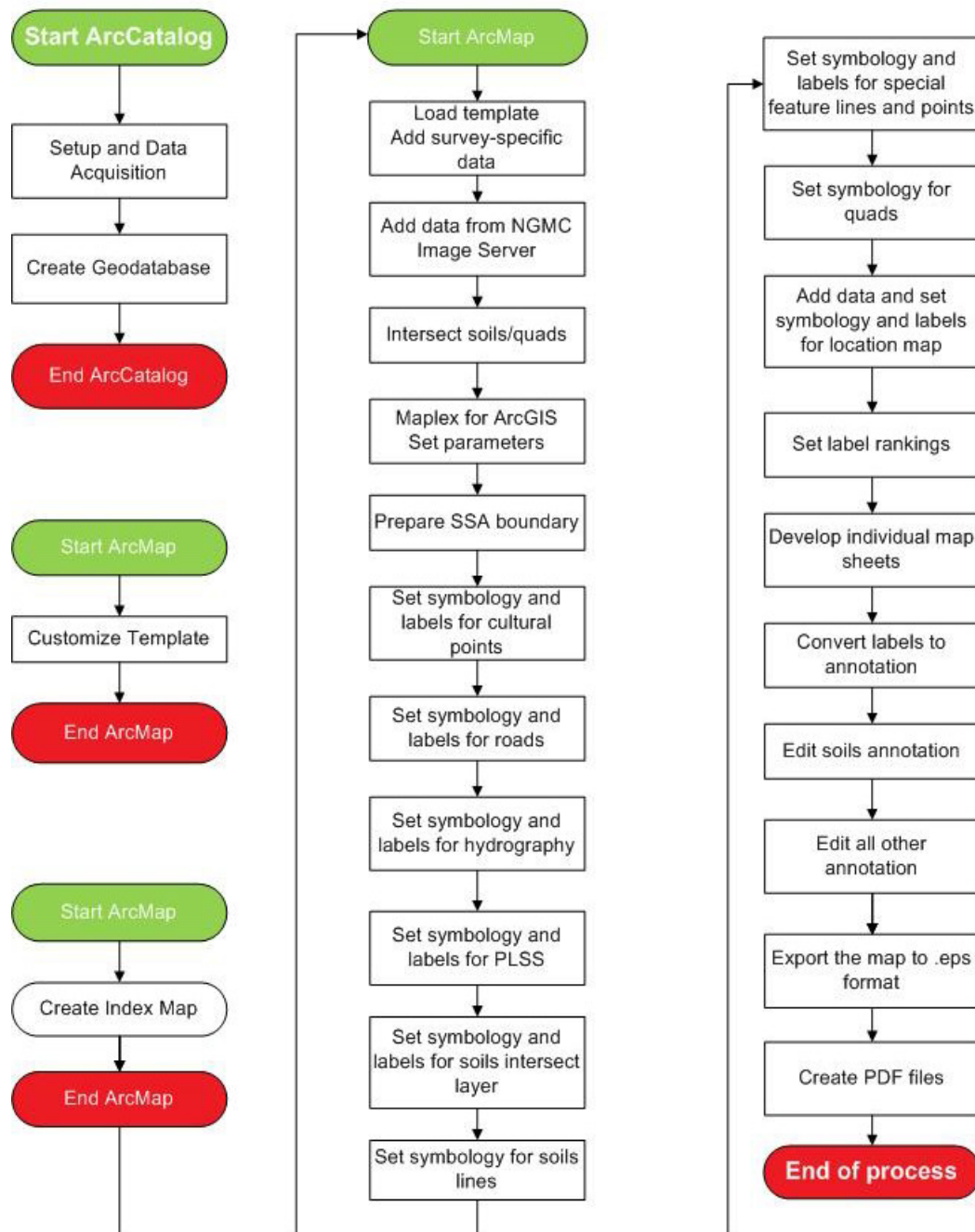
Soil Survey Regional Director

Date

MLRA Regional Office Leader

Date

647.11 Digital Map Finishing and Print-on-Demand Maps Flowchart



647.12 Digital Map Finishing and Print-on-Demand Maps Specifications

The new Digital Map Finishing and Print-On-Demand Maps (DMF–PODM) process uses ArcMap™ Version 9.3.1 with the Maplex for ArcGIS® extension.

(Note: All measurements cited are approximate. Do not adjust these elements on the templates.)

DMF–PODM Template

Agency Name

Location: Upper left corner of map, 0.5 inch below map margin.

Text: color = black (R–0, G–0, B–0); font size = 10; font = Times New Roman (uppercase)

Soil Survey Area Name

Location: Upper right corner of map, 0.7 inch above map neat line and 0.5 inch below map margin. Also located in lower right corner of map, 0.5 inch below map neat line and 2.1 inches above map margin.

Text: color = black (R–0, G–0, B–0); font size = 10; font = Times New Roman (uppercase)

Quadrangle Name

Location: Upper right corner of map, 0.5 inch above map neat line and 0.7 inch below map margin.

Text: color = black (R–0, G–0, B–0); font size = 10; font = Times New Roman (uppercase)

Quadrangle Sheet Number

Location: Upper right corner of map, 0.3 inch above map neat line and 1 inch below map margin. Also located in lower right corner of map, 1 inch below map neat line and 1.7 inches above map margin.

Text: color = black (R–0, G–0, B–0); font size = 10; font = Times New Roman (uppercase)

Bar Scale Information

Three separate bar scales are located in the lower center of each map as follows:

- The first bar scale represents the mile increment, about 1 inch below the map neat line.
- The second bar scale represents the kilometer increment, 0.5 inch below the first scale.
- The third bar scale represents the foot increment, 0.5 inch below the second scale.

Map Scale Information

Location: Lower center of map below bar scales.

Map scale: 1:12,000, 1:24,000; other scales may be used in special circumstances

Text: color = black (R–0, G–0, B–0); font size = 10; font = Arial (uppercase)

Source Note Information

Location: Lower left corner of map, 0.2 inch below map neat line. Lower limit not to exceed 2.2 inches below map neat line (0.5 inch above map margin).

Text: color = black (R–0, G–0, B–0); font size = 8; font = Times New Roman (uppercase and lowercase)

Adjoining Sheet Names

Location: Four adjoining sheet names positioned at the map corners, at a 45-degree angle and within 0.25 inch from map neat line corner. Four additional adjoining sheet names (two parallel and two perpendicular) positioned at map centers and within 0.2 inch from map neat line.

Text: color = black (R–0, G–0, B–0); font size = 6; font = Arial (uppercase and lowercase)

State Coordinate Ticks and Values (optional)

Location: Along the map neat line in 1000-meter increments. Values oriented horizontally.

Text: color = black (R–0, G–0, B–0); font size = 6; font = Arial (uppercase)

Geographic Coordinate Ticks and Values

- The geographic coordinate values are indicated as latitude and longitude at each map corner.
- The coordinate values are 15-minute, 7.5-minute, or 3.75-minute. For 7.5-minute quadrangle format maps, coordinate values representing the 2.5-minute ticks are represented.

North Arrow

A north arrow is displayed between the source note and scale bar, 5.5 inches from the left side map neat line.

Soil Survey Area Information

Text: color = black (R-0, G-0, B-0); font size = 10; font = Times New Roman (uppercase)

Map Projection Information

- Universal Transverse Mercator (UTM), North American Datum of 1983 (NAD 83).
- World Geographic System Datum of 1984 (WGS 84).
- The digital map finishing template is set to UTM projection with GRS 80 spheroid and NAD 83 datum.

Index Map – Quadrangle Index

Location: At the bottom of the map, centrally between the scale bar and the soil survey area name.

Line Symbol: fill color = no color; outline color = black (R-0, G-0, B-0); line width = 0.4

Text: color = black (R-0, G-0, B-0); font size = 4 to 6; font = Arial (uppercase)

Data Layers

Geographic Area Names – Populated Places

Point Symbol: color = no color; size = 0

Text: color = black (R-0, G-0, B-0); font size = 8 to 10; font = Times New Roman (uppercase and lowercase)

Geographic Area Names – Non-Populated Places

Point Symbol: color = no color; size = 8

Text: color = black (R-0, G-0, B-0); font size = 8; font = Arial (uppercase and lowercase) or Times New Roman (uppercase and lowercase)

Hypsographic Features

Text: color = black (R-0, G-0, B-0); font size = 6 to 16; font = Arial (uppercase and lowercase)

Road Names

Text: color = black (R-0, G-0, B-0); font size = 7; font = Arial (uppercase)

Road Emblems

Line Symbol: color = no color

Text: For U.S. Interstate HWY: color = white (R-255, G-255, B-255); font size = 7; font = Arial bold (uppercase).

For U.S. Route HWY and State Route HWY: color = black (R-0, G-0, B-0); font size = 7; font = Arial bold (uppercase)

Hydrography Points/Lines

Point/Line Symbol: color = cyan (R-0, G-255, B-255); point size = 10; line width = 0.25 to 0.65

Text: color = cyan (R-0, G-255, B-255); font size = 6 to 16; font = Times New Roman italic (uppercase and lowercase)

PLSS

Line Symbol: line color = light green (R-170, G-255, B-0); fill color = no color; line width = 0.2

Text: color = light green (R-170, G-255, B-0); font size = 12; font = Arial (uppercase)

Soil Boundaries

Line Symbol: fill color = no color; outline color = black (R-0, G-0, B-0) or amber (R-255, G-190, B-0); line width = 0.5 to 1.0

Political/Administrative Boundaries

Location (Text): Parallel to the boundary line symbol, 0.2 inch above line. There is a 0.3-inch space between boundary name word components and a 1-inch space between county/parish or MLRA name and State name word components.

Line Symbol: fill color = no color; outline color = black (R-0, G-0, B-0); line width = 1.0

Text: color = black (R-0, G-0, B-0); font size = 8; font = Times New Roman (uppercase)

Political/Administrative Areas – Map Interior

Line Symbol: fill color = no color; outline color = black (R-0, G-0, B-0); line width = 1.0

Text: color = black (R-0, G-0, B-0); font size = 12; font = Times New Roman (uppercase)

Soil Labels (Soil Intersect Layer)

Line Symbol: fill color = no color; outline color = no color

Text: color = black (R-0, G-0, B-0) or amber (R-255, G-190, B-0); font size = 6 to 8 (default = 8); font = Arial (uppercase and lowercase)

Soil Leaders

Line Symbol: color = black (R-0, G-0, B-0); line width = 0.005 inch

Special Feature Points/Lines

Point/Line Symbol: color = magenta (R-255, G-0, B-200); point size = 10; line size = 8

Index Map – Quadrangle Index

Location: The bottom of the map, centrally between the scale bar and the soil survey area name.

Line Symbol: fill color = no color; outline color = black (R-0, G-0, B-0); line width = 0.4

Text: color = black (R-0, G-0, B-0); font size = 4 to 6; font = Arial (uppercase)

Index Map – Limit-of-Soil-Survey Boundary

Location: The bottom of the map, centrally between the scale bar and the soil survey area name.

Line Symbol: fill color = no color; outline = red (R-255, G-0, B-0); line width = 0

647.13 Digital Map Finishing Checklist

Soil Survey Area Name: _____

Publication Map Sheet Number _____ of _____

Field Sheet Numbers: _____

USGS Quadrangle Name: _____

Scale: 1: _____

UTM Zone _____ and Datum _____

SW Corner Coordinate Values Lat. ____/____/____, Long. ____/____/____

Editor's Name: _____

Adjoining Sheet Number and Quadrangle Name:/Date Match Completed:

North: _____

East: _____

South: _____

West: _____

___ All features join from map to map

Marginalia

- ___ Join notes are present and correct
- ___ Range and township values are present and correct
- ___ Soil survey area title is correct and accurately placed
- ___ Publication sheet number is correct
- ___ Source note is accurate and correctly located

Culture

- ___ All cultural features appearing on the check maps are approved in Form NRCS–SOI–37A and are the correct symbol and line weight
- ___ All boundaries are indicated in the appropriate line symbol
- ___ All road emblems are correct and accurately placed
- ___ Section lines and numbers have been correctly indicated
- ___ All cultural features match the publication imagery

Hydrography

- ___ All hydrographic features appearing on the check maps are approved in Form NRCS–SOI–37A and are the correct symbol and line weight
- ___ All hydrographic features match the publication imagery
- ___ Hydrographic features do not coincide with other publication features
- ___ All lines are complete without skips or overshoots

Soils

- ___ Soil data is derived from a copy of the certified Soil Survey Geographic Database (SSURGO)
- ___ Soil labels are legible and placed horizontally where space permits
- ___ All soil lines are complete without skips or overshoots
- ___ All leaders are properly positioned to ensure correct association with the soil unit they represent
- ___ Soil lines and labels do not coincide with other features
- ___ All water polygons are labeled with the appropriate soil map unit label

Text

Title 430 – National Soil Survey Handbook

- ___ All text is correctly spelled and placed in the correct location
- ___ All text is in the appropriate font style and size for all named features

Materials

The following materials are available:

- ___ Check plots of each publication map with correct features
- ___ Index to publication maps
- ___ Final correlation document
- ___ All source material needed for review
- ___ Encapsulated postscript (.eps) files and PDFs
- ___ All DMF–PODM specifications have been adhered to (see Part 647, Subpart B, Exhibits, Section 647.9 of the National Soil Survey Handbook)

647.14 Digital Map Finishing Certification

Soil Survey Area Name: _____

Digital Map Finishing

1. The map finishing was performed according to the NRCS specifications as described in Part 647, Subpart A, Section 647.6 of the National Soil Survey Handbook (NSSH) and the Digital Map Finishing and Print-on-Demand Maps User Guide (2010).
2. The soil data are derived from the certified Soil Survey Geographic Database.
3. A 100 percent edit has been completed.

I certify that all of the above statements are true.

Soil Survey Regional Director

Date

647.15 Glossary

Ad hoc features	Ad hoc features are special surface soil features that are too small to delineate at the mapping scale but are large enough and contrasting enough to significantly influence use and management. Ad hoc features are not mapped when the feature they represent is a common component in the map unit. Features that are common components in the map unit should be named, described, and located on the landscape in the map unit description. When mapped, ad hoc features are represented as points or lines.
Annotation	Information or markings on a map for clarification, such as numbers, letters, symbols, and signs.
Approved symbols	Soil survey, cultural, and hydrographic features that have been approved and certified during progressive or final correlation.
Attribute	A characteristic of a geographic feature. Attribute data are linked or related to a feature by an identifier. For example, a soil symbol is linked to an attribute that describes the percentage of slope for the map unit area.
Base map	A map showing background reference information (landforms, roads, boundaries, etc.). Other data themes can be placed on top of the base map.
Coinciding features	Any features that occupy the same place in space.
Compilation	The production of a new map from existing maps, aerial photographs, surveys, new data, and other sources. The new map is generally a geodetically controlled map.
Compilation bases	Base maps, to which previously collected data is transferred, used for map finishing or digitizing. They are generally digital orthoimagery or rectified photographs.
Conventional features	Natural or manmade objects or situations that are represented graphically with standard symbols that are adopted by Federal mapping agencies. These features are referred to as cultural and hydrographic features.

Coordinate pair	A set of Cartesian coordinates describing the two-dimensional location of a point, line, or polygon feature in relation to the common coordinate system of the database.
Cultural features	Any feature created or modified by humans.
Digital	Of or relating to data in the form of numerical digits in binary form.
Digital Map Finishing and Print-on-Demand Maps (DMF-PODM)	A new digital map finishing process that uses ArcGIS/ArcMap and the Maplex extension.
Digital orthoimagery	An image in which individual parts have been shifted to correct displacements caused by tip, tilt, and relief.
Digital orthoimagery quadrangle	Maps prepared from high-resolution aerial photographs that are corrected to eliminate the displacements of perspective, camera tilt, and terrain relief. They are scale true, meet national map accuracy standards, and permit accurate linear or area measurements.
Digital Raster Graphic (DRG)	A raster image of a scanned USGS standard series topographic map.
Digitizing	The process of converting information shown on an analog map into a digital format of x and y coordinates for use in a computer.
Edge matching	An editing procedure which ensures that all features crossing adjacent map sheets have the same edge locations, attribute descriptions, and feature classes.
Export	The process of transferring data or software from one system to another system.
Feature	A representation of a geographic entity, such as a line, point, or polygon.
Field mapping imagery	Rectified or unrectified aerial photographs used for mapping soils or other land features in the field. Field mapping media is generally a paper print with a surface which will take pencil or ink. Sometimes referred to as field map sheet.

Field sheet	Any kind of map provided to field personnel for use in recording collected data. Generally, these are photographs of various kinds, including mosaics, unrectified and rectified digital orthoimagery graphs, and high- or low-altitude flights in varying formats, sizes, and scales.
Geodatabase	A container used to store, query, and manipulate spatial and attribute data.
Geographic Information System (GIS)	A combination of software, hardware, data, and people used to input, store, manipulate, analyze, and display geographically referenced spatial and associated attribute information.
Geographic coordinates	A spherical coordinate system used to define the position of points on the Earth.
Georeference	The process of establishing the relationship between page coordinates on an analog map and known real-world coordinates.
Heads-up digitizing	Manual digitization by tracing a mouse or using a stylus over features displayed on a computer monitor.
Hydrography	The science of the measurement, description, and mapping of the surface water of the Earth.
Index map	Maps that show the location or coverage of other maps. Examples are the soil survey map sheet index and the USGS topographic quadrangle index.
Index to field map sheets	A map of a smaller scale on which is depicted the location of field map sheets. It is used for locating field map sheets and referencing the publication map sheets.
Label	A description of a feature.
Leaders	A short line pointing to a label. Used to lead the eye across a space too small or narrow to contain the label.
Limit of soil survey	A boundary that marks the extent of soil survey mapping in a soil survey area. A soil survey area is usually a county, but it may consist of multiple counties or parts of counties or coincide with other political boundaries, physiographic boundaries, or general land office survey sections.
Line	A set of ordered coordinates that represents the shape of a geographic entity too narrow to be displayed as an area.

Manual digitizing	The process of converting an analog map or other graphics display into a digital format with the use of a digitizing tablet and the manual entry of coordinates with a cursor.
Manuscript	Synonymous with document.
Map finishing	The final transfer of all map features to publication format by either manual (scribing) or digital (plotting) methods. The end products of the process are press-ready film negatives.
Metadata	Information about the content, quality, condition, and other characteristics of data.
NAIP	National Agriculture Imagery Program. It provides aerial digital orthoimagery to the Federal government and public. It is administered by the Farm Service Agency's Aerial Photography Field Office.
Neat line	The line surrounding or limiting the image area of the map.
Negative	Film containing an image in which the values of the original are reversed so that the dark areas appear light and vice versa.
Node	The beginning or ending location of a line; the location where lines connect or the location where lines intersect.
Nominal scale	The actual scale (with no rectification) at which photography is flown.
Planimetric map	A large-scale map in which all features are projected perpendicularly onto a horizontal datum plane so that horizontal distances can be measured on the map with accuracy.
Public Land Survey System (PLSS)	A method used in the United States to locate and identify land, particularly for titles and deeds of farm or rural land. Its basic units of area are the township and section.
Point	A single x, y coordinate for a geographic feature too small to be represented as an area or line.
Polygon	A closed area that is described by a string of coordinates that represent the boundary of the area. The beginning and ending points are the same. A series of attributes are usually assigned to the set of boundary coordinates that make up the unit.

Publication index	A map developed using a county highway map as a base which depicts the layout of a soil survey's map sheets; an index to map sheets for publication. It generally includes the publication sheet numbers that are referenced with topographic quadrangles and longitude and latitude graticules.
Raster	A regular grid or array of cells covering a spatial area. A raster is often viewed as consisting of rows and columns of grid cells.
Raster scanning	See Scanning.
Raster digitizing	See Scanning.
Resolution	The accuracy at which the location and shape of map features can be depicted for a given map scale.
Scale	The relationship between a distance on a map and the corresponding distance on the Earth.
Scanning	The process of using a device, generally referred to as a scanner, to capture a raster copy of a map in a digital bitmap or binary format and then saving the copy in a computer-readable file. This process is also an approach to convert black-and-white or color aerial photography into a digital format depicting up to 256 shades of gray or a nearly infinite number of color shades and hues.
ShadedRelief (Hillshade)	An elevation data (derivative) raster image showing a three-dimensional effect of elevation changes and a sense of visual relief for cartography.
Source document	Any document that is used as a source for providing information. For example, the source document for compilation is the field sheet. For scan digitizing, it is the overlay to which the compiled information has been transferred.
Special features	Symbols with unique definitions and uses that are standard to a specified group of users but that are not adopted by all mapping agencies. Examples of special features include those identified for soil survey and SSURGO on the legend on Form NRCS–SOI–37A.

Soil Survey Geographic (SSURGO) database	The most detailed in scale of the three NRCS soil geographic databases. Mapping is generally at scales of 1:12,000 or 1:24,000 but may range to 1:63,360. The database consists of georeferenced digital spatial data, metadata, and a tabular soil database, which gives the proportionate extent of the component soils and their properties for each map unit.
Soil area	A delineation of the mapped soil unit. It is identified by a symbol. A soil boundary depicts the limit of the soil area (a polygon).
Soil legend	A list of the soil map symbols and their names.
Spatial data	Data pertaining to the location of geographical entities together with their spatial dimensions. Spatial data are classified as point, line, and polygon.
Text	Any lettered information that appears on maps.
Topology	A procedure that uses lists of features for explicitly defining spatial relationships. For example, an area is defined by the chains (arcs) comprising its border.
United States National Cartographic Standards for Spatial Accuracy (NCSSA)	The standards that define spatial accuracy as it pertains to map products at scales of (NCSSA) 1:250,000 or larger produced by Federal agencies. They supersede the National Map Accuracy Standards (NMAS) issued June 10, 1941, and most recently revised on June 17, 1947, by the former U.S. Bureau of the Budget.
Vector	A line showing the direction and distance between vertices. A vertex is the termination or intersection of lines or curves.
Vector data	A form of digital data comprising x, y coordinate representations that are portrayed by points, lines (strings of points), or polygons (closed lines).
Vector digitizing	See Heads-up digitizing.

647.16 SSURGO Metadata Template

Identification_Information:

Citation:

Citation_Information:

Originator: U.S. Department of Agriculture, Natural Resources
Conservation Service

Publication_Date: __ (1) __

Title: Soil Survey Geographic (SSURGO) database for
____ (2) ____

Publication_Information:

Publication_Place: Fort Worth, Texas

Publisher: U.S. Department of Agriculture, Natural Resources
Conservation Service

Other_Citation_Details: __ (2a) __

Online_Linkage:

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053631

Description:

Abstract:

This data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a planimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.

This data set consists of georeferenced digital map data and computerized attribute data. The map data are in a soil survey area extent format and include a detailed, field verified inventory of soils and nonsoil areas that normally occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped. A special soil features layer (point and line features) is optional. This layer displays the location of features too small to delineate at the mapping scale, but they are large enough and contrasting enough to significantly influence use and management. The soil map units are linked to attributes in the National Soil Information System relational database, which gives the proportionate extent of the component soils and their properties.

Purpose:

SSURGO depicts information about the kinds and distribution of soils on the landscape. The soil map and data used in the SSURGO product were prepared by soil scientists as part of the National Cooperative Soil Survey.

Supplemental_Information:

Digital versions of hydrography, cultural features, and other associated layers that are not part of the SSURGO data set may be available from the primary organization listed in the Point of

Contact.

Time_Period_of_Content:

Time_Period_Information:

Range_of_Dates/Times:

Beginning_Date: ____ (4) ____

Ending_Date: ____ (4a) ____

Currentness_Reference: publication date

Status:

Progress: Complete

Maintenance_and_Update_Frequency: As needed

Spatial_Domain:

Bounding_Coordinates:

West_Bounding_Coordinate: ____ (5) ____

East_Bounding_Coordinate: ____ (6) ____

North_Bounding_Coordinate: ____ (7) ____

South_Bounding_Coordinate: ____ (8) ____

Keywords:

Theme:

Theme_Keyword_Thesaurus: None

Theme_Keyword: soil survey

Theme_Keyword: soils

Theme_Keyword: Soil Survey Geographic

Theme_Keyword: SSURGO

Place:

Place_Keyword_Thesaurus:

Counties and County Equivalents of the States of the United

States and the District of Columbia (FIPS Pub 6-3)

Place_Keyword: ____ (9) ____

Place:

Place_Keyword_Thesaurus:

Counties and County Equivalents of the States of the United

States and the District of Columbia (FIPS Pub 6-3)

Place_Keyword: ____ (10) ____

Place:

Place_Keyword_Thesaurus: USGS Topographic Map Names Data Base

Place_Keyword: ____ (11) ____

Place_Keyword: ____ (11) ____

Place_Keyword: ____ (11) ____

Place_Keyword: ____ (11) ____

Place_Keyword: ____ (11) ____

Access_Constraints: None

Use_Constraints:

The U.S. Department of Agriculture, Natural Resources Conservation

Service, should be acknowledged as the data source in products

derived from these data.

This data set is not designed for use as a primary regulatory tool

Title 430 – National Soil Survey Handbook

in permitting or citing decisions, but may be used as a reference source. This is public information and may be interpreted by organizations, agencies, units of government, or others based on needs; however, they are responsible for the appropriate application. Federal, State, or local regulatory bodies are not to reassign to the Natural Resources Conservation Service any authority for the decisions that they make. The Natural Resources Conservation Service will not perform any evaluations of these maps for purposes related solely to State or local regulatory programs.

Photographic or digital enlargement of these maps to scales greater than at which they were originally mapped can cause misinterpretation of the data. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale. The depicted soil boundaries, interpretations, and analysis derived from them do not eliminate the need for onsite sampling, testing, and detailed study of specific sites for intensive uses. Thus, these data and their interpretations are intended for planning purposes only. Digital data files are periodically updated. Files are dated, and users are responsible for obtaining the latest version of the data.

Point_of_Contact:

Contact_Information:

Contact_Organization_Primary:

Contact_Organization: U.S. Department of Agriculture, Natural Resources Conservation Service

Contact_Position:

Contact_Address:

Address_Type: mailing address

Address: _____(12)_____

City: _____(13)_____

State_or_Province: _____(14)_____

Postal_Code: _____(15)_____

Contact_Voice_Telephone: _____(16)_____

Contact_TDD/TTY_Telephone: 202 720 7808

Contact_Facsimile_Telephone: _____(17)_____

Cross_Reference:

Citation_Information:

Originator: U.S. Department of Agriculture, _____(18)_____

Publication_Date: _____(19)_____

Title: Soil Survey of _____(20)_____

Geospatial_Data_Presentation_Form: atlas

Other_Citation_Details:

This soil survey contains information that can be applied in managing farms and wetlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

This soil survey depicts information about the kinds and distribution of soils on the landscape. The soil map and data

used in the SSURGO product were prepared by soil scientists as part of the National Cooperative Soil Survey.

Data_Quality_Information:

Attribute_Accuracy:

Attribute_Accuracy_Report: Attribute accuracy is tested by manual comparison of the source with hard copy plots and/or symbolized display of the map data on an interactive computer graphic system. Selected attributes that cannot be visually verified on plots or on screen are interactively queried and verified on screen. In addition, the attributes are tested against a master set of valid attributes. All attribute data conform to the attribute codes in the signed classification and correlation document and amendment(s).

Logical_Consistency_Report:

Certain node/geometry and topology GT- polygon/chain relationships are collected or generated to satisfy topological requirements (the GT-polygon corresponds to the soil delineation). Some of these requirements include: chains must begin and end at nodes, chains must connect to each other at nodes, chains do not extend through nodes, left and right GT-polygons are defined for each chain element and are consistent throughout, and the chains representing the limits of the file are free of gaps. The tests of logical consistency are performed using vendor software. All internal polygons are tested for closure with vendor software and are checked on hard copy plots. All data are checked for common soil lines (i.e., adjacent polygons with the same label). Edge locations generally do not deviate from centerline to centerline by more than 0.01 inch.

_____(20a)_____.

Completeness_Report:

A map unit is a collection of areas defined and named the same in terms of their soil and/or nonsoil areas. Each map unit differs in some respect from all others in a survey area and is uniquely identified. Each individual area is a delineation. Each map unit consists of one or more components.

Soil scientists identify small areas of soils or miscellaneous (nonsoil) areas that have properties and behavior significantly different than the named soils in the surrounding map unit. These minor components may be indicated as special features. If they have a minimal effect on use and management, or could not be precisely located, they may not be indicated on the map.

Specific National Cooperative Soil Survey standards and procedures were used in the classification of soils, design and name of map units, and location of special soil features. These standards are outlined in Agricultural Handbook 18, Soil Survey Manual, 1993, USDA, SCS; Agricultural Handbook 436, Soil Taxonomy, Soil Survey Staff, 1999, USDA, NRCS; and all Amendments; Keys to Soil Taxonomy,

Soil Survey Staff; National Soil Survey Handbook, title 430-VI.

The actual composition and interpretive purity of the map unit delineations were based on data collected by scientists during the course of preparing the soil maps. Adherence to National Cooperative Soil Survey standards and procedures is based on peer review, quality control, and quality assurance. Quality control is outlined in the memorandum of understanding for the soil survey area and in documents that reside with the Natural Resources Conservation Service state soil scientist. Four kinds of map units are used in soil surveys: consociations, complexes, associations, and undifferentiated groups.

Consociations - Consociations are named for the dominant soil. In a consociation, delineated areas are dominated by a single soil taxon and similar soils. At least one half of the pedons in each delineation are of the same soil component so similar to the named soil that major interpretations are not affected significantly. The total amount of dissimilar inclusions of other components in a map unit generally does not exceed about 15 percent if limiting and 25 percent if nonlimiting. A single component of a dissimilar limiting inclusion generally does not exceed 10 percent if very contrasting.

Complexes and associations - Complexes and associations are named for two or more dissimilar components with the dominant component listed first. They occur in a regularly repeating pattern. The major components of a complex cannot be mapped separately at a scale of about 1:24,000. The major components of an association can be separated at a scale of about 1:24,000. In each delineation of either a complex or an association, each major component is normally present, though their proportions may vary appreciably from one delineation to another. The total amount of inclusions in a map unit that are dissimilar to any of the major components does not exceed 15 percent if limiting and 25 percent if nonlimiting. A single kind of dissimilar limiting inclusion usually does not exceed 10 percent.

Undifferentiated groups - Undifferentiated groups consist of two or more components that do not always occur together in the same delineation, but are included in the same named map unit because use and management are the same or similar for common uses. Every delineation has at least one of the major components and some may have all of them. The same principles regarding proportion of inclusions apply to undifferentiated groups as to consociations.

Minimum documentation consists of three complete soil profile descriptions that are collected for each soil added to the legend, one additional per 3,000 acres mapped; three 10 observation transects for each map unit, one additional 10 point transect per

4,000 acres.

A defined standard or level of confidence in the interpretive purity of the map unit delineations is attained by adjusting the kind and intensity of field investigations. Field investigations and data collection are carried out in sufficient detail to name map units and to identify accurately and consistently areas of about ____ (21) ____ acres.

Positional_Accuracy:

Horizontal_Positional_Accuracy:

Horizontal_Positional_Accuracy_Report:

The accuracy of these digital data is based upon their compilation to base maps that meet National Map Accuracy Standards. The difference in positional accuracy between the soil boundaries and special soil features locations in the field and their digitized map locations is unknown. The locational accuracy of soil delineations on the ground varies with the transition between map units.

For example, on long gently sloping landscapes the transition occurs gradually over many feet. Where landscapes change abruptly from steep to level, the transition will be very narrow. Soil delineation boundaries and special soil features generally were digitized within 0.01 inch of their locations on the digitizing source. The digital map elements are edge matched between data sets. The data along each quadrangle edge are matched against the data for the adjacent quadrangle. Edge locations generally do not deviate from centerline to centerline by more than 0.01 inch.

Lineage:

Source_Information:

Source_Citation:

Citation_Information:

Originator: _____ (22) _____

Publication_Date: ____ (23) ____

Title: _____ (24) _____

Geospatial_Data_Presentation_Form: _____ (25) _____

Publication_Information:

Publication_Place: _____ (26) _____

Publisher: _____ (27) _____

Source_Scale_Denominator: ____ (28) ____

Type_of_Source_Media: ____ (29) ____

Source_Time_Period_of_Content:

Time_Period_Information:

Single_Date/Time:

Calendar_Date: ____ (30) ____

Source_Currentness_Reference: _____ (31) _____

Source_Citation_Abbreviation: _____ (32) _____

Title 430 – National Soil Survey Handbook

Source_Contribution: _____(33)_____

Source_Information:

Source_Citation:

Citation_Information:

Originator: _____(22)_____

Publication_Date: ____ (23) ____

Title: _____(24)_____

Geospatial_Data_Presentation_Form: _____(25)_____

Publication_Information:

Publication_Place: _____(26)_____

Publisher: _____(27)_____

Source_Scale_Denominator: ____ (28) ____

Type_of_Source_Media: ____ (29) ____

Source_Time_Period_of_Content:

Time_Period_Information:

Range_of_Dates/Times:

Beginning_Date: ____ (30a) ____

Ending_Date: ____ (30b) ____

Source_Currentness_Reference: _____(31) _____

Source_Citation_Abbreviation: _____(32)_____

Source_Contribution: _____(33) _____

Process_Step:

Process_Description: _____(34) _____

Source_Used_Citation_Abbreviation: _____(36)_____

Process_Date: ____ (35) ____

Process_Step:

Process_Description: _____(34) _____

Source_Used_Citation_Abbreviation: _____(36)_____

Process_Date: ____ (35) ____

Spatial_Data_Organization_Information:

Direct_Spatial_Reference_Method: Vector

Spatial_Reference_Information:

Horizontal_Coordinate_System_Definition:

Geographic:

Latitude_Resolution: 0.0000001

Longitude_Resolution: 0.0000001

Geographic_Coordinate_Units: decimal degrees

Geodetic_Model:

Horizontal_Datum_Name: North American Datum of 1983

Ellipsoid_Name: Geodetic Reference System 80

Semi-major_Axis: 6378137.0

Denominator_of_Flattening_Ratio: 298.257

Entity_and_Attribute_Information:

Detailed_Description:

Entity_Type:

Entity_Type_Label: Special Soil Features

Entity_Type_Definition:

Special Soil Features represent soil, nonsoil, or landform features that are too small to be digitized as soil delineations (area features).

Title 430 – National Soil Survey Handbook

Entity_Type_Definition_Source:

U.S. Department of Agriculture. 1993. Soil Survey Manual.
Soil Surv. Staff, U.S. Dep. Agric. Handb. 18.

Attribute:

Attribute_Label: Special Soil Features Codes

Attribute_Definition:

Special Soil Features Codes represent specific Special Soil Features. These features are identified with a major code, a minor code, and a descriptive label. The codes and label are assigned to the point or line assigned to represent the feature on published maps.

Attribute_Definition_Source:

U.S. Department of Agriculture. 1993. Soil Survey Manual.
Soil Surv. Staff, U.S. Dep. Agric. Handb. 18; U.S. Department of Agriculture. (current issue). National Soil Survey Handbook, title 430-VI, part 647. Soil Conserv. Serv.

Attribute_Domain_Values:

Codeset_Domain:

Codeset_Name:

Classification and Correlation of the Soils of ____ (45) ____

Codeset_Source:

U.S. Department of Agriculture, Natural Resources
Conservation Service

Overview_Description:

Entity_and_Attribute_Overview:

Map Unit Delineations are closed polygons that may be dominated by a single soil or nonsoil component plus allowable similar or dissimilar soils, or they can be geographic mixtures of groups of soils or soils and nonsoil areas.

The map unit symbol uniquely identifies each closed delineation map unit. Each symbol corresponds to a map unit name. The map unit key is used to link to information in the National Soil Information System tables.

Map Unit Delineations are described by the National Soil Information System database. This attribute database gives the proportionate extent of the component soils and the properties for each soil. The database contains both estimated and measured data on the physical and chemical soil properties and soil interpretations for engineering, water management, recreation, agronomic, woodland, range, and wildlife uses of the soil.

The National Soil Information System database contains static metadata. It documents the data structure and includes such information as what tables, columns, indexes, and relationships are defined as well as a variety of attributes of each of these database objects. Attributes include table and column descriptions and detailed domain information.

Title 430 – National Soil Survey Handbook

The National Soil Information System database also contains a distribution metadata. It records the criteria used for selecting map units and components for inclusion in the set of distributed data.

Special features are described in the feature table. It includes a feature label, feature name, and feature description for each special and ad hoc feature in the survey area.

Entity_and_Attribute_Detail_Citation:

U.S. Department of Agriculture. 1999. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys. Natural Resources Conserv. Serv., U.S. Dep. Agric. Handb. 436.

U.S. Department of Agriculture. (current issue). Keys to Soil Taxonomy. Soil Surv. Staff, Natural Resources Conserv. Serv.

U.S. Department of Agriculture. (current issue). National Soil Survey Handbook, title 430-VI. Soil Surv. Staff, Natural Resources Conservation Service.

U.S. Department of Agriculture. 1993. Soil Survey Manual. Soil Surv. Staff, U.S. Dep. Agric. Handb. 18.

Distribution_Information:

Distributor:

Contact_Information:

Contact_Organization_Primary:

Resource_Description: _____(46)_____ SSURGO

Distribution_Liability:

Although these data have been processed successfully on a computer system at the U.S. Department of Agriculture, no warranty expressed or implied is made by the Agency regarding the utility of the data on any other system, nor shall the act of distribution constitute any such warranty. The U.S. Department of Agriculture will warrant the delivery of this product in computer readable format, and will offer appropriate adjustment of credit when the product is determined unreadable by correctly adjusted computer input peripherals, or when the physical medium is delivered in damaged condition. Request for adjustment of credit must be made within 90 days from the date of this shipment from the ordering site.

The U.S. Department of Agriculture, nor any of its agencies are liable for misuse of the data, for damage, for transmission of viruses, or for computer contamination through the distribution of these data sets. The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, sexual orientation, or marital or family status.

(Not all prohibited bases apply to all programs.)

Standard_Order_Process:

Digital_Form:

Digital_Transfer_Information:

Format_Name: ARC/INFO coverage

Format_Information_Content: spatial

Transfer_Size: ____ (48) ____

Digital_Transfer_Option:

Offline_Option:

Offline_Media: CD-ROM

Recording_Format: ISO 9660 Level 1

Digital_Form:

Digital_Transfer_Information:

Format_Name: ARCE

Format_Information_Content: spatial

Transfer_Size: ____ (48) ____

Digital_Transfer_Option:

Offline_Option:

Offline_Media: CD-ROM

Recording_Format: ISO 9660 Level 1

Digital_Form:

Digital_Transfer_Information:

Format_Name: ArcView shapefile

Format_Information_Content: spatial

Transfer_Size: ____ (48) ____

Digital_Transfer_Option:

Offline_Option:

Offline_Media: CD-ROM

Recording_Format: ISO 9660 Level 1

Digital_Form:

Digital_Transfer_Information:

Format_Name: ASCII

Format_Information_Content: keys and attributes

Transfer_Size: ____ (49) ____

Digital_Transfer_Option:

Offline_Option:

Offline_Media: CD-ROM

Recording_Format: ISO 9660 Level 1

Fees:

The charge is \$50 for a CD-ROM that contains one or more data sets. A data set is one soil survey area that includes both spatial and attribute data.

Ordering_Instructions:

Call or write to organizations listed under Distributor. Spatial line data and locations of special feature symbols are in ARC/INFO coverage and export formats, and ArcView shapefile format. The National Soil Information System attribute soil data are available in variable length, pipe delimited, ASCII file format.

Title 430 – National Soil Survey Handbook

Turnaround: 10 working days

Metadata_Reference_Information:

Metadata_Date: ____ (51) ____

Metadata_Contact:

Contact_Information:

Contact_Organization_Primary:

Contact_Organization: U.S. Department of Agriculture, Natural
Resources Conservation Service

Contact_Position: State Soil Scientist

Contact_Address:

Address_Type: mailing address

Address: _____ (53) _____

City: _____ (54) _____

State_or_Province: __ (55) _

Postal_Code: __ (56) _

Contact_Voice_Telephone: _____ (57) _____

Contact_Facsimile_Telephone: _____ (58) _____

Metadata_Standard_Name: Content Standard for Digital Geospatial Metadata

Metadata_Standard_Version: FGDC-STD-001-1998

Title 430 – National Soil Survey Handbook
EXPLANATION OF METADATA TEMPLATE’S NUMBERED ELEMENTS

[Unless otherwise noted, all references refer to *Content Standards for Digital Geospatial Metadata* (Federal Geographic Data Committee. 1998. Washington, DC).]

Numbers in Identification Information Section

1 *Publication Date*.—The date when the data set is published or otherwise made available for release. Enter the year the data are submitted for archiving and distribution. Enter the year in the date format YYYY. Reference is from p. 53, sec. 8.2. Example:

Publication Date: 1994

2 *Title*.—The name by which the data set is known. Enter the complete name of the soil survey area as defined in the memorandum of understanding. Reference is from p. 53, sec. 8.4. Example:

Title: Polk County, Iowa

2a *Other Citation Details*.—The non-MLRA soil survey area symbol. Enter the non-MLRA soil survey area symbol as defined in the National Soil Survey Handbook Part 608, Section 608.02. Reference is from p. 54, sec. 8.9. Example:

Other Citation Details: IA153

4 *Beginning Date*.—The first year of the event. Enter the year in the date format YYYYMMDD. Reference is from p. 56, sec. 9.3.1. Example:

Beginning Date: 19980601

4a *Ending Date*.—The last year of the event. Enter the year in the date format YYYYMMDD. Reference is from p. 56, sec. 9.3.1. Example:

Ending Date: 20080930

Bounding Coordinates.—The limits of coverage of a data set expressed by latitude and longitude values in the order westernmost, easternmost, northernmost, and southernmost. The bounding coordinates are for the soil survey area.

5 *West Bounding Coordinate*.—The westernmost coordinate of the limit of coverage expressed in longitude. Enter the coordinate in decimal degrees. Reference is from p. 5. Example:

West Bounding Coordinate: -93.750

6 *East Bounding Coordinate*.—The easternmost coordinate of the limit of coverage expressed in longitude. Enter the coordinate in decimal degrees. Reference is from p. 5. Example:

East Bounding Coordinate: -93.250

7 *North Bounding Coordinate*.—The northernmost coordinate of the limit of coverage expressed in latitude. Enter the coordinate in decimal degrees. Reference is from p. 5. Example:

Title 430 – National Soil Survey Handbook

North Bounding Coordinate: 41.750

8 *South Bounding Coordinate*.—The southernmost coordinate of the limit of coverage expressed in latitude. Enter the coordinate in decimal degrees. Reference is from p. 5. Example :

South Bounding Coordinate: 41.375

9 *Place Keyword*.—The name of the State that the data set is in. Enter multiple States as separate entries. Reference is from p. 7. Example:

Place Keyword: Nevada

Place Keyword: Utah

10 *Place Keyword*.—The name of the county that the data set is in. Enter multiple counties as separate entries. Reference is from p. 7. Example:

Place Keyword: Rains County

Place Keyword: Hopkins County

11 *Place Keyword*.—The name of the quadrangle in the data set. Enter the USGS quadrangle name from the National Topographic Map Names database. The quadrangle numbers are available from the SSURGO Support Section, National Geospatial Management Center. The quadrangle names and numbers are also in the NASIS Area table where Area Type Name equals “USGS 7.5 Minute Quadrangles.” Enter all quadrangles that make up the soil survey area and enter each as a separate entry. Reference is from p. 7. Example:

Place Keyword: Pleasantville Quadrangle (s4109338)

Place Keyword: Hartford Quadrangle (s4109337)

12 *Address*.—The address line. Reference is from p. 59, sec. 10.4.2. Example:

Address: 210 Walnut Street, Suite 693

13 *City*.—The city of the address. Reference is from p. 59, sec. 10.4.3. Example:

City: Des Moines

14 *State or Province*.—The State or province of the address. Reference is from p. 59, sec. 10.4.4. Example:

State or Province: Iowa

15 *Postal Code*.—The ZIP or other postal code of the address. Reference is from p. 59, sec. 10.4.5. Example:

Postal Code: 50309–2180

16 *Contact Voice Telephone*.—The telephone number by which individuals can speak to the organization or individual. Reference is from p. 59, sec. 10.5. Example:

Contact Voice Telephone: 402 437 5499

17 *Contact Facsimile Telephone*.—The telephone number of a facsimile machine of the organization or individual. Reference is from p. 60, sec. 10.7. Example:

Contact Facsimile Telephone: 402 437 5336

18 *Originator*.—The name of an organization that developed the data set. This is the name from the published document. Reference is from p. 53, sec. 8.1. Example:

Originator: Natural Resources Conservation Service or Originator: Soil Conservation Service

19 *Publication Date*.—The date when the data set is published or otherwise made available for release. Enter the year the data is submitted for archiving and distribution. Enter the year in the date format YYYY. Reference is from p. 53, sec. 8.2. Example:

Publication Date: 1994

20 *Title*.—The name by which the data set is known. Enter the complete name of the soil survey area as defined in the memorandum of understanding. Reference is from p. 53, sec. 8.4. Example:

Title: Polk County, Iowa

20a *Edge Match Statements*.—Edge matching of digital data is described in terms of accuracy of matching of feature edges, feature labels, and descriptive attributes between quadrangles or data sets. In SSURGO, all three are required to match between adjacent quadrangles within the survey. Only the soil survey boundaries are required to match between surveys. Examples of edge match statements for adjacent soil surveys:

The quadrangles in this soil survey are not edge matched to quadrangles in adjacent soil surveys.

The quadrangles in this soil survey are edge matched to quadrangles in adjacent soil surveys.

The quadrangles in this soil survey are edge matched to quadrangles in the Alpha Soil Survey, but are not edge matched to those in the Beta or Gamma Soil Surveys.

Feature edges and descriptive attributes of quadrangles in this soil survey are matched to those in adjacent soil surveys. Feature labels do not match.

21 *Minimum Size Delineation*.—The minimum size of map unit delineation as defined in the memorandum of understanding for the data set. Enter the size in acres. Example:

Numbers in Data Quality Information Section

The Spatial Data Transfer Standard Data Quality Report consists of five parts covering lineage, positional accuracy, attribute accuracy, logical consistency, and completeness. The Data Quality Report is presented in part 1, section 3 of the Spatial Data Transfer Standard.

22 *Originator*.—The name of an organization or individual that developed the data set. Reference is from p. 53, sec. 8.4. Example:

Originator: U.S. Geological Survey

23 *Publication Date*.—The date when the data set is published or otherwise made available for release. Enter the year in the date format YYYY. Reference is from p. 53, sec. 8.2. Example:

Publication Date: 1983

24 *Title*.—The name by which the data set is known. Reference is from p. 53, sec. 8.4. Example:

Title: Soil Survey of Polk County, Iowa

25 *Geospatial Data Presentation Form*.—The mode in which the geospatial data is presented. Reference is from p. 54, sec. 8.6. Example:

Geospatial Data Presentation Form: Topographic quadrangle map

26 *Publication Place*.—The name of the city and State where the data set was published or released. Reference is from p. 54, sec. 8.8.1. Example:

Publication Place: Reston, Virginia

27 *Publisher*.—The name of the individual or organization that published the data set. Reference is from p. 54, sec. 8.8.2. Example:

Publisher: U.S. Geological Survey

28 *Source Scale Denominator*.—The denominator of the representative fraction on a map. Reference is from p. 13, sec. 2.5.1.2. Example:

Source Scale Denominator: 12000

29 *Type of Source Media*.—The medium of the source data set. Reference is from p. 13, sec. 2.5.1.3. Example:

Type of Source Media: Stable-base material

Single Date/Time.—This is a single element and must be followed with the element Calendar Date.

30 *Calendar Date*.—The year. Enter the year in the date format YYYY. Reference is from p. 56, sec. 9.1.1. Example:

Calendar Date: 1960

Range of Dates/Times.—This is a compound element and must be followed with the elements Beginning Date and Ending Date.

30a *Beginning Date*.—The first year of the event. Enter the year in the date format YYYY. Reference is

from p. 56, sec. 9.3.1. Example:

Beginning Date: 1989

30b *Ending Date*.—The last year for the event. Enter the year in the date format YYYY. Reference is from p. 56, sec. 9.3.1. Example:

Ending Date: 1992

31 *Source Currentness Reference*.—The basis on which the source time period of content information of the source data set is determined. Reference is from p. 14, sec. 2.5.1.4.1. Example:

Source Currentness Reference: Publication date

32 *Source Citation Abbreviation*.—The short-form alias for the Source Citation. Reference is from p.14, sec. 2.5.1.5. Example:

Source Citation Abbreviation: NRCS1

33 *Source Contribution*.—A brief statement identifying the information contributed by the source to the data set. Reference is from p. 14, sec. 2.5.1.6. Example:

Source Contribution: Digitizing source

34 *Process Description*.—An explanation of the event and related parameters or tolerances. Reference is from p. 14, sec. 2.5.2.1.

35 *Process Date*.—The date when the event was completed. Enter the year in the date format YYYY. Reference is from p. 14, sec. 2.5.2.3. Example:

Process Date: 1993

36 *Source Used Citation Abbreviation*.—The source citation abbreviation of a data set used in the processing step. Reference is from p. 14, sec. 2.5.2.2. Example:

Source Used Citation Abbreviation: NRCS1

Numbers in Spatial Reference Information Section

45 *Codeset Name*.—The name of the soil survey area as it appears in the title of the soil classification and correlation document. Example:

Codeset Name: Polk County, Iowa

Numbers in Distribution Information Section

46 *Resource Description*.—The identifier by which the distributor knows the data set. Reference is from p. 43, sec. 6.2. Example:

Resource Description: Polk Country, Iowa SSURGO

48 *Transfer Size*.—The size, or estimated size, of the transferred data set in megabytes. This is the sum for all DLGs in the data set. Reference is from p. 45, sec. 6.4.2.1.7. Example:

Transfer Size: 14.4

49 *Transfer Size*.—The size, or estimated size, of the transferred data set in megabytes. This is the sum for all attribute tables in the data set. Reference is from p. 45, sec. 6.4.2.1.7. Example:

Transfer Size: 0.4

Numbers in Metadata Reference Information Section

51 *Metadata Date*.—The date that the metadata were created or last updated. Enter the date in the format YYYYMMDD. Reference is from p. 50, sec. 7.1. Example:

Metadata Date: 19940311

53 *Address*.—The address line. Reference is from p. 59, sec. 10.4.2. Example:

Address: 210 Walnut Street, Suite 693

54 *City*.—The city of the address. Reference is from p. 59, sec. 10.4.3. Example:

City: Des Moines

55 *State or Province*.—The State or province of the address. Reference is from p. 59, sec. 10.4.4. Example:

State or Province: Iowa

56 *Postal Code*.—The ZIP or other postal code of the address. Reference is from p. 59, sec. 10.4.5. Example:

Postal Code: 50309-2180

57 *Contact Voice Telephone*.—The telephone number by which individuals can speak to the organization or individual. Reference is from p. 59, sec. 10.5. Example:

Contact Voice Telephone: 402 437 5499

58 *Contact Facsimile Telephone*.—The telephone number of a facsimile machine of the organization or individual. Reference is from p. 60, sec. 10.7. Example:

Contact Facsimile Telephone: 402 437 5336

Part 648 – Digital Soil Mapping – Raster Products for Soil Survey

Subpart A – General Information

648.0 Definition and Purpose

A. Definition

1. Digital soil mapping is the production of georeferenced soil databases based on the quantitative relationships between measurements made in the field or laboratory and environmental data (McBratney et al. 2003). Digital soil mapping products may represent either discrete classes (soil map units) or continuous soil properties and are delivered as raster or gridded data (i.e., rows and columns of pixels with geographic locations storing categorical or continuous data). Both digital and traditional soil mapping use expert knowledge and a conceptual soil-landscape model as a means for organizing environmental information.
2. Digital methods rely on quantitative relationships between observations and the environmental information to spatially predict soil map unit divisions or continuous variation in soil properties across the landscape. Traditional methods qualitatively approximate relationships of the environmental information to spatially represent soil map unit divisions and are produced and delivered in a vector data structure (see section 647.4).

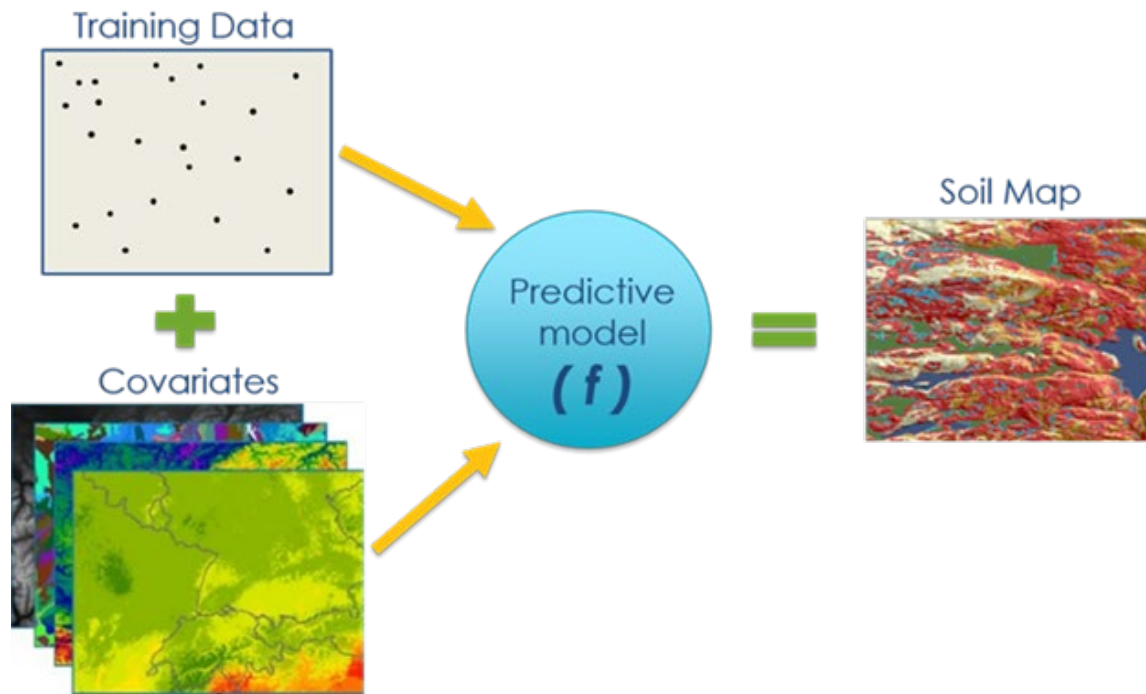
B. Purpose

1. The purpose of part 648 is to provide standards regarding procedures, data development, responsibilities, mapping strategies, and raster soil survey (RSS) products associated with digital soil mapping products. The scientific process and methodology for creating digital soil mapping products is covered in chapter 5 of the Soil Survey Manual. These standards are used to provide consistency in the production of statewide databases corresponding to state RSS areas and national, continuous soil property layers.
2. The need for this guidance has been driven by significant advances in computer technology enabling soil survey information to be developed with an improved, quantifiable, and consistent representation of spatial variability. This evolution in soil information benefits conservation planners, modelers, policy makers, soil survey partners, and other stakeholders making land inventory, assessment, and management decisions.
3. This part is not a step-by-step procedure for how to implement digital soil mapping methodologies to produce RSS products. For more detailed information on digital soil mapping methodologies, see chapter 5 of the Soil Survey Manual.

C. Digital Soil Mapping Strategies

The term “strategy” here refers to the approach and operations applied towards the goal of developing consistent soil information using digital soil mapping methods. The strategy used for digital soil mapping is dependent on the availability and quality of existing soil and environmental data (see figure 648A-1). RSSs can fill the voids in the current inventory or be used to refine or supplement the existing inventory by more explicitly and consistently identifying a soil class (map unit). Soil Landscapes of the United States (SOLUS) is a national product focused on providing a consistent set of spatially continuous soil property maps to support large scope soil investigations and land use decisions.

Figure 648A-1: The Digital Soil Mapping Process Combines Field or Laboratory Observations with Environmental Data in a Statistical Algorithm to Produce a Map of Either Soil Type (Raster Soil Surveys) or Continuous Properties (Soil Landscapes of the United States).



648.1 Raster Soil Surveys

A. Raster Soil Survey Mapping

This type of mapping identifies unique soil map units supported by expert knowledge, field observations, and associated geographic and environmental data. The quantitative relationships between these data are explored, and discrete classes (map units) are established. RSSs use the tabular data structure of the Soil Survey Geographic (SSURGO) database to support property and interpretation generation.

1. Raster Soil Survey Project Types

- a. Major Land Resource Area (MLRA) Project Mapping (see part 610).—Digital soil mapping products advance the currently existing official SSURGO inventories with detailed, refined, spatially explicit, and seamless soil information across county, parish, or state boundaries. These projects are often applied on a map unit, landform, or ecological unit basis. Data updates are delivered in statewide RSS databases and published to the NRCS Geospatial Data Gateway. Magnitude of vector spatial updates based on RSS results are discretionary based on project objectives.
- b. Initial Project Mapping (see part 627).—Digital soil mapping products are foundational to providing detailed soil information in unmapped areas as part of the non-MLRA progressive soil survey. The soil survey project is part of a statewide RSS area, and the related National Soil Information System (NASIS) objects (i.e., legend, map unit, data map unit, etc.) are populated in the same manner as a traditional soil survey. A tabular and vector SSURGO product is created from the data collected during the project, including using the final raster map to develop SSURGO map units.

- c. For all RSS project mapping, the target pixel value represents the map unit key and relates to tabular data stored in the NASIS database.

B. Procedure

1. **MLRA Project Mapping.**—A NASIS project plan is developed by the Soil Survey Office and follows the project approval process (see section 610.1(A)(3)). Project milestones and associated progress are actively managed and generally follow digital soil mapping stages and processes, as outlined in chapter 5 of the Soil Survey Manual.
2. **Initial Project Mapping.**—A working agreement is required (see part 606). A NASIS project is created and follows the project approval process (see section 610.1(A)(3)). Project milestones and associated progress are actively managed and generally follow digital soil mapping stages and processes, as outlined in chapter 5 of the Soil Survey Manual.
3. Raster soil survey mapping resolution is determined by the available data and intended use, and is defined on a project basis. Project spatial data resolution is established in the project proposal or other working agreement. Projects (MLRA and initial) completed at resolutions other than 10 meters are resampled or aggregated to 10 meters to fit seamlessly within a state RSS database.
4. The tabular information collected during MLRA or initial project mapping is stored and maintained in NASIS. The accompanying spatial data are stored in a statewide geodatabase with a corresponding tabular export and posted to the USDA-NRCS Geospatial Data Gateway.
5. Raster soil survey efforts are pursued using accepted exploratory and prediction methods, such as unsupervised (e.g., ISODATA, k-means) and supervised classification (e.g., predictive modeling, knowledge-based). These methods are found in geographic information system (GIS) and statistical software and peer-reviewed literature, and are discussed in chapter 5 of the Soil Survey Manual. Consistent approaches should be considered for projects across similar landscapes or landforms, such as MLRAs or flood plains.
6. In most instances, SSURGO vector data will reflect the findings of MLRA or initial project mapping in coincident areas. MLRA project mapping is not necessarily carried out to require the development of a more detailed SSURGO product. Regional discretion, with concurrence from state conservationists (or designated appointee), the board of advisors (see section 609.1(B)(3)), technical teams, and cooperators, is used to determine the degree to which findings from MLRA RSS projects are incorporated into existing SSURGO spatial and tabular information. The intent is to refine and improve upon the information that has already been inventoried. Digital soil mapping products must support consistent soil survey products across political boundaries, including correlation of existing SSURGO products into MLRA map units across natural landforms over broad areas (see section 610.1(A)(4)).
7. Raster soil survey products are quantitatively validated as part of the modeling process using accepted validation methods (see section 648.3). These estimates of accuracy and uncertainty are published alongside the raster soil maps and published in the metadata. Examples are overall map accuracy, standard error, uncertainty, or probability maps.
8. Legend development is based on project areas reflecting the needs of the project and are built and managed in an RSS area corresponding to a respective state or territory. Publication map unit symbols are the same as the national map unit symbol.
9. These datasets are incorporated into National Soil Survey Geographic Database (gNATSGO) annually.
10. Spatial data resulting from RSS mapping are aligned to the state gSSURGO or gNATSGO map unit key (MUKEY) grid and delivered using the following projected or geographic coordinate system:

(430-648-H, 1st Ed., Amend. 40, June 2023)

Title 430 – National Soil Survey Handbook

- a. CONUS: NAD 1983 Contiguous USA Albers (EPSG 5070)
- b. Puerto Rico and U.S.V.I: NAD 1983 State Plane Puerto Rico Virgin Islands FIPS 5200 (EPSG 32161)
- c. Hawaii: WGS84 (EPSG 4326)
- d. Alaska: Alaska Albers Equal Area Conic (EPSG 3338)
- e. PAC Basin (FM – Federated States of Micronesia, GU – Guam, MH – Marshall Islands, MP – Northern Mariana Islands, PW – Palau): WGS84 (EPSG 4326)
- f. American Samoa: WGS84 (EPSG 4326)

C. Mapping Data Development

1. Spatial Data.—Spatial data used for digital soil mapping projects meets the National Standard for Spatial Data Accuracy, set forth by the Federal Geographic Data Committee. This organized structure of federal geospatial professionals and constituents provide executive, managerial, and advisory direction and oversight for geospatial decisions and initiatives across the Federal Government.
 - a. The data delivered to project offices is coordinated and validated by regional GIS specialists to ensure the consistency of coordinate systems, proper selection of datum transformations, resampling techniques, resolution, data types, coregistration, and so on. Examples of data used include those listed below, although many options exist for data and derivatives beyond those presented here. See relevant job aids at the GIS and Digital Mapping for Soil Survey web page.
 - b. Digital elevation models (SRTM, NED, IFSAR, LiDAR) and derivatives
 - (1) Slope gradient
 - (2) Slope aspect
 - (3) Topographic wetness index
 - (4) Slope curvature (total, profile, plan, tangential, etc.)
 - c. Spectral data (LANDSAT, Sentinel) and derivatives
 - (1) Band ratios
 - (2) Tasseled Cap Transformation
 - (3) Principal components
 - d. Thematic data
 - (1) National Land Cover Database
 - (2) Gap Analysis Program
 - (3) Landforms
 - (4) National Wetland Inventory
 - e. Climatic data
 - (1) PRISM
 - (2) Water balance
 - (3) Incoming solar radiation
2. Data Capture.—Data capture relates to the process of maintaining, storing, and delivering information from a raster mapping project into a data product capable of generating soil properties and interpretations.
 - a. MLRA Project Mapping
 - (1) Resources guiding MLRA RSS projects include information already present within map unit descriptions (soil survey publications), historical documentation (transects, pedons, or general soil maps), local expert knowledge, and environmental data (digital elevation, spectral, or thematic).
 - (2) Suitable extent is identified for improvement of official data (map units, landform, ecological sites, etc.). The corresponding extent coincides with SSURGO polygon information and serves as the area over which the MLRA raster project is completed. Projects extending

Title 430 – National Soil Survey Handbook

across very large areas can be further subdivided if soil forming factors, such as climate, vary considerably across the identified extent. Refined raster classes (map units) are identified and proposed combining digital soil mapping methods, expert knowledge, field observations, and image analysis.

- (3) Correlation occurs based on articulating the class (map unit) concepts through model training data (field observations or ancillary data), model outputs, environmental data (digital elevation and spectral data), independent validation data (field observations and ground truthing), field reviews, visual analysis, estimates of accuracy or uncertainty, and documentation of the correlation in the NASIS project object.
 - (4) Every state has an RSS area and an accompanying RSS legend in NASIS, identified with an area symbol using the state abbreviation (e.g., MA for Massachusetts). Raster classes (map units) identified in MLRA projects are populated at the map unit level and below within the state RSS area.
 - (5) Each MLRA project will be distinguished in the state RSS area through the Legend Area Overlap (Legend Area Overlap Type: Raster Soil Survey Project). All associated map units and proportionate map unit area overlap acres will be identified.
 - (6) Field observations (training and validation data) are entered as NASIS pedons.
 - (7) Accuracy and uncertainty metrics are produced (see figures 648A-5 and 648A-6). Validation measures for overall map accuracy, as well as individual class accuracy, are referenced. See section 648.3 for details on suggested methods and minimum overall map accuracy requirements. Validation using an independent data set is highly recommended, but not required, for all projects. Cross-validation or other appropriate data-splitting methods may be used in the absence of an independent validation data set.
 - (8) A file geodatabase is established for each state RSS area (see section 648.12). Results of project mapping (MLRA or initial) accumulate in this geodatabase, including raster datasets and tabular exports.
 - (9) SSURGO products developed or updated from MLRA mapping efforts may require considerations of correlation and map unit design to create a more generalized representation of spatial and tabular data.
 - (10) Soil survey order of mapping (as defined in chapter 4 of the Soil Survey Manual) for SSURGO resulting from MLRA project mapping is approximated using Levels of Raster Soil Survey (see section 648.1(F) of this handbook and 430 NI § 309.10) in combination with considerations of map scale and minimum legible area (see section 648.13).
 - (11) The state soil scientist certifies the data for publication in the NASIS Legend Export Certification History table and creates the SSURGO export from NASIS to accompany the spatial data for publication.
 - (12) The state RSS area geodatabase, which includes the state raster and tabular data, is published to the NRCS Data Gateway as two data packages. The first is a file geodatabase containing both the raster dataset and tables, and the second is a directory containing the raster dataset in compressed tagged image file format (.tif) and tabular data as text files in pipe delimited format. The RSS datasets are also delivered in the gNATSGO composite database, as the best available gridded soils information.
 - (13) The naming convention for the state raster workspace or directory is the product and area symbol (e.g., RSS_MA). Within the directory is a 32-bit unsigned integer thematic raster (MapunitRaster_10m_state_yearmonth).
 - (14) Raster NoData cells are assigned the value “2147483627” (the NoData value automatically assigned during the creation of the geodatabase).
- b. Initial Project Mapping.—Information aiding the development of initial RSSs includes soil

observations, local expert knowledge, adjoining SSURGO soil survey areas, STATSGO2, geological maps, and environmental data (digital elevation, spectral, or thematic data).

- (1) Soil classes (map units) are identified and proposed based on the needs of the project set forth in the project plan or working agreement using digital soil mapping methods, expert knowledge, field observations, and image analysis.
- (2) Correlation occurs based on articulating the class (map unit) concepts through model training data (field observations or ancillary data), environmental data (digital elevation and spectral data), model outputs, independent validation data (field observations), field reviews, visual analysis, estimates of accuracy or uncertainty, and documentation of the correlation in the NASIS project object.
- (3) Every state has an RSS area and an accompanying RSS legend in NASIS, identified with an area symbol using the state abbreviation (e.g., MA) (see section 648.12). Raster classes identified in initial projects are populated as map units and below within the state RSS area.
- (4) Each initial project will be distinguished in the state RSS area through the Legend Area Overlap (Legend Area Overlap Type: Raster Soil Survey Project). All associated map units and proportionate map unit area overlap acres will be identified.
- (5) Additionally, initial RSS projects have a non-MLRA soil survey area legend and below populated in NASIS for incorporating into SSURGO and Web Soil Survey.
- (6) Field observations (training and validation data) are entered as NASIS pedons.
- (7) Accuracy and uncertainty metrics are produced (see figures 648A-5 and 648A-6). Validation measures for overall map accuracy, as well as individual class accuracy, are referenced. See section 648.3 for details on suggested methods and minimum overall map accuracy requirements. Validation using an independent validation data set is highly recommended, but not required, for all projects. Cross-validation or other appropriate data-splitting methods may be used in the absence of an independent validation data set.
- (8) A file geodatabase is established for each RSS area (see section 648.12). Results of project mapping (MLRA or initial) accumulate in this geodatabase, including raster datasets and NASIS tabular exports.
- (9) SSURGO products developed from initial RSS efforts may require considerations of correlation and map unit design to create a more generalized representation of spatial and tabular data.
- (10) Soil survey order of mapping (as defined in chapter 4 of the Soil Survey Manual) for SSURGO resulting from initial projects is approximated using Levels of Raster Soil Survey (see section 648.1(F) of this handbook and 430 NI § 309.10) in combination with Initial Soil Survey Project Classification Scheme (see 430 NI 309) and considerations of map scale and minimum legible area (see section 648.13).
- (11) The state soil scientist certifies the data for publication in the NASIS Legend Export Certification History table and creates the SSURGO export of the non-MLRA soil survey area from NASIS to accompany the spatial data for publication.
- (12) The state RSS area geodatabase, which includes the state raster and tabular data, is published to the NRCS Data Gateway as two data packages. The first is a file geodatabase system containing both the raster dataset and tables, and the second is a directory containing the raster dataset in compressed tagged image format (.tif) and tabular data as text files in pipe delimited format. The RSS datasets are also delivered in the gNATSGO composite database, as the best available gridded soils information.
- (13) The naming convention for the state raster workspace or directory is the product and area symbol (e.g., RSS_MA). Within the directory is a 32-bit unsigned integer thematic raster (MapunitRaster_10m_state_yearmonth).

- (14) Raster NoData cells are assigned the value “2147483647” (the NoData value automatically assigned during the creation of the geodatabase).

D. Responsibilities.—National headquarters provides overall direction, policy, guidance, and leadership for the National Cooperative Soil Survey (NCSS) within NRCS. See section 608.1 of this handbook for more detailed information on the responsibilities of national headquarters and the other NRCS offices mentioned in this section.

1. National Soil Survey Center (NSSC)—
 - a. NASIS database support
 - b. RSS Research
 - c. RSS Analysis
 - d. National coordination and oversight of RSS project mapping
 - (1) Coordinating RSS delivery to the NRCS Data Gateway
 - (2) Packaging and delivery of the gridded National Soil Survey Geographic Database (gNATSGO)
2. Soil Survey Regional Offices—
 - a. The production and quality assurance of project spatial and tabular data
 - b. Ensuring soil scientists receive digital soil mapping training
 - c. Correlation and project management guidance
 - d. Quality assurance and legend development
 - e. Acquiring and distributing project spatial data (elevation, spectral, others)
 - f. Aggregating supporting documentation to document process and generating metadata
 - g. Packaging and delivering RSSs to the NSSC
3. State Offices (see section 609.1(B)(3))—
 - a. State Conservationist (or designated appointee)
 - (1) Certifying RSSs
 - b. State Soil Scientist
 - (1) Providing certification of state RSS area data and interpretations
 - (2) Creating SSURGO export from NASIS to support RSS publication and delivering to Regional Office staff
 - (3) Promoting RSS products to internal and external customers and providing technical assistance in their use
4. MLRA Soil Survey Offices—
 - a. Completing digital soil mapping training
 - b. Managing and populating MLRA and initial projects in NASIS
 - c. Providing supporting documentation and detailed logic on raster class (map unit) development using pedons and detailed text notes linked to the project and component data in NASIS
 - d. Conducting quality control for projects and spatial and tabular data, including pedon data entry
 - e. Providing quality-controlled projects to Regional Office staff for quality assurance
 - f. Promoting RSS products to internal and external customers and providing technical assistance in their use
5. FPAC-GEO Branch—
 - a. Assisting regions and the NSSC with publication and resolving problems related to submitting raster data to the Geospatial Data Gateway
 - b. Providing technical assistance on metadata development

E. Metadata.—Metadata describes the contents and characteristics of a dataset. It provides a concise summary of the procedures used to generate the data. The level of detail provided may vary depending on

the dataset in question. For example, gNATSGO includes SSURGO, STATSGO2, and RSS. Therefore, the metadata for gNATSGO does not include an exhaustive summary of each component sub-dataset. Regardless, more granular information should be documented within the NASIS project for each RSS project.

1. A broad overview of RSSs will be provided on a separate agency web page.
2. NASIS projects should document all the processing steps (see chapter 5 of the Soil Survey Manual) and correlation decisions used to generate the data. This may include the information specified in part 610 of this handbook, in addition to the following details:
 - a. Data sources and preprocessing
 - b. Sampling strategy and the quantity and source of documentation used in the modelling process (e.g., pedons, transects)
 - c. Soil classes (map units) or properties and preprocessing steps (e.g., legend development, depth function transformations)
 - d. Modeling methods (e.g., classification method, membership functions, logistic regression, multivariate regression, etc.)
 - e. Evaluation approaches and accuracy assessment (e.g., data-splitting)
 - f. Post-processing and SSURGO development (e.g., filtering and clumping, correlation decisions)
3. A summary of the processing steps for individual projects should be copied to the NASIS Legend Certification History table and metadata documents as projects are certified. A separate metadata process step will detail each project amended to the state RSS area. This summary will begin with a brief narrative statement confirming the certification, and will also include:
 - a. Tabular reference (for project)
 - (1) Legend Area Overlap Type: Raster Soil Survey Project
 - (2) Legend Area Overlap Symbol
 - (3) Legend Area Overlap Name
 - (4) Conversion Legend (for referencing confusion matrix)
 - b. Raster Soil Survey Level (see figure 648A-2)
 - c. Model Development (details)
 - (1) Data referenced for model training
 - (a) Number
 - (b) Source
 - (c) Sample design
 - (2) Digital environmental data
 - (a) Data sources
 - (b) Number of covariates used
 - (c) Data resolution
 - (3) Modeling methods
 - d. Map Accuracy
 - (1) Error matrix
 - (2) Validation data source
 - (a) Sample design
 - (b) Considerations of confidence and precision
 - (c) Spatial tolerance
 - (d) External or internal validation
 - (3) Overall accuracy metrics
4. The format for metadata may be either FGDC CSDGM or ISO19115. The FGDC is moving towards the ISO format.
 - a. Metadata development avoids the use of escape characters such as:

- (1) double quotes (“ ”)
 - (2) single quote or apostrophe (’)
 - (3) greater than (>)
 - (4) less than (<)
 - (5) ampersand (&)
5. Additional information on metadata can be found on the FGDC web page.

F. Levels of Raster Soil Survey

1. **Significance.**—Vector-based soil surveys are made by delineating areas that represent soil-landscape relationships. Soil surveys are produced with varying levels of intensity depending upon the management needs of the project area. Similarly, RSSs may vary by levels of precision and accuracy. RSS spatial representation may increase from detailed spatial patterns to aggregate landscape units with a decrease in intensity and is supported by accompanying accuracy and uncertainty metrics.
2. **Usage.**—RSS levels have similar considerations to Soil Survey Order as defined in chapter 4 of the Soil Survey Manual. Soil Survey Order is defined by field procedures which affect the minimum mappable area. RSS level decreases with more intensive soil survey projects, in a similar fashion as Soil Survey Order (see figure 648A-2). Level A and Level B RSSs represent intensive soil survey projects that build upon existing detailed soil survey information. Level C, Level D, and Level E RSSs are considered extensive soil survey projects and may inform broadly framed update projects and initial soil survey investigations.
3. RSS levels are documented upon project certification in Map Unit Text (Kind: Certification Statement, Category: Raster Soil Survey, Subcategory: level, Text Entry: A, B, C, D, E).
Considerations for RSS level are:
 - a. **Observation Density and Spatial Distribution.**—Density of observations, as generally defined across the project area, is evaluated both in spatial extent across the project and in feature space related to the distribution of covariate values relevant to classification.

The minimum number of observations per correlated, modeled class varies with RSS level. RSS Level A requires a minimum of 15 observations, RSS Level B, a minimum of 10, and RSS Level C and D a minimum of 5 observations, and RSS Level E has very low observation density, often less than 5 observations per class.
 - b. **Class Representation.**—Class representation is an accounting of training data observations per class (i.e., RSS map units) within the RSS project area. Ideally, observations should be evenly distributed in both feature and geographic space.

Class Balance – Class balance refers to the number of observations per modeled class. Ideally, balanced data contain a nearly uniform number of observations per class. Conversely, imbalanced data have a highly variable number of observations per class.
 - c. **Raster Soil Survey Map Unit Kind.**—Soil map units differ in their degree of contrast with adjacent and associated soils (see section 627.3). The map units of RSSs have similar kinds and definitions to conventional soil map units but with unique considerations as follows:
 - (1) **Consociations.**—The named major component of a consociation map unit is a single major soil meeting the criteria for the taxonomic class (series, family, or taxadjunct) used to name the map unit with ranges that may include similar soils. The major component is expected to be present in mapped areas. Mapping intent matches the correlated RSS consociation map unit. Mapped areas are dominated by a single family-level taxonomic class. At least one-half of the pedons in the map unit match all the most relevant diagnostic features of the named soil, and this is confirmed through published map accuracy. Most misclassifications do not have a significant effect on major interpretations. Major component range in characteristics

typically capture about 80 percent of observed variability, and minor soils are limited.

Prediction uncertainty in most areas is expected to be low.

- (2) Association.—The named major components represent a broad expression of limitations and potential for use and management. For an association map unit in an RSS, the final classification is broadly defined. Mapped areas are composed of two or more dissimilar taxonomic classes, commonly expressed above the family level. Major components are less commonly present in mapped areas, and proportions are expected to vary appreciably. Published accuracies may be lower than common thresholds, and areas may have high prediction uncertainty. This may occur where the spatial resolution is not fine enough to separate the soil components (e.g., > 10 m).
 - (3) Complexes.—The named major components of a complex map unit consist of two or more soils meeting the criteria for the taxonomic class (series, family, taxadjunct, or higher taxa) used to name the map unit plus similar soils. Major components are most expected to be present in mapped areas, although the proportions may vary appreciably. Mapping intent may match or be broader than the correlated RSS complex map unit. Mapped areas are dominated by two dissimilar taxonomic classes. Typically, at least one-half of the pedons in the map unit match all the most relevant diagnostic features of the named soils, and this is confirmed through published accuracy. Major components are geographically associated soils that best represent the variability of mapped areas.
 - (4) Undifferentiated Groups.—The RSS undifferentiated group map unit may commonly be broader than the mapping intent. Mapped areas are composed of two or more dissimilar taxonomic classes. Major components are less commonly present in mapped areas, and proportions are expected to vary appreciably. The major components of an undifferentiated group map unit consist of soils meeting the criteria for the taxonomic class (series, family, taxadjunct, or higher taxa) used to name the map unit plus similar soils. Published accuracies may indicate that less than one-half of the pedons in the map unit or areas match all the most relevant diagnostic features and may display high prediction uncertainty.
- d. Modeling Data Resolution.—“Resolution” in this context refers to the finest spatial resolution of the covariate data used for modeling and the resulting classification, independent of the published spatial resolution (e.g., 10 m) and the minimum legible area (MLA). The MLA can be determined by the map scale number and the minimum legible delineation (section 648.13) and commonly increases with increased data resolution. Therefore, RSS Level A has a smaller MLA size compared to RSS Level E.
 - e. Map Accuracy.—“Accuracy” refers to overall map accuracy of the final RSS product as computed in a confusion matrix. Overall map accuracy is tabulated following correlation and resampling. Overall accuracy may be reported as geographically weighted to account for class proportionality. Observations must be discretely and consistently correlated to a single class. However, the map unit data may broaden to account for geographic association and uncertainty. Additional methods of accuracy (figure 648A-5) are also encouraged to evaluate model performance.

Figure 648A-2: Raster Soil Survey Levels and Characteristics¹

RSS Level	Observation Density ²	Spatial Distribution	Class (Map Unit) Representation	RSS Map Unit Kinds	Modeling Data Resolution (m) ³	Validation Methods	Final Map Accuracy (%)
Level A	≥ 15 observations per class	80-90% of project area has observations that are evenly distributed	Balanced class representation	Consociations, some complexes, and undifferentiated groups	≤ 10	External validation procedures; independent validation	≥ 70
Level B	≥ 10 observations per class	70-80% of project area has observations that are evenly distributed	Little to no class representation issues Data may not be representative of the spatial distribution of complexes	Consociations, some complexes, and undifferentiated groups	5 to 10	External validation procedures; data splitting validation	≥ 60
Level C	≥ 5 observations per class	50 to 70% of the project area has observations that are evenly distributed	Little to moderate class representation issues Data may not be representative of the spatial distribution of complexes	Mostly complexes and consociations with some undifferentiated groups	10	External validation procedures; data splitting validation	≥ 60
Level D	≥ 5 observations per class	25 to 50% of the project area has observations that are evenly distributed	Moderate class representation issues	Mostly complexes and consociations with some undifferentiated groups and minimal associations	10 to 30	Internal validation procedures; resampling method	≥ 50
Level E	very low observation density	Less than 25% of the project area has observations that are evenly distributed	Class representation issues are likely present with majority of observation data being sporadic and remotely sensed	Contains mostly complexes and associations	≥ 30	Internal validation procedures; resampling method	≥ 30

¹ The columns for observation density, modeling data resolution, validation methods, and final map accuracy list the minimum standards for each RSS level. More stringent methods may be used for any given project depending on project needs.

² This minimum number reflects the amount of training data necessary to properly capture the class variability within feature space.

³ See section 648.13 for relationship of data resolution to minimum legible area.

648.2 Soil Landscapes of the United States

- A. Continuous Property Mapping.—This type of mapping predicts physical or chemical soil properties in horizontal and vertical dimensions. The soil properties are represented across a continuous range of values.
 1. Continuous property maps are named “SOLUS.”
 2. Raster datasets of select soil properties are predicted at specified depths or depth intervals.
 3. SOLUS is developed through collaboration of Soil and Plant Science Division staff and NCSS cooperators and coordinated by the NSSC.
 4. The target for SOLUS maps is a pixel that stores a quantitative value for the respective property.
 5. SOLUS maps will be delivered online as individual raster datasets for each property and each depth with corresponding uncertainty datasets representing the prediction interval high, low, and width or relative prediction interval.
- B. Procedure
 1. SOLUS continuous property maps will be generated at specified depths or depth intervals
 - a. GlobalSoilMap standards (GlobalSoilMap Science Committee 2015) specify the following intervals: 0-5 cm, 5-15 cm, 15-30 cm, 30-60 cm, 60-100 cm, 100-200 cm; however, other depths or depth intervals may be preferable and specific to a given dataset and are acceptable for SOLUS products.
 - b. Unless necessity dictates otherwise, the following standard depths are recommended: 0 cm, 5 cm, 15 cm, 30 cm, 60 cm, 100 cm, and 150 cm.
 - c. Several methods exist to harmonize soil profile depths by resampling genetic horizon depths to fixed or ad hoc depths or intervals. Examples include simply segmenting the original genetic horizons into new depths, computing weighted averages over the fixed depth intervals, or interpolating new depths or intervals using splines (e.g., mass preserving equal area) (Beaudette et al. 2016; Minansy et al. 2016; Nauman et al. 2019).
 2. SOLUS continuous properties will, at a minimum, include all the following:
 - a. Total profile depth (cm)
 - b. Depth to restriction (cm)
 - c. Organic carbon (g/100 g)(%)
 - d. pH
 - e. Sand (g/100 g)(%)
 - f. Silt (g/100 g)(%)
 - g. Clay (g/100 g)(%)
 - h. Gravel ($\text{m}^3 \text{ m}^{-3}$)(%)
 - i. Effective Cation Exchange Capacity (ECEC)(meq/100 g)
 - j. Bulk density of fine earth (< 2 mm) fraction (excluding gravel) (g/cm^3)
 - k. Bulk density of whole soil (including gravel) (g/cm^3)
 - l. Available water holding capacity (cm)
 3. Published spatial resolution for SOLUS maps will initially be 100 m but may vary with the version of the product and be seamless for the contiguous United States (CONUS) and other states and territories outside the contiguous United States (OCONUS). The minimum legible area can be determined by the map scale number and the minimum legible delineation and commonly increases with increased data resolution. Therefore, as spatial resolution increases, so does the minimum legible area.

Title 430 – National Soil Survey Handbook

4. SOLUS products are quantitatively validated as part of the modeling process using accepted validation methods (see section 648.3). These estimates of accuracy and uncertainty are published alongside the raster soil maps and published in the metadata. Examples are root mean square error, mean error, and prediction intervals.
5. Spatial data resulting from SOLUS property mapping are aligned to the state gSSURGO or gNATSGO MUKEY grid and delivered using the following projected or geographic coordinate system:
 - a. CONUS: NAD 1983 Contiguous USA Albers (EPSG 5070)
 - b. Puerto Rico and U.S.V.I: NAD 1983 State Plane Puerto Rico Virgin Islands FIPS 5200 (EPSG 32161)
 - c. Hawaii: WGS84 (EPSG 4326)
 - d. Alaska: Alaska Albers Equal Area Conic (EPSG 3338)
 - e. PAC Basin (FM – Federated States of Micronesia, GU – Guam, MH – Marshall Islands, MP – Northern Mariana Islands, PW – Palau): WGS84 (EPSG 4326)
 - f. American Samoa: WGS84 (EPSG 4326)

C. Mapping Data Development

1. Spatial Data.—Spatial data used for digital soil mapping projects meets the National Standard for Spatial Data Accuracy, set forth by the Federal Geographic Data Committee (FGDC). This organized structure of federal geospatial professionals and constituents provide executive, managerial, and advisory direction and oversight for geospatial decisions and initiatives across the Federal Government.
 - a. The data is coordinated and validated by NSSC staff to ensure the consistency of coordinate systems, proper selection of datum transformations, resampling techniques, resolution, data types, coregistration, and so on. Examples of data used include those listed below, although many options exist for data and derivatives beyond those presented here. See relevant job aids at the GIS and Digital Mapping for Soil Survey web page.
 - b. Digital elevation models (SRTM, NED, IFSAR, LiDAR) and derivatives
 - (1) Slope gradient
 - (2) Slope aspect
 - (3) Topographic wetness index
 - (4) Slope curvature (total, profile, plan, tangential, etc.)
 - c. Spectral data (LANDSAT, Sentinel) and derivatives
 - (1) Band ratios
 - (2) Tasseled Cap Transformation
 - (3) Principal components
 - d. Thematic data
 - (1) National Land Cover Database
 - (2) Gap Analysis Program
 - (3) Landforms
 - (4) National Wetland Inventory
 - e. Climatic data
 - (1) PRISM
 - (2) Water balance
 - (3) Incoming solar radiation

2. Data Capture.—Soil properties are predicted from soil observations and environmental data using digital soil mapping methods, such as regression or interpolation. For more detailed information on digital soil mapping, see chapter 5 of the Soil Survey Manual.
 - a. Soil observations (training and validation data) are curated from existing data sources, such as the NCSS Soil Characterization Database or NASIS pedons, and are scrutinized for quality
 - b. A map of prediction uncertainty is produced for each property and depth interval representing the 90- or 95-percent prediction interval (high, low, width, or relative prediction interval)
 - c. The primary spatial entity is a pixel, and the initial spatial resolution will be 100 m
 - d. The naming convention will be “SOLUS,” followed by the spatial resolution (e.g., SOLUS100 for 100 m spatial resolution maps)
 - e. NASIS projects will be developed for each version of SOLUS using the following naming convention: SOLUS_spatialresolution_fiscalyear (e.g., SOLUS_100_2023)
 - f. The raster datasets will be delivered as compressed tagged image format (.tif) by property and depth (property_depth_units_x) online with the following naming convention (e.g., clay content at 5 cm):
 - (1) claytotal_5_cm_p (predicted property values)
 - (2) claytotal_5_cm_w (prediction interval width)
 - (3) claytotal_5_cm_rpi (relative prediction interval)
 - (4) claytotal_5_cm_l (prediction interval low)
 - (5) claytotal_5_cm_h (prediction interval high)
- D. Responsibilities.—National headquarters provides overall direction, policy, guidance, and leadership for the NCSS within NRCS. See section 608.1 of this handbook for more detailed information on the responsibilities of national headquarters and the other NRCS offices mentioned in this section.
 1. The National Soil Survey Center—
 - a. NASIS SOLUS project support
 - b. RSS Research
 - c. RSS Analysis
 - d. Coordination of SOLUS property mapping
 - (1) Developing of maps and metadata
 - (2) Soliciting qualitative review
 - (3) Updating products annually
 - (4) Packaging and delivering SOLUS to an online repository, web, and map services
 2. Soil Survey Regional Offices—
 - a. Ensuring soil scientists receive digital soil mapping training
 - b. The qualitative review of SOLUS
 3. MLRA Soil Survey Offices—
 - a. Completing digital soil mapping training
 - b. The qualitative review of SOLUS
- E. Metadata.—Metadata describes the contents and characteristics of a dataset. It provides a concise summary of the procedures used to generate the data. The level of detail provided may vary depending on the dataset in question. Granular information should be documented within the NASIS project for each SOLUS version.
 1. A broad overview of SOLUS will be provided on a separate agency web page.
 2. NASIS projects should document all the processing steps (see chapter 5 of the Soil Survey Manual) and decisions used to generate the data. This may include the following details (see section 648, subpart B for an example):

- a. Data sources and preprocessing
 - b. Sampling strategy and the quantity and source of documentation used in the modelling process (e.g., pedons)
 - c. Properties and pre-processing steps (e.g., data transformations, depth function transformations)
 - d. Modeling methods (e.g., regression type, parameters)
 - e. Evaluation approaches, accuracy, and uncertainty methods (e.g., data-splitting)
 - f. Post-processing (e.g., masking)
3. A summary of the processing steps should be included in metadata documents as projects are certified. This summary will begin with a brief narrative statement confirming the certification and will also include:
- a. Reference to NASIS project
SOLUS project name for current version as populated in NASIS
 - b. Model development (details)
 - (1) Data referenced for model training
 - (a) Number
 - (b) Source
 - (c) Sample design
 - (2) Digital environmental data
 - (a) Data sources
 - (b) Number of covariates used
 - (c) Data resolution
 - (3) Modeling methods
 - c. Prediction accuracy
Validation data source
 - (a) Sample design
 - (b) Considerations of confidence and precision
 - (c) Spatial tolerance
 - (d) External or internal validation
 - d. Prediction uncertainty
Uncertainty method and associated parameters
 - e. Resulting datasets, including individual layer names and version
4. The format for metadata may be either FGDC Content Standard for Digital Geospatial Metadata or ISO19115. The FGDC is moving towards the ISO format.
Metadata development avoids the use of escape characters such as:
- (1) double quotes (“)
 - (2) single quote or apostrophe (‘)
 - (3) greater than (>)
 - (4) less than (<)
 - (5) ampersand (&)
5. Additional information on metadata can be found on the FGDC web page.

648.3 Accuracy and Uncertainty

- A. Significance.—The quality control (QC) and quality assurance (QA) process for traditional soil mapping is based on many forms of evaluation and relies heavily on qualitative information (e.g., field experience, expert knowledge, institutional knowledge). RSS validation relies on the same qualitative information and incorporates quantitative approaches to evaluating mapping results. The goal is to account for and communicate the variability inherent in soil and associated environmental systems. It is recommended

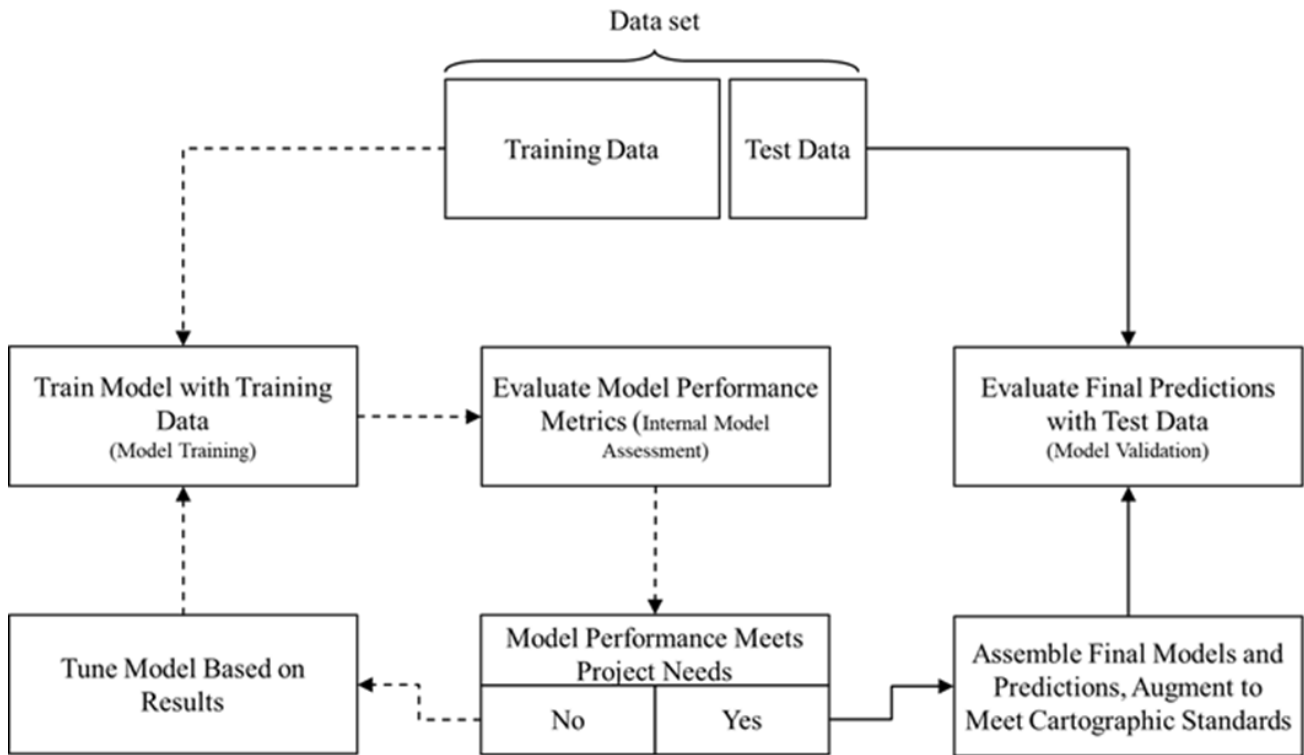
that more than one method of both accuracy and uncertainty be used to evaluate the results of the digital soil mapping project to explore, correlate, and communicate prediction results.

- B. Usage.—Metrics for accuracy and uncertainty may be generated throughout the modeling process. Appropriate handling of observation data and a clear distinction between data utilized for building versus assessing models is imperative (see figure 648A-3). The following definitions represent the basic principles and key components of accuracy and uncertainty metrics.
1. Training Data.—A set of data gathered, correlated, and assembled for use in model training only. A probabilistic sampling design is recommended.
 2. Test Data.—A set of data for use in validation activities to calculate measures of accuracy and uncertainty. These data may be obtained by data splitting or collected independently.
 - a. Data Splitting.—Techniques whereby data are split into one or more training and test datasets. Various strategies may be employed depending on data availability and the complexity of the modeling needs.
 - (1) If the original sample design was probabilistic and data is abundant, the data can be split into unique training and test datasets. The test data is set aside for external model validation, discussed below. This data is not used in model training.
 - (2) If the data are split more than once during model training, the process is referred to as resampling. Common examples of resampling are bootstrapping and cross-validation. The test data set in this scenario is sometimes referred to as “calibration data” (Zumel and Mount 2020), an “assessment set” (Kuhn and Johnson 2020), or a “validation set” (Hastie et al. 2009; James et al. 2021).
 - b. Independent Test Data.—A set of test data that is gathered completely separately from the training data to assess the quality of the prediction. Not used in model training.
 3. Model Training.—The development of a model utilizing the training data set.
 4. Internal Model Validation.—The assessment of a model’s accuracy and uncertainty utilizing test data derived from resampling methods (Harrell 2015, Guisan et al., 2017). This approach is sometimes referred to as “model calibration” (Zumel and Mount 2020) or “model assessment.”

Data from test set splits may be utilized for final map validations when resources for a full independent validation are not available. These methods are the minimum standards for RSS Levels D and E in section 648.1.
 5. External Model Validation.—The assessment of a model’s accuracy and uncertainty utilizing a unique test dataset. Sometimes this approach is referred to as “map validation,” “final validation,” “external validation,” or “independent validation.”
 - a. Test data used in external model validation can be derived from either independent sample designs or a unique test set derived from data splitting methods (see figure 648A-4).
 - (1) Independent Validation.—Test data for independent validation are derived from a stratified random sampling design based on the final model (Stehman and Foody 2019). An equal number of samples per class or a weighting scheme, such as class spatial proportion, should be employed to determine sample stratification.
 - (a) This approach is the most stringent and only recommended with a sufficiently large sample size of test data (Brus et al. 2011; Harrell 2015)
 - (b) Independent validation is the minimum standard for RSS Level A in section 648.1
 - (2) Data Splitting Validation.—Final validation using a unique set of test data derived from data splitting techniques
 - (a) This approach is useful where data are limited but still numerous enough to perform a final model evaluation
 - (b) Data splitting validation is the minimum standard for RSS Levels B and C in section 648.1

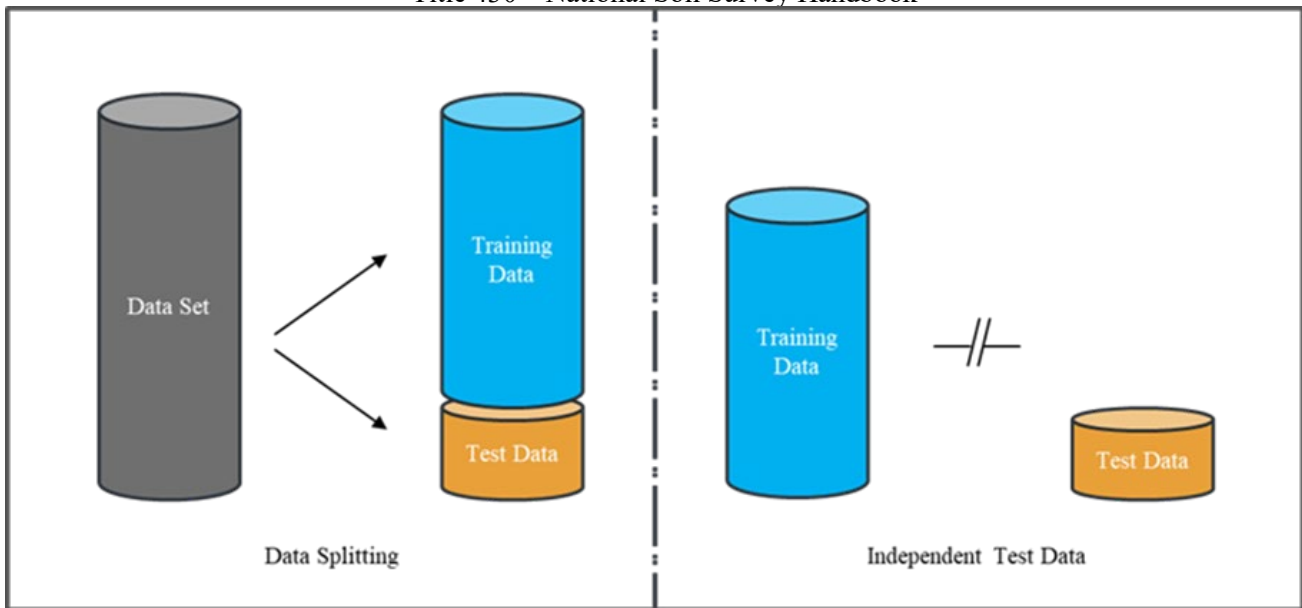
- b. Knowledge-based classification can only be evaluated using external model validation
- c. Combining disparate modeling methods requires external model validation for assessment

Figure 648A-3: Modeling and Validation Workflow



A modeling and validation workflow diagram that starts with training and test data. Using training data, you can conduct model training, complete an internal model assessment, and review that the model performance meets the project needs. If the model does not meet your project needs, you should tune the model based on results and go back at the model training. If the model does meet your project needs, you should assemble the final models and predictions, and then augment it to meet cartographic standards. You will then conduct a model validation to evaluate the final predictions with the test data. You may also start with the training and test data to conduct a model validation to evaluate the final predictions with the test data.

Figure 648A-4: Data Sets Utilized in the Model Training Process. Left: A Data Set Compiled and Split into Two Unique Training and Test Data Sets. Right: An Independent Test Data Set Where Training and Test Datasets Were Compiled Independently of One Another.



C. Suggested Methods of Accuracy and Uncertainty

1. Many options exist to generate metrics for accuracy and uncertainty to assess prediction quality. Appropriate methods should be chosen based on whether classification or regression was employed to create the final model and map. Classification is used to generate RSSs, and regression is used to generate SOLUS products. See the figure 648A-5 through 648A-8 for recommended methods for each approach.
2. Calculation of more than one measure of accuracy and uncertainty is common practice. Methods that allow for weighting class distances or probabilities (e.g., “degrees” of right or wrong) are encouraged.

Figure 648A-5: Suggested Methods of Class Accuracy¹

Method	Description	Pros	Cons	Reference
Overall Accuracy	The proportion of correctly classified observations as tabulated in the confusion matrix. ²³	Simple to calculate and interpret, based entirely on the confusion matrix.	Does not account for mistakes due to chance. Does not incorporate prior knowledge of class proportions. Does not incorporate class similarity. Does not incorporate information contained within vector of predicted probabilities. ⁴	Story and Congalton 1986
Kappa Coefficient	An index that represents the agreement between predicted and observed values and accounts for chance agreement.	Easily calculated from the confusion matrix Generated by most software packages along with the confusion matrix	Interpretation of Kappa values between 0 and 1 is largely arbitrary. A value of < 0 indicates no agreement, and a value of 1 indicates perfect agreement. Recommended to use Kappa along with other measures of accuracy. Numerous authors now question the utility and assumptions of Kappa.	Congalton and Mead 1983; Foody 2020
Tau Index	An index of agreement that accounts for agreement by chance—effectively a replacement for Kappa.	The index is more informative when appropriate class proportions are supplied. Index values can be referenced to concepts such as “better” or “worse” than random allocation.	Appropriate prior class proportions are method dependent. Interpretation requires some training.	N/A
Weighted Tau Index	Alternative version of the tau index that accommodates class similarity.	The index is more informative when appropriate class proportions are supplied. Class similarity down-weights mistakes between similar classes.	Appropriate prior class proportions are method dependent. There is no universal method for estimating class similarity weights. Interpretation requires some training.	Rossiter et al. 2017

¹ The “overall accuracy” and unweighted Tau index are computed from the confusion matrix.

² The rows within the confusion matrix record counts of predicted classes, and the columns record counts of actual classes.

³ The row-wise proportion of correct entries in the confusion matrix is typically described as the “user’s accuracy” (map unit purity). The column-wise proportion of correct entries in the confusion matrix is typically described as the “producer’s accuracy” (or soil class representation).

⁴ Most predictions from a model of soil classes are represented as a vector of class-wise probabilities typically associated with each pixel in the modeling domain. Entries within the confusion matrix use only the most likely (highest probability) class.

Title 430 – National Soil Survey Handbook

Brier Score	In the case of binary outcomes (e.g., 1 vs. 0), it is equivalent to the Mean Square Error, where a positive outcome equals 1 minus the predicted probability. For multinomial outcomes, the squared error is averaged for all classes. Lower values denote higher accuracy.	Integrates more information about predictions (all probabilities) vs. the most likely class used by overall accuracy or tau index.	Interpretation requires some training. Does not incorporate prior knowledge of class proportions. Does not incorporate class similarity.	Brier 1950; Harrell 2015
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Table 648A-6: Suggested Methods of Class Uncertainty¹

Method	Description	Pros	Cons	Reference
Shannon Entropy	Quantitative measure of “information,” “complexity,” “certainty,” or “diversity” contained within a vector of probabilities. Larger values denote less information, higher complexity, less certainty, and greater diversity.	Integrates “confusion” over all probabilities. Entropy values from different models (e.g., differing numbers of classes) can be directly compared.	May not be implemented in all software packages.	Shannon 1948
Normalized Shannon Entropy	An alternate version of Shannon Entropy that is constrained to the interval [0,1].	Integrates “confusion” over all probabilities. Constrained to [0,1].	Cannot be used to compare models with differing numbers of classes. May not be implemented in all software packages.	Kempen et al. 2009
Confusion Index	An index of confusion among the top two most likely classes.	Simple calculation and constrained to [0,1].	Cannot be used to compare models with differing numbers of classes. Only describes uncertainty of top two classes. May not be implemented in all software packages.	Burrough et al. 1997

¹ Differences between Shannon Entropy and the Confusion Index are more pronounced when there are a large number of classes or median class probability is low (e.g., there is no clear dominant class in the predictions).
(430-648-H, 1st Ed., Amend. 40, June 2023)

Table 648A-7: Suggested Methods of Regression Accuracy for Soil Properties

Method	Description	Pros	Cons	Reference
Mean Error (ME)/Prediction Error/Bias	Quantifies whether the overall error is positive or negative; the closer to 0, the better.	In the same units as the original values.	N/A	N/A
Mean Square Error (MSE)	Squared estimate of the average error size.	N/A	Not in the same units as the original values.	N/A
Root Mean Square Error (RMSE)	Positive estimate of the average error size; the smaller, the better.	In the same units as the original values	N/A	N/A
Coefficient of Determination (R^2)	Explains the proportion of variance.	Values range between 0 and 1. Values < 0 can occur if the prediction is worse than simply predicting the average value.	Over-optimistic when extreme values or skewed distributions are present. Often confused with the squared Pearson's correlation coefficient.	Kutner et al. 2004; Zumel and Mount 2020

Table 648A-8: Suggested Methods of Regression Uncertainty for Soil Properties

Method	Description	Pros	Cons	Reference
Standard Error (SE)	Error in the model parameters (e.g., coefficients or overall prediction).	N/A	N/A	N/A
Confidence Interval (CI)	Conversion of the SE to an interval according to a given probability (e.g., 95 percent); its range is narrower than the prediction interval.	N/A	Assumes a normal distribution, unless transformed or bootstrapped.	Webster 2001
Prediction Interval (PI)	Interval designed to capture the range in values of a prediction according to a given probability.	N/A	N/A	N/A
Relative Prediction Interval	Ratio of the 95 percent prediction interval range to the 95 percent observed inter-quantile range in values. Can use different probability values (e.g., 90 percent PI to 90 percent inter-quantile range).	Typically ranges between 0 and 1; values larger than 1 indicate very high model uncertainty. No distribution assumptions.	N/A	Nauman and Duniway 2019

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Part 648 – Digital Soil Mapping – Raster Products for Soil Survey

Subpart B – Exhibits

648.10 Glossary

- A. Accuracy.—The difference between the predicted value at a location and the measured or observed value at the same location. For overall accuracy, this is the proportion of correctly allocated instances to the most probable class.
- B. Class (soil).—Discrete representation of soil information based on a range of shared values or attributes (e.g., environmental, spectral, SSURGO, lab)
- C. Continuous raster.—A type of raster used to communicate information on a topic that varies progressively across a surface for phenomena that have no distinct borders, such as temperature, precipitation, or elevation.
- D. Geostatistics.—A range of statistical techniques for modeling spatial patterns as a function of distance to adjacent observations.
- E. ISODATA.—Iterative Self Organizing Data Analysis Technique; a variation on k-means clustering.
- F. K-means clustering.—An iterative process that creates class clusters in data and classifies pixels until the change of class assignment at each pixel location is small and final classes are defined.
- G. Knowledge-based classification.—Prediction methods that use an expert’s knowledge as rules and data within an inference engine to predict target classes.
- H. Map unit key.—Often represented in its shorthand notation, MUKEY. This value comes from the NASIS legend map unit ID column and relates a map unit to its legend and a component to its map unit.
- I. Pixel.—The smallest unit of information represented in a raster, typically square. Alternatively referred to as a “grid cell.”
- J. Prediction interval.—A measure which reports the range of values within which the true value is likely to occur (e.g., a 90-percent prediction interval indicates the range in values in which a new measurement will be found 9 times out of 10).
- K. Predictive modeling.—The process of developing a mathematical model that approximates the true relationship between soil classes or properties and environmental covariates to produce an accurate prediction (e.g., tree-based models, regression).
- L. Raster.—A regular grid or array of cells covering a spatial area. A raster is often viewed as consisting of rows and columns of grid cells.
- M. Supervised classification.—Prediction methods that require soil observations (training data) covering the area of interest and the target classes. Class definitions from training data are combined with carefully selected environmental data, and the applied algorithm assigns a class to each pixel.
- N. Uncertainty.—For continuous data types, the prediction interval is used to communicate a range of values within which the true value at any prediction location is expected. For example, a 90-percent prediction interval is often used and indicates the range of values in which a new measurement is likely to occur 9 times out of 10 (or 90 percent of the time). For categorical data types (class data), a numerical value conveying confidence for the predicted outcome. An increase in the number of potential outcomes indicates a higher degree of uncertainty present within the model.
- O. Unsupervised classification.—Exploratory methods most reliant on computer automation and the only method that does not require soil observations (training data) covering the area of interest. The algorithm uncovers statistical patterns inherent in the data and groups pixels with similar characteristics into unique clusters (classes) based on statistically determined criteria.

648.11 Digital Soil Mapping Workflow

- A. The generalized stages of a digital soil mapping workflow identified in the Soil Survey Manual.
1. **Define area and project scope**
 - a. Define and refine objective: soil classes or properties
 2. **Identify physical features of interest**
 - a. Important covariates and appropriate data
 - b. Scale of processes and measurements
 - c. Available measurements (field and remote sensing)
 3. **Data sources and preprocessing**
 - a. Identify and acquire data
 - b. Assess data quality
 - c. Organize data
 - d. Preprocess data
 4. **Data exploration and landform analysis**
 - a. Derive terrain and spectral data products
 - b. Select appropriate predictors
 5. **Sample for training data**
 - a. Case-based and a priori samples
 - b. Field samples
 - (1) Review and assess:
 - (a) Do the data layers represent the important environmental covariates?
 - Yes—proceed to stage 6
 - No—return to stages 2, 3, and 4
 - (b) Are the training data adequate to predict the classes or properties of interest?
 - Yes—proceed to stage 6
 - No—return to stage 5
 6. **Predict soil classes or properties**
 - a. Choose and apply appropriate prediction method
 - (1) Soil classes – unsupervised or supervised classification, predictive modeling
 - (2) Soil properties – predictive modeling, geostatistics
 - (a) Review and assess:
 - Are the prediction results reasonable?
 - Yes—proceed to stage 7
 - No—apply a different prediction method, combination of predictors, or set of training data—return to stages 4, 5, and 6
 7. **Calculate accuracy and uncertainty of results**
 - a. Review and assess:
 - (1) Are accuracy and uncertainty results acceptable?
 - (a) Yes—proceed to stage 8
 - (b) No—revisit prediction method, predictors, and training data—return to stages 4, 5, and 6
 8. **Apply digital soil mapping**
 - a. Produce soil class or property maps
 - b. Evaluate existing maps
 - c. Create soil information products
 - d. Apply to other disciplines

648.12 Raster Soil Survey Areas

1	AK	16	HT	31	MP	46	PA
2	AL	17	IA	32	MS	47	PR
3	AR	18	ID	33	MT	48	PW
4	AS	19	IL	34	MX	49	RI
5	AZ	20	IN	35	NC	50	SC
6	CA	21	KS	36	ND	51	SD
7	CO	22	KY	37	NE	52	TN
8	CT	23	LA	38	NH	53	TX
9	DC	24	MA	39	NJ	54	UT
10	DE	25	MD	40	NM	55	VA
11	FL	26	ME	41	NV	56	VT
12	FM	27	MH	42	NY	57	WA
13	GA	28	MI	43	OH	58	WI
14	GU	29	MN	44	OK	59	WV
15	HI	30	MO	45	OR	60	WY

648.13 Map Scale

- A. Map scale, or cartographic scale, is the ratio of the ground distance to the map distance. Typically, the ratio is 1 cm on the map equals 24,000 cm on the ground; this is written as 1:24,000. The denominator is referred to as the scale number (SN). Besides providing a conversion between the map and ground distances, the map scale limits the size of the minimum legible delineation (MLD) and the precision with which points can be plotted on the map (Forbes et al. 1987; Eswaran et al. 1981; Rossiter 2000). The MLD is the smallest size a polygon on a map can be before the map unit symbol is no longer legible. Therefore, the MLD is a function of the SN and minimum legible area (MLA), whereby $SN = \sqrt{(MLA/MLD)}$. In contrast with the MLD, the MLA⁹ is the smallest area on the ground a polygon can be (section 648.13).
- B. The MLD is arbitrary, but for consistency, the USDA uses a MLD of 0.4 cm² (Soil Survey Staff 1993)¹⁰. In the case of raster data, both Tobler (1987) and McBratney et al. (2003) suggested a MLD of 0.01 cm². Additionally, with raster data it is necessary to multiply the MLA by a factor of 4 or increase the scale by a factor of 2 (Tobler 1987; Rossiter 2000; McBratney et al. 2003) to delineate polygons from the raster data layer. This is not to say that smaller objects do not exist, just that they are too small to be displayed appropriately at that scale. Thus, the MLA of polygons delineated from a 10 m raster should be 400 m² in size (i.e., (10 × 2)²). For example, to delineate a polygon from a collection of neighboring pixels, their minimum combined area should total 4 pixels.
- C. An important point to note about map scale is that while 1:24,000 vector maps can be rasterized to a resolution of 10 m, this transformation does not change the inherent scale of the data. The same is true of raster data resampled to finer resolutions (e.g., from 10 m to 5 m) by nearest neighbor or other conventional GIS interpolation approaches. A change in the scale of the data only occurs when either vector or raster data is aggregated to a larger MLA. Such an aggregation or rescaling is necessary when converting an RSS to SSURGO, so the polygons generated from the RSS have the same MLD as

⁹ The 1993 Soil Survey Manual uses the term, minimum size delineation, instead of the MLA, which is inconsistent with the other literature.

¹⁰ While the 1993 Soil Survey Manual lists 0.06cm² in the text, table 2-2 (on the same page) and table 2-1 actually correspond with 0.4cm², which is consistent with the USDA standard discussed by Eswaran et al. (1981).

SSURGO. The original scale of an RSS is determined by the smallest resolution of the covariates used to develop it (see figure 648A-2).

- D. It is generally assumed that maps with smaller scale numbers (i.e., more detailed maps) are more accurate; however, this is not always the case. Scale and accuracy are different properties of maps. Generally, it is true that more detailed covariates result in stronger correlations with soil properties (Roecker and Thompson 2010; Maynard and Johnson 2014) and higher accuracies. However, there is typically a threshold below which finer resolution grid sizes result in more noise and less signal (e.g., lower accuracies). This is also true for the spatial support of digital soil mapping (DSM) predictions. For example, Bishop et al. (2015) and Han et al. (2022) demonstrated more accurate predictions with larger supports (e.g., blocks or strata).
- E. Current research is experimenting with variable resolution raster maps to better convey a map's spatial precision. However, because map scale is a function of the minimum size delineation, the overall map scale may not change. A more useful metric of the map's complexity is the average delineation size (ASD). Forbes et al. (1987) suggested that a map's ASD should be at least 4 times the MLD.
- F. Eswaran et al. (1981) discussed the work of others on using sampling density as a better metric of survey reliability; however, the systematic densities suggested are only appropriate when predicting soil classes or properties by interpolation. Although it is implied that Order 2 soil surveys have a higher density of observation, no such information is documented in soil survey reports. Furthermore, sampling density is noticeably absent from the 1993 version of the Soil Survey Manual, even though it is present in other literature discussing the relationship between map scale and soil survey orders.

Figure 648B-1: Relationship of Scale Number to Minimum Legible Area to Data Resolution for Various Raster and Vector Map Products.

Examples	Scale Number	Minimum Legible Area ¹¹			Resolution
		Acres	Hectares	Meters ²	Meters
5-meter	1:5,000	0.025	0.01	100	5
10-meter	1:10,000	0.099	0.04	400	10
30-meter	1:30,000	0.89	0.36	3,600	30
100-meter	1:100,000	9.9	4	40,000	100
1-kilometer	1:1,000,000	990	400	4,000,000	1,000
SSURGO	1:12,000	1.4	0.58	5,800	38
SSURGO	1:24,000	5.7	2.3	23,000	75
STATSGO	1:250,000	620	250	2,500,000	800
LRU	1:1,000,000	9,900.00	4,000.00	40,000,000	3,200
MLRA	1:3,500,000	120,000.00	49,000.00	490,000,000	11,000
LRR	1:7,500,000	560,000.00	220,000.00	2,200,000,000	24,000

¹¹ The minimum legible areas listed above assume a minimum legible delineation size of 0.4 cm² for vector maps and 0.01 cm² for raster maps. In addition, the MLAs for all raster maps are multiplied by a factor of 4. All results are rounded to the nearest 2 significant digits.

648.14 Digital Soil Mapping Project – Final Correlation Document Example

Classification and Correlation of the MLRA 90A – Mille Lacs Uplands Coarse-Loamy Basal Till Investigation – Raster Soil Survey Publication

Progressive Publication of Raster Soil Survey: Minnesota

UNITED STATES DEPARTMENT OF AGRICULTURE Natural Resources Conservation Service

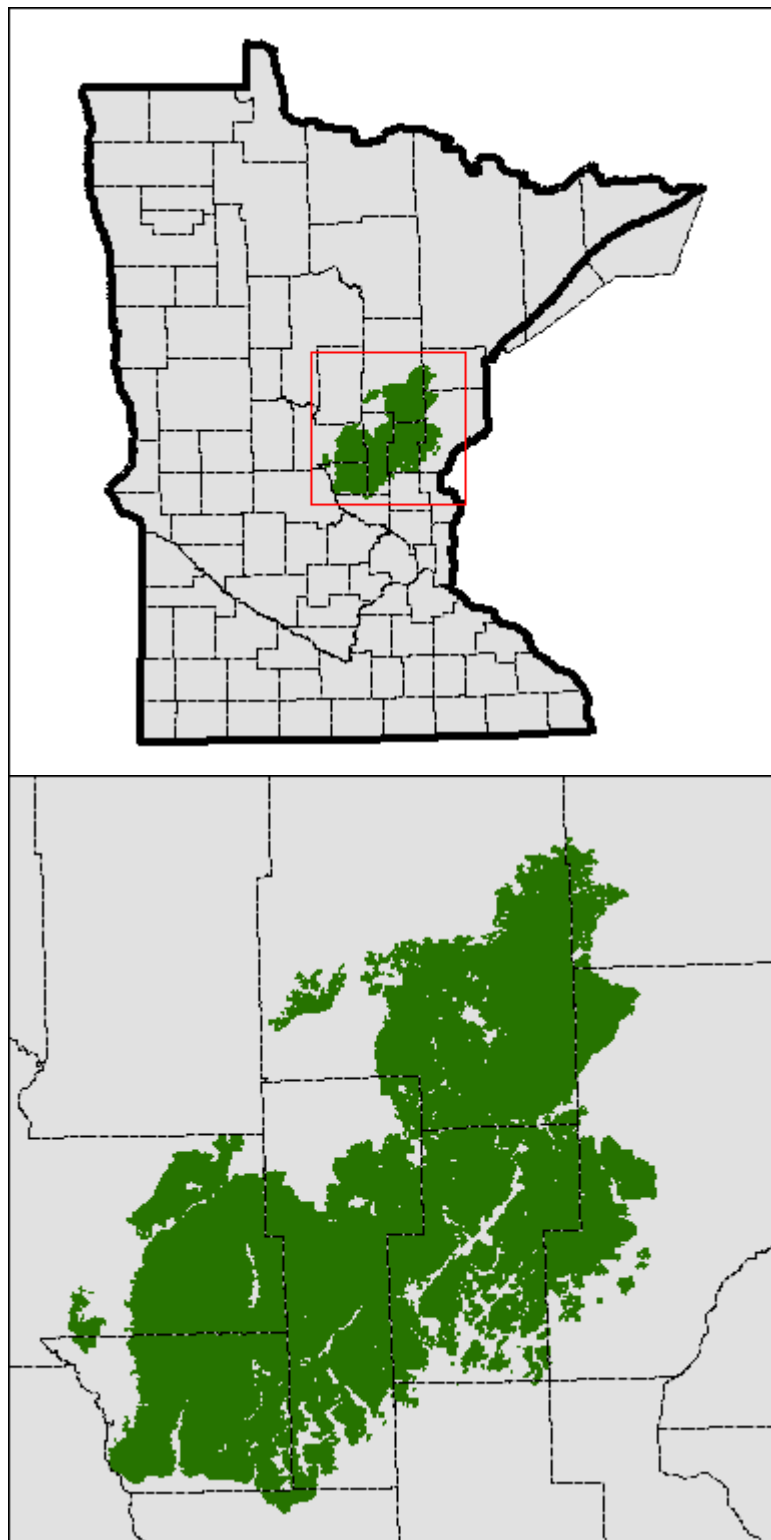
The United States Department of Agriculture (USDA) is an equal opportunity provider and employer. This correlation amendment was prepared by Joseph J. Brennan and Betsy M. Schug, Natural Resources Conservation Service-Soil and Plant Science Division, Saint Paul, Minnesota, in October 2019, to accompany the publication of data in the Minnesota (MN) Raster Soil Survey (RSS) Area.

Project Scope and Area Definition

Geomorphic surface-based progressive correlation was planned for the project – Pine County, Minnesota – Initial Soil Survey in 2017. One geomorphic surface in the west-central part of the county was delineated by project staff as the Hinckley Till Plain, which consists of several short advances and retreats of the Superior lobe of Wisconsin glaciation between the Beroun and Split Rock phases. The first phase, the Beroun phase, deposited basal till averaging 12 percent clay. The second phase—the Hinckley, North Hinckley, Grindstone, and Sandstone phase—represents the gradual retreat of the Beroun phase and deposited similar till. Further evaluations identified very similar parent materials in the earlier St. Croix advances to the south and west, well into the drumlin fields in Benton and Morrison Counties near the terminus the Superior advance. The project scope was expanded through the inventory and assessment phase to include a much larger footprint than initially described as the Hinckley Till Plain. This revised project footprint can generally be described as the Mille Lacs Uplands, an ecological subsection of the Wisconsin and Minnesota Thin Loess and Till, Northern Part (MLRA 90A). This major landscape covering approximately 1.2 million acres across East-Central Minnesota is composed of gently rolling drumlins ground and stagnation moraines of coarse-loamy basal till. Parts of the landscape have a thin mantle of loess or glaciolacustrine deposits likely remnant of the Grantsburg Sublobe of Des Moines Lobe. Major land use in the project area is broken down as roughly 40 percent deciduous and mixed forest, 30 percent wetlands (including extensive areas of peatlands), 20 percent hay and pasture, and 10 percent cropland. Principle hardwoods include red oak, sugar maple, basswood, and aspen-birch. Common crops include corn, oats, and hay.

General soil maps reference much of the area as the Ronneby-Parent-Mora association. Detailed soil surveys typically identify the Milaca, Mora, and Brennyville soil series in upland positions on glacial drumlins, ground and recessional moraines in the area. The Milaca series was established in 1927 in Mille Lacs Co., Minnesota, and currently classifies coarse-loamy, mixed, superactive, frigid Oxyaquic Glossudalfs and is a benchmark soil. The Mora series was established in 1970 in Benton Co., Minnesota, and currently classifies as coarse-loamy, mixed, superactive, frigid Aquic Glossudalfs. The Brennyville soils are a silt loam capped, over coarse-loamy basal till. Brennyville was established in 1995 and currently classifies as coarse-loamy, mixed, superactive, frigid Aquic Glossudalfs and is described as having a 38 to 76 centimeters thick silt loam cap overlying the coarse-loamy basal till. Many similar taxons were also identified in the geomorphic surface. Additional hydric soils identified within the context of this catena include: Cebana, Haybrook, Freer, Giese and similar soils, along with several histosols. Coarse-loamy basal till soils of the Brainerd catena mapped in Rainy Lobe sediments were also identified in the project area. These soils were evaluated and re-correlated where they exist on Superior lobe till within the project area in Morrison Co., Minnesota.

Figure 1: Project Location



Several correlation inconsistencies were reflected in property and interpretive results between county SSURGO subsets. Inconsistencies are well documented in the project plan. Approximately 100,000 acres of this project area lacked detailed soil survey information in SSURGO prior to this project.

Project Objectives Include:

1. Reconcile legacy correlation issues resulting in extensive spatial and tabular join concerns and re-correlate to MLRA map units as appropriate
2. Evaluate spatial trends across geomorphic surfaces using historical documentation, laboratory analysis, and cooperator data to reconcile physical and chemical inconsistencies evident in correlated map units in the area
3. Explore digital soil mapping methods to augment consistency and efficiency in applying mapping conventions in conjunction with MLRA updates and initial soil survey projects
4. Develop RSS products to render more detailed representation of soil spatial variability across the project area

Physical Features of Interest

A. The following is a list of the most significant physical features of interest guiding documentation strategy and all mapping activities in the project area:

1. Depth of Silty Mantle Materials – Depth of surficial deposits with mineral particles < 30 percent (by weight) > 0.25 mm (fine sand and coarser) in size in the fine earth fraction
2. Stoniness – Fragments > 250 mm covering > 0.01 percent of the surface
3. Ponding or Flooding
4. Silt content in the lower tier (= 23 percent silt is typical of Superior lobe parent material; < 23 percent is more typical of Rainy lobe parent materials)
5. Clay content in the particle size control section (> 25 percent is dissimilar of catenas represented in the project area)

B. The following are the most critical diagnostic features guiding documentation and mapping activities in the project area:

1. Histic Epipedon
2. Mollic Epipedon
3. Albic Horizon
4. Argillic Horizon
5. Glossic Horizon
6. Aquic Conditions
7. Identifiable Secondary Carbonates
8. Kind of Organic Soil Materials
9. Thickness of Organic Soil Materials
10. Densic Contact

C. The following is a list of soils and associated catenas framed as provisional hypothesis of concepts required to capture variability in features of interest across the project area:

Silty Mantled Upland Sequence

Taxon/Concept Subgroup Classification

Cebana	Mollic Glossaqualfs
Freer	Aeric Glossaqualfs
Brennyville	Aquic Glossudalfs
Freeon	Oxyaquic Glossudalfs
Santiago	Haplic Glossudalfs

Unmantled Upland Sequence

Taxon/Concept Subgroup Classification

Parent	Typic Epiaquolls
Ronneby	Aeric Glossaqualfs
Mora	Aquic Glossudalfs
Milaca	Oxyaquic Glossudalfs
Amery	Haplic Glossudalfs

Recessional Moraine Associated Soil

Taxon/Concept Subgroup Classification

Millward Assoc.	Inceptic Hapludalfs
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Wet Mineral Sequence

Taxon/Concept Subgroup Classification

Twig	Histic Humaquepts
Giese	Typic Humaquepts

Histosols

Taxon/Concept Family Classification

Cathro	Loamy, euic, Terric Haplosaprist
Beseman	Loamy, dysic, Terric Haplosaprist
Seelyeville	Euic Typic Haplosaprist
Tacoosh	Loamy, euic, Terric Haplohemist
Rifle	Euic Typic Haplohemist
Greenwood	Dysic Typic Haplohemist

Alluvial Associated Soils

Taxon/Concept Great Group/Subgroup Classification

Alluvial Assoc.	Fluvaquents/Fluvaquentic Haplosaprists
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D. For digital soil mapping within the project extent, the above features of interest were narrowed to the following response variables to evaluate potential for model development:

1. Organic Soil Material Thickness (cm)¹
 - a. O_Hz_Thk – Organic layer thickness
 - (1) Grouped for binary response as:
 - (a) NonMineral (> 0 cm)
 - (b) Histic (> 30 cm)
 - (c) Terric (> 50 cm)
 - (d) Deep_O (> 100 cm)
 - (e) VD_O (> 150 cm)
 - (f) NonMinHist (> 200 cm)

2. Organic Soil Material Decomposition
 - a. Hemist – binary response for histosols
3. Organic Soil Reaction Class
 - a. Dysic – binary response for histosols
4. Depth of Aquic Conditions
 - a. Hydro (grouped in classes below)
 - (1) Grouped for binary response as:
 - (a) Oxyaquic (subgroup or wetter) – redox features within 100 cm
 - (b) Aquic (subgroup or wetter) – redox depletions within 50 cm
 - (c) Aeris (subgroup or wetter) – below epipedon
 - i. Chroma 2 or less with concentrations
 - ii. Chroma 3 or less with concentrations AND depletions
 - (d) Hydric (soil) – Directly below epipedon – Chroma 1 or less with concentrations; Meet hydric indicator
 - (e) Ponded – Organic soil materials or mucky mineral hydric soils
5. Silty Mantle Materials = 40 cm thick
 - a. Mantle – Binary response for non-ponded mineral soils
6. Densic Contact
 - a. Densic_dep – depth to densic contact (cm)
 - (1) Grouped for binary response as:
 - (a) MD_Densic (< 100 cm from the surface)

Data sources, Processing, and Covariates

A. Covariate Preprocessing (Terrain)

Using 1m Bare Earth LiDAR, the desired project area was prepared for terrain modeling by:

1. Masking out Cultural Features and interpolating across voids
2. Resampling to 5 m (median)
3. Pit filling in three iterations
4. Applying low pass filter

Covariate Development

1. Terrain

Predictor Variable	Description
curv30d	Curvature – 30 m Diameter (Shi)
dep_cost	Depression Cost – Cost distance (slope cost) from natural depression
mncv30_210	Average Curvature Values Generated from 30 m Diameter Intervals (Shi) – Mean 30/60/90/120/150/180/210
mrvmf	Maximum value of 3 iterations of Multi-resolution Valley Bottom Flatness (Slope Thresholds of 7/10/15 and .2/.8 .3/.7
plan20d	Plan – 20 m Diameter Mean (Shi)
prof20d	Profile – 20 m Diameter Mean (Shi)
re15_45	Relative Position 15–45 m Radius Average – Mean 15/20/25/30/35/40/45
re200_800	Relative Position 200–800 m Radius Average – Mean 200/300/400/600/800
re50_150	Relative Position 50–150 m Radius Average – Mean 50/75/100/125/150
relstd100	Relative Relief Standard Deviation 100 m Radius
relstd200	Relative Relief Standard Deviation 200 m Radius

(430-648-H, 1st Ed., Amend. 40, June 2023)

Predictor Variable	Description
slp20d	Slope Gradient – 20 m Diameter (Shi)
slphetr100	Relative Slope Heterogeneity – 100 m Radius
wetness	Wetness (SAGA)
2. Spectral	
Predictor Variable	Description
ndmi0510	LANDSAT 7 Normalized Difference Moisture Index – (Band 4 - Band 5) / (Band 4 + Band 5) – May 19, 2010, Scene
ndmi0707	LANDSAT 5 Normalized Difference Moisture Index – (Band 4 - Band 5) / (Band 4 + Band 5) – July 30, 2007 Scene
ndmi1016	LANDSAT 8 Normalized Difference Moisture Index – (Band 5 - Band 6) / (Band 5 + Band 6) – October 10, 2016 Scene
ndvi0510	LANDSAT 7 Normalized Difference Vegetative Index – (Band 4 - Band 3) / (Band 4 + Band 3) – May 19, 2010 Scene
ndvi0707	LANDSAT 5 Normalized Difference Vegetative Index – (Band 4 - Band 3) / (Band 4 + Band 3) – July 30, 2007 Scene
ndvi1016	LANDSAT 8 Normalized Difference Vegetative Index – (Band 5 - Band 4) / (Band 5 + Band 4) – October 10, 2016 Scene
therm0510	LANDSAT 7 Thermal Band 6 – May 19, 2010 Scene
therm0707	LANDSAT 5 Thermal Band 6 – July 30, 2007 Scene
therm1016	LANDSAT 8 Thermal Band 10/11 – October 10, 2016 Scene

3. Ancillary Datasets and Secondary Covariates

Predictor Variable	Description
drain_cost	Drainage Cost – Cost distance (slope cost) from MNDNR NWI stream
lndfrm_hgm	Hydrogeomorphic Landform Classification MNDNR NWI
lncsp_hgm	Hydrogeomorphic Landscape Classification MNDNR NWI
maat	Mean Annual Air Temperature (PRISM) 1980–2010
mntle_srce	Cost distance (slope cost) from known sources of Silt Loam Mantle (Glacial Lake Grantsburg margin extending Northward Upgradient; Leeward of Mille Lacs)
species_in	Distance weighted density of Big Woods indicator species from GLO - PLSS Bearing Tree Data (Sugar Maple - 4/Elm - 2/Hickory - 2/Basswood - 1 /Ironwood - 1 /Maple - 1 /Red Oak - 1)

Data Exploration and Landform Analysis

Existing trends in the SSURGO data (where available) were utilized to assess the most significant covariates for developing a sampling scheme across mineral soils. Response variables were evaluated from SSURGO tabular data, including:

1. Dep2Densic – depth to densic contact (cm)
2. Relative_Wetness - Arrayed relative modal wetness class of project map units (1 – Very Poorly Drained – 7 – Well Drained)
3. TOC_0_100 – Total organic carbon (kg/sq. m.) in upper 100 cm
4. MantleThkAquic – Mantle presence/absence in wet soils
5. MantleThkUdic – Mantle presence/absence in upland soils

The tabular data from 46,175 SSURGO delineations were populated with the above response variables. These polygons were further analyzed for median values from a subset of indexed values from terrain-based predictor variables assessed (curv30d; mncrv30210; dep_cost; re15_45; re200_800; re50_150; relstd100; relstd200; slope20d; slopehetr100; wetness) to aid in establishing a sampling plan.

Eight models were developed, with variable importance assessed across each model. The three most significant predictor variables across all models were re15_45, slp20d, and wetness. These predictor variables were selected to develop a model directed sampling plan.

Several environmental datasets were evaluated for potential to stratify in a large project area. Land cover was selected for stratification due to the spatial trends of increasing agricultural lands moving to the south and west in the project area, and a higher proportion of cropland in the silty mantled soil catena.

In Pine County, Minnesota, where no SSURGO soils information was available, a 1941 reconnaissance soil survey and the 1:100,000 surficial geology plate from the County Atlas Series (Minnesota Geological Survey) along with point data from geologic investigations, well logs, and prior soil survey investigations were intersected into a single classification to develop a sampling strategy and stratify the project area for planning field work.

Sampling for Training Data

A. Sample Design and Training Data Development

The project was stratified into two separate areas to address sampling uniquely in initial and update areas:

1. Pine County – Initial Area
 - a. Purposive Traverse Sampling Scheme
 - b. Stratified into zones from reconnaissance soil survey, STATSGO, and surficial geology. Voids were targeted with locations of historical documentation considered.
 - c. Historical Documentation included:
 - (1) 5 Historical Pedons²
 - (2) 204 historical site observations (soil observations from previous projects)³
 - (3) 52 resource soil scientist field mapping polygons⁴
 - (4) 66 borings from Minnesota Geological Survey⁵
 - (5) 100 drillers well logs from Minnesota Department of Health⁶
 - d. Planned Training Documentation:
 - (1) 82 pedon descriptions⁷
 - (2) 3 KSSL laboratory pedons⁸
 - (3) 51 field observations⁹
2. Mille Lacs Uplands Update Area
 - a. Stratified and Model-directed scheme applied with purposive offset descriptions documented in adjacent landform positions.
 - b. Stratification considered relative balance of existing historical pedon data and the current map units within the project area to sample proportionately. This evaluation indicated a higher balance of historical documentation in agricultural land (crop, hay, or pasture) relative to wooded land (forest and bog dominant). Agriculture and wooded was classified from the National Land Cover Database (NLCD) layer. Seventy-one historical pedons were documented in agricultural lands, and 57 historical pedons documented in wooded lands. To improve proportionate balance, 70 percent of the planned documentation was targeted in wooded lands with 30 percent in agricultural lands.

- c. The generated sampling scheme on agricultural lands was confined to specific areas with granted access determined using the common land unit layer to confine the sampling areas to cooperating producers. Sampling on wooded lands was confined to public lands for training data locations. Covariate statistics were evaluated on the targeted land unit areas in comparison to the overall strata across the project area to assure the identified footprint was representative of the project area.
- d. Conditioned Latin Hypercube Sampling method (cLHS) was chosen to generate sampling points. This method was chosen due to the ability to capture variability of the selected covariates (re15_45/slp20d/wetness) across the project area. The cLHS method was ran using the Terrain Ecological Unit Inventory (TEUI) toolkit on each strata: 1) permission area for agricultural land; 2) permission area for wooded land.
- e. Historical Documentation included:
 - (1) 114 Historical Pedons¹⁰
 - (2) 14 KSSL laboratory pedons¹¹
 - (3) 24 University of Minnesota laboratory pedons¹²
- f. Planned Training Documentation:
 - (1) 82 pedon descriptions (40 training points and 42 purposive offsets)¹³

The training dataset (1 and 2 above) compiled all point data collected during project (laboratory sampling, historical point data, and point data collected from the Minnesota DNR Peatland Survey). This resulted in 479 total descriptions used for model training. During the collection of training points, a plot radius was documented in the field as a measured distance (meters) from the observation to the minimum distance of an observable change in soil class. This is typically a morphometric transition or an observed change in vegetation. Using the plot radius measurement, a buffer was placed around each observation, and covariate values were tabulated for all 5 m pixel within the distance radius of the buffer. For points where plot radius was not documented, such as historical data, a 5 m plot radius was used to avoid overweight of an estimated position. Any radius documented as being greater than 50 m was restricted to 50 m as to not overweigh the data from large neighborhoods.

Using plot radius on the 479 training points, the seed cells were expanded to region areas to include 8,062 cells (479 training points plus cells within buffer distance) relating the response class to covariate values of all cells in the region. This information was then compiled into a separate data frame that could be used to assist in classification of soil moisture classes: hydric, aeric, aquic, oxyaquic, and typic classes.

B. Field Documentation

All training point pedons described through the project conformed to a minimum dataset outlined by the project lead to assure the physical features of interest were consistently documented.

Investigation planning included laboratory sampling in the initial soil survey area targeting identifiable voids in characterization data. A hydrology study on project soils instrumented to continuously monitor piezometers (10/17) in evaluating variation in saturation within and above a restricted layer. A site was established adjacent to a NOAA Climate Reference Network (CRN) weather station at the Audubon Center of the North Woods near Sandstone, Minnesota and continues to log observations.

C. Training Data Frames

Training datasets include physical features of interest (II) and all relevant predictor covariates (III).

1. MODEL_TRAINING_MLM
 - Observation-based Training Dataset
 - a. 307 Project Linked NASIS Pedons
 - b. 172 MNDNR Peatland Survey Points
 - c. 479 Total Training Points

2. **MODEL_TRAINING_MLM_PLOT_RADIUS**
Region-Based (observation expanded) Training Dataset to evaluate hydrology classes and taxons (479 training points plus cells confined within plot radius buffer)
 - a. 307 Project Linked NASIS Pedons
 - b. 8,062 Total Training Points
3. **EXP_ORG_TRAINING_MLM**
Organic dataset including MNDNR peatland data beyond project footprint but within modeling domain.
 - a. 418 Organic Points
 - b. 418 Total Training Points
4. **Alluvial Training**
Existing SSURGO project delineations including soils with occasional of more frequent flooding class and adjacent delineations of histosols. Training points generated at 50m intervals within delineations.
 - a. 191,520 Generated Points
 - b. 191,520 Total Training Points
5. **SSURGO_SAPRIST**
Existing SSURGO project delineations with deep histosols as major components. SSURGO polygons beyond project footprint, but within modeling domain were included. Training points generated at centroid of soil polygon (within soil polygon)
 - a. 4,455 Generated Points
 - b. 4,455 Total Training Points

Modeling

1. Features of Interest Modeling

A. Densic Property Index (DENSIC)

1. Modeling the Presence or Absence of Densic Contact Using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM
3. Response: 0 – Densic (Contact > 100 cm); 1 – Moderately Deep Densic (Contact < 100 cm)
4. Predictor covariates selected for modeling:
 - a. Relative Position 50-150m Radius Average (re50_150)
 - b. Multi-Resolution Valley Bottom Flatness (mrvbf)
 - c. Mean Annual Air Temperature (PRISM) 1980–2010 (maat)
5. Method: Logistic Regression Model
Obs: 479
0: 419
1: 60
2: 0.772

B. Silty Mantle Development Index (MANTLE)

1. Modeling the Presence or Absence of a Silty Mantle using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM
3. Response: 1 – Mantle Present; 0 – Unmantled; –1 Excluded
4. Predictor covariates selected for modeling:
 - a. Species Index (spec_in)
 - b. Mantle Source (mntle_srce)
 - c. Mean Annual Air Temperature (PRISM) 1980–2010 (maat)
 - d. Slope Heterogeneity – 100 m Radius (slphetr100)
 - e. Average Curvature Values – 30 m Diameter Intervals (mncv30_210)
5. Method: Logistic Regression Model
Obs: 263 0: 164

1: 99

C: 0.771

6. Results were reclassified and scaled (0-100) to establish landscape and landform scale trends.

C. No Mineral Organic Index (NONMIN)

1. Modeling Organic Soils with no mineral observed within 200 cm using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM
3. Response: 1 – No Mineral Identified; 0 – Mineral within zone of observation
4. Predictor covariates selected for modeling:
 - a. Multi-Resolution Valley Bottom Flatness (mrvbf)
 - b. Euclidean Distance to a NWI Wetland (nwi_dist)
 - c. Relative Position 200–800 m Radius Average (re200_800)
 - d. Relative Relief Standard Deviation 200 m Radius (relstd200)
5. Method: Logistic Regression Model
Obs: 479
0: 379
1: 100
C: 0.918

D. Very Deep Organic Index (VDO)

1. Modeling Organic Soils with no mineral observed within 150 cm using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM
3. Response: 1 – No Mineral Identified < 150 cm; 0 – Mineral within zone of observation
4. Predictor covariates selected for modeling:
 - a. LANDSAT 5 Thermal Band 6 – July 30, 2007 Scene (therm0707)
 - b. Euclidean Distance to a NWI Wetland (nwi_dist)
 - c. Relative Position 200–800 m Radius Average (re200_800)
 - d. Relative Relief Standard Deviation 200 m Radius (relstd200)
 - e. Wetness (wetness)
5. Method: Logistic Regression Model
Obs: 479
0: 352
1: 127
C: 0.934

E. Deep Organic Index (DEEPO)

1. Modeling Organic Soils with no mineral observed within 100 cm using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM
3. Response: 1 – No Mineral Identified < 100 cm; 0 – Mineral within zone of observation
4. Predictor covariates selected for modeling:
 - a. Euclidean Distance to a NWI Wetland (nwi_dist)
 - b. Multi-Resolution Valley Bottom Flatness (mrvbf)
 - c. Slope Heterogeneity – 100 m Radius (slphetr100)
5. Method: Logistic Regression Model
Obs: 479
0: 320
1: 159
C: 0.954

F. Terric Organic Index (TERRIC)

1. Modeling Histosols (terrific and deeper) using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM
3. Response: 1 – No Mineral Identified < 40 cm; 0 – Mineral within zone of observation
4. Predictor covariates selected for modeling:
 - a. Euclidean Distance to a NWI Wetland (nwi_dist)
 - b. Relative Position 200–800 m Radius Average (re200_800)
 - c. Relative Relief Standard Deviation 200 m Radius (relstd200)
 - d. LANDSAT 5 Thermal Band 6 – July 30, 2007 Scene (therm0707)
5. Method: Logistic Regression Model
Obs: 479
0: 295
1: 154
C: 0.982

G. Histic Epipedon Index (HISTIC)

1. Modeling soils with a histic epipedon or deeper organic accumulation using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM
3. Response: 1 – Organic Soil Materials > 20 cm; 0 – Mineral within zone of observation
4. Predictor covariates selected for modeling:
 - a. Multi-Resolution Valley Bottom Flatness (mrvbf)
 - b. Relative Position 200–800 m Radius Average (re200_800)
 - c. Euclidean Distance to a NWI Wetland (nwi_dist)
 - d. LANDSAT 5 Thermal Band 6 – July 30, 2007 Scene (therm0707)
5. Method: Logistic Regression Model
Obs: 479
0: 281
1: 198
C: 0.986

H. Mucky Mineral Index (MUCKY)

1. Modeling soils with a histic epipedon or deeper organic accumulation using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM
3. Response: 1 – Soil with mucky mineral surface or deeper organic accumulation; 0 – No mucky or histic surface
4. Predictor covariates selected for modeling:
 - a. Multi-Resolution Valley Bottom Flatness (mrvbf)
 - b. Relative Position 50–150 m Radius Average (re50_150)
 - c. Relative Position 200–800 m Radius (re200_800)
 - d. LANDSAT 5 Thermal Band 6 – July 30, 2007 Scene (therm0707)
5. Method: Logistic Regression Model
Obs: 479
0: 257
1: 222
C: 0.977

I. Composite Histic Index (HIST_IDX)

1. Summed Index Values
2. No Mineral Organic Index + Very Deep Organic Index + Deep Organic Index + Terric Organic Index + Histic Epipedon Index + Mucky Mineral Index

J. Oxyaquic Index (OXY)

1. Modeling oxyaquic (subgroup or wetter) using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM_PLOT_RADIUS
3. Response: 1 – Oxyaquic (subgroup or wetter); 0 – Better drained
4. Predictor covariates selected for modeling:
 - a. Cost Distance from MNDNR NWI stream (drain_cost)
 - b. Relative Position 200–800 m Radius (re200_800)
 - c. Relative Relief Standard Deviation 200 m Radius (relstd200)
 - d. Slope Heterogeneity – 100 m Radius (slphetr100)
5. Method: Logistic Regression Model
 Obs: 8062
 0: 170
 1: 7892
 C: 0.891

K. Aquic Index (AQUIC)

1. Modeling aquic (subgroup or wetter) using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM_PLOT_RADIUS
3. Response: 1 – Aquic (subgroup or wetter); 0 – Better drained
4. Predictor covariates selected for modeling:
 - a. Cost Distance from Natural Depression (dep_cost)
 - b. Average Curvature Values – 30 m Diameter Intervals (mncv30_210)
 - c. LANDSAT 7 Normalized Difference Moisture Index – (Band 4 - Band 5) / (Band 4 + Band 5) – May 19, 2010 Scene (ndmi0510)
 - d. LANDSAT 8 Normalized Difference Vegetative Index – (Band 5 - Band 4) / (Band 5 + Band 4) – October 10, 2016 Scene (ndvi1016)
 - e. Euclidean Distance to a NWI wetland margin (nwi_dist)
 - f. Relative Position 15–45 m Radius Average (re15_45)
 - g. Relative Position 50–150 m Radius Average (re50_150)
 - h. Relative Slope Heterogeneity – 100 m Radius (slphetr100)
5. Method: Logistic Regression Model
 Obs: 8062
 0: 1796
 1: 6266
 C: 0.872

L. Aeris Index (AERIC)

1. Modeling aeris (subgroup or wetter) using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM_PLOT_RADIUS
3. Response: 1 – Aeris (subgroup or wetter); 0 – Better drained
4. Predictor covariates selected for modeling:
 - a. Multi-Resolution Valley Bottom Flatness (mrvbf)
 - b. Relative Position 15–45 m Radius Average (re15_45)
 - c. Relative Position 50–150 m Radius Average (re50_150)
 - d. Slope Gradient – 20 m Diameter (slp20d)
 - e. Relative Slope Heterogeneity – 100 m Radius (slphetr100)
 - f. LANDSAT 7 Thermal Band 6 – May 19, 2010 Scene (therm0510)
 - g. Wetness (wetness)
5. Method: Logistic Regression Model
 Obs 8062
 0 5330

1 3339
C 0.978

M. HYDRIC Index (HYDRIC)

1. Modeling hydric (subgroup or wetter) using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM_PLOT_RADIUS
3. Response: 1 – Hydric soil; 0 – Better drained
4. Predictor covariates selected for modeling:
 - a. Multi-Resolution Valley Bottom Flatness (mrvbf)
 - b. Relative Position 15–45 m Radius Average (re15_45)
 - c. Relative Position 50–150 m Radius Average (re50_150)
 - d. Slope Gradient – 20 m Diameter (slp20d)
 - e. Relative Slope Heterogeneity – 100 m Radius (slphetr100)
 - f. LANDSAT 7 Thermal Band 6 – May 19, 2010 Scene (therm0510)
 - g. Wetness (wetness)
5. Method: Logistic Regression Model
Obs: 8062
0: 4723
1: 2732
C: 0.987

N. PONDED Index (PONDED)

1. Modeling ponded using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM_PLOT_RADIUS
3. Response: 1 – Pondered; 0 – Better drained
4. Predictor covariates selected for modeling:
 - a. Multi-Resolution Valley Bottom Flatness (mrvbf)
 - b. Euclidean Distance to a NWI wetland margin (nwi_dist)
 - c. Relative Position 200–800 m Radius (re200_800)
 - d. Relative Relief Standard Deviation 100 m Radius (relstd100)
 - e. Relative Slope Heterogeneity – 100 m Radius (slphetr100)
 - f. LANDSAT 7 Thermal Band 6 – May 19, 2010 Scene (therm0510)
5. Method: Logistic Regression Model
Obs: 8062
0: 5586
1: 2476
C: 0.989

O. Composite Hydrology Index (HYD_IDX)

1. Summed Index Values
2. Oxyaquic Index + Aquic Index + Aerice Index + Hydric Index + Pondered Index

P. Dysic Index (DYSIC)

1. Modeling Organic Soils with Dysic Reaction Class using Logistic Regression
2. Training Dataset: MODEL_TRAINING_MLM
3. Response: 1 – Dysic Reaction Class; 0 – Euic Reaction Class; –1 Excluded
4. Predictor covariates selected for modeling:
 - a. Multi-Resolution Valley Bottom Flatness (mrvbf)
 - b. LANDSAT 7 Normalized Difference Moisture Index – (Band 4 - Band 5) / (Band 4 + Band 5) – May 19, 2010 Scene (ndmi0510)

c. LANDSAT 5 Normalized Difference Moisture Index – (Band 4 - Band 5) / (Band 4 + Band 5) – July 30, 2007 Scene (ndvi0707)

d. LANDSAT 7 Thermal Band 6 – May 19, 2010 Scene (therm0510)

5. Method: Logistic Regression Model

Obs 191

0: 133

1: 58

C: 0.880

Q. Hemic Soil Materials Index (HEMIC)

1. Modeling Organic Soils with Dysic Reaction Class using Logistic Regression

2. Training Dataset: MODEL_TRAINING_MLM

3. Response: 1 – Hemic Materials Dominant < 100 cm; 0 – Sapric Materials Dominant < 100 cm; –1 Excluded

4. Predictor covariates selected for modeling:

a. Cost distance from natural depression (dep_cost)

b. Hydrogeomorphic Landform Classification MNDNR NWI (lndfrm_hgm)

c. Mean Annual Air Temperature (PRISM) 1980–2010 (maat)

d. LANDSAT 8 Normalized Difference Moisture Index – (Band 5 - Band 6) / (Band 5 + Band 6) – October 10, 2016 Scene (ndmi1016)

e. Relative Slope Heterogeneity – 100 m Radius (slphetr100)

5. Method: Logistic Regression Model

Obs: 188

0: 20

1: 168

C: 0.826

R. Sapric Soil Materials Index (SAP1)

1. Modeling Deep Organic Soil Decomposition from Von Post Textures using Logistic Regression

2. Training Dataset: EXP_ORG_TRAINING_MLM

3. Response: 1 – Sapric Materials Dominant < 100 cm; 0 – Hemic Materials Dominant < 100 cm

4. Predictor covariates selected for modeling:

a. Hydrogeomorphic Landform Classification MNDNR NWI (lndfrm_hgm)

b. LANDSAT 5 Normalized Difference Moisture Index – (Band 4 - Band 5) / (Band 4 + Band 5) – July 30, 2007 Scene (ndmi0707)

c. LANDSAT 8 Normalized Difference Vegetative Index – (Band 5 - Band 4) / (Band 5 + Band 4) – October 10, 2016 Scene (ndvi1016)

d. Mean Annual Air Temperature (PRISM) 1980–2010 (maat)

e. Relative Relief Standard Deviation 100m Radius (relstd100)

5. Method: Logistic Regression Model

Obs 418

0: 360

1: 58

C: 0.727

S. SSURGO Sapric Soil Index (SAP2)

1. Modeling SSURGO Deep Organic Map Units Identified as Sapric using Logistic Regression

2. Training Dataset: SSURGO_SAPRIST

3. Response: 1 – Sapric Materials Dominant < 100 cm; 0 – Hemic Materials Dominant < 100 cm

4. Predictor covariates selected for modeling:

a. Cost distance from MNDNR NWI stream (drain_cost)

- b. LANDSAT 5 Normalized Difference Moisture Index – (Band 4 - Band 5) / (Band 4 + Band 5) – July 30, 2007 Scene (ndmi0707)
- c. LANDSAT 8 Normalized Difference Vegetative Index – (Band 5 - Band 4) / (Band 5 + Band 4) – October 10, 2016 Scene (ndvi1016)
- d. Mean Annual Air Temperature (PRISM) 1980–2010 (maat)
- e. LANDSAT 7 Normalized Difference Moisture Index – (Band 4 - Band 5) / (Band 4 + Band 5) – May 19, 2010 Scene (ndmi0510)
- f. Euclidean Distance to an NWI wetland margin (nwi_dist)
- 5. Method: Logistic Regression Model
 - Obs: 4455
 - 0: 1267
 - 1: 3188
 - C: 0.717

T. Composite Sapric Index (SAP_IDX)

- 1. Summed Index Values
- 2. (1 – Hemic Soil Materials Index) + Sapric Soil Materials Index + SSURGO Sapric Soil Index

U. Alluvial Index (ALLUV)

- 1. Discerning flood plain mapping in SSURGO from adjacent delineations of histosols
- 2. Training Dataset: ALLUVIAL_TRAINING
- 3. Response: 1 – Map unit with flooding; 0 – No flooding in major soils
- 4. Predictor covariates selected for modeling:
 - a. Cost distance from MNDNR NWI stream (drain_cost)
 - b. Composite Hydrology Index
- 5. Method: Logistic Regression Model
 - Obs: 191520
 - 0: 124797
 - 1: 66723
 - C: 0.873

2. Knowledge-Based Classification

Features of interest index results were aggregated into mappable taxon and concepts using fuzzy membership to establish relationships between indexes and a taxon/concept with ArcSIE. Index values were integrated into training dataset (MODEL_TRAINING_MLM_PLOT_RADIUS) along with taxon/concept assignments from field-based keys. Rule-based reasoning and factor weighting was established by evaluating descriptive statistics per taxon/concept (or aggregation of concepts where appropriate), along with further data exploration and tacit knowledge. Several iterations of weighting and membership were evaluated in local areas prior to establishing the rule set below as stratified by landform:

A. Mantled Upland Sequence – 5 Classes; Inputs – 9 Features of Interest; 0 Covariates

Taxon/Soil Feature/Covariate		Weight(%)	Curve	v1, w1, r1	v2, w2, r2
Santiago	DENSIC	20	S	0.35, 0.15, 3	
	HYD_IDX	25	Z		1 0.5, 1
	MANTLE	30	S	86, 37, 1	
	OXY	20	Bell	0.98, 0.20, 3	0.98, 0.15, 3
	AQUIC	5	Z		0.1, 0.3, 6
Freeon	DENSIC	10	Bell	0.225, 0.075, 6	0.325, 0.025, 2.5

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Taxon/Soil	Feature/Covariate	Weight(%)	Curve	v1, w1, r1	v2, w2, r2
	HYD_IDX	25	Bell	1.1, 0.1, 1.5	1.7, 0.6, 2.5
	MANTLE	30	S	86, 37, 2	
	OXY	20	S	0.95, 0.25, 2	
	AQUIC	5	Bell	0.1, 0.1, 7	0.25, 0.35, 1
	AERIC	5	Z		0.01, 0.04, 2
Brennyville	DENSIC	5	Z		0.3, 0.05, 4
	HYD_IDX	25	Bell	1.8, 0.2, 1	2.2, 0.4, 4
	MANTLE	30	S	86, 37, 2	
	OXY	10	S	0.99, 0.09, 6	
	AQUIC	15	S	0.8, 0.3, 1	
	AERIC	10	Z		0.1, 0.05, 1
	HISTIC_IDX	5	Z		0.15, 0.075, 2
Freer	HYD_IDX	25	Bell	2.3, 0.25, 2	3.2, 0.7, 1
	MANTLE	30	S	86, 37, 2	
	AQUIC	10	S	0.95, 0.1, 8	
	AERIC	20	Z		0.6, 0.2, 7
	HYDRIC	5	Z		0.05, 0.45, 2
	HISTIC_IDX	10	Z		0.15, 0.1, 2
Cebana	HYD_IDX	25	Bell	3.5, 0.7, 1	4.1, 0.6, 1
	MANTLE	30	S	86, 37, 2	
	AERIC	10	S	0.9, 0.1, 4	
	HYDRIC	20	S	0.6, 0.1, 2	
	PONDED	5	Z		0.1, 0.2, 2
	HISTIC_IDX	10	Bell	0.08, 0.08, 2	0.9, 2.1, 1

B. Unmantled Upland Sequence – 5 Classes; Inputs - 9 Features of Interest; 0 Covariates

Taxon/Soil	Feature/Covariate	Weight(%)	Curve	v1, w1, r1	v2, w2, r2
Amery	DENSIC	20	S	0.35, 0.15, 3	
	HYD_IDX	25	Z		1, 0.5, 1
	MANTLE	30	Z		10, 38, 2
	OXY	20	Bell	0.98, 0.20, 3	0.98, 0.15, 3
	AQUIC	5	Z		0.1, 0.3, 6
Milaca	DENSIC	10	Bell	0.225, 0.075, 6	0.325, 0.025, 2.5
	HYD_IDX	25	Bell	1, 0.1, 1.4	1.7, 0.6, 2.5
	MANTLE	30	Z		10, 38, 2
	OXY	20	S	0.98, 0.25, 2	
	AQUIC	5	Bell	0.1, 0.1, 7	0.25, 0.35, 1

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Taxon/Soil Feature/Covariate		Weight(%)	Curve	v1, w1, r1	v2, w2, r2
	AERIC	10	Z		0.01, 0.04, 2
Mora	DENSIC	5	Z		0.3, 0.05, 4
	HYD_IDX	25	Bell	1.8, 0.2, 2	2.2, 0.4, 1
	MANTLE	30	Z		10, 38, 2
	OXY	10	S	0.99, 0.09, 6	
	AQUIC	15	S	0.7, 0.3, 3	
	AERIC	10	Z		0.1, 0.05, 1
	HISTIC_IDX	5	Z		0.05, 0.075, 1.2
Ronneby	HYD_IDX	25	Bell	1.75, 0.25, 5	3.2, 0.6, 3
	MANTLE	30	Z		10, 38, 2
	AQUIC	10	S	0.95, 0.18, 8	
	AERIC	20	Z		0.56, 0.4, 9
	HYDRIC	5	Z		0.05, 0.2, 2
	HISTIC_IDX	10	Z		0.15, 0.1, 2
Parent	Hydrology	25	Bell	2.9, 1.6, 1	3.8, 0.4, 3
	MANTLE	30	Z		10, 38, 2
	AERIC	10	S	0.8, 0.05, 1.1	
	HYDRIC	20	S	0.5, 0.1, 3	
	PONDED	5	Z		0.01, 0.05, 4
	HISTIC_IDX	10	Bell	0.08, 0.08, 2	0.9, 2.1, 1

C. Recessional Moraine Associated Soil – 1 Class; 2 Features of Interest; 3 Covariates

Taxon/Soil Feature/Covariate		Weight(%)	Curve	v1, w1, r1	v2, w2, r2
Millward	MANTLE	5	S	10, 38, 2	
	OXY	50	Z		0.88, 0.05, 6.5
	drain_cost	5	S	1200, 580, 7.2	
	re200_800	20	S	3, 1.1, 4.6	
	slphetr100	20	S	3.3, 0.9, 3.35	

D. Wet Mineral Sequence – 2 Classes; 4 Features of Interest; 0 Covariates

Taxon/Soil Feature/Covariate		Weight(%)	Curve	v1, w1, r1	v2, w2, r2
Giese	HYD_IDX	35	Bell	4.4, 0.4, 1	4.9, 0.05, 1
	HYDRIC	10	S	0.95, 0.2, 1	
	PONDED	20	S	0.95, 0.45, 0.5	
	HISTIC_IDX	35	Bell	0.1455, 0.1, 2	0.1455, 0.1, 2
Twig	HYD_IDX	30	S	4.95, 0.3, 2	
	HYDRIC	10	S	0.95, 0.1, 1	

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Taxon/Soil Feature/Covariate	Weight(%)	Curve	v1, w1, r1	v2, w2, r2
PONDED	20	S	0.95, 0.15, 1	
HISTIC_IDX	40	Bell	0.9, 0.1, 10	1.5, 0.4, 3

E. Histosols – 6 Classes; 4 Features of Interest; 0 Covariates

Taxon/Soil Feature/Covariate	Weight(%)	Curve	v1, w1, r1	v2, w2, r2
Cathro	HYD_IDX	20	S	4.95, 0.15, 2
	HISTIC_IDX	40	Bell	3, 1.4, 2
	DYSIC	20	Z	0.1, 0.4, 1
	SAP_IDX	20	S	1.5, 0.3, 4
Beseman	HYD_IDX	20	S	4.95, 0.15, 2
	HISTIC_IDX	40	Bell	3, 1.4, 2
	DYSIC	20	S	0.7, 0.2, 1
	SAP_IDX	20	S	1, 0.3, 6
Tacoosh	HYD_IDX	20	S	4.95, 0.15, 2
	HISTIC_IDX	40	Bell	3, 1.4, 2
	DYSIC	20	Z	0.1, 0.4, 1
	SAP_IDX	20	Z	0.7, 0.5, 4
Seelyeville	HYD_IDX	20	S	4.95, 0.15, 2
	HISTIC_IDX	40	S	3.8, 0.5, 2
	DYSIC	20	Z	0.05, 0.15, 4
	SAP_IDX	20	S	1.1, 0.1, 2
Rifle	HYD_IDX	20	S	4.95, 0.15, 2
	HISTIC_IDX	40	S	3.8, 0.5, 2
	DYSIC	20	Z	0.05, 0.15, 4
	SAP_IDX	20	Z	1.1, 0.1, 2
Greenwood	HYD_IDX	20	S	4.95, 0.15, 2
	HISTIC_IDX	40	S	3.8, 0.5, 2
	DYSIC	20	S	0.3, 0.5, 4
	SAP_IDX	20	Bell	0.8, 0.2, 2

D. Alluvial

Taxon/Soil Feature/Covariate	Weight(%)	Curve	v1, w1, r1	v2, w2, r2
Alluvials	ALLUV	60	S	0.58, 0.08, 3.1
	drain_cost	30	S	3, 2, 2
	WATER_MASK	10	Ordinal	1

Project Classification Output (Mille Lacs Uplands)

Field Symbol (ID) Hardened Classification Field Name

1	Beseman
2	Bowstring
3	Brennyville
4	Cathro
5	Cebana
6	Freeon
7	Freer
8	Giese
9	Greenwood
10	Milaca
11	Millward
12	Mora
13	Parent
14	Rifle
15	Ronneby
16	Santiago
17	Seelyeville
18	Amery
19	Tacoosh
20	Twig
21	Water

Evaluation

1. Accuracy Assessment

A. Independent dataset targeting:

1. 95 percent Confidence Level
2. 10 percent Precision
3. 21 classes (11 percent – largest proportion class) – Targeted minimum of 5 independent field observations per class
4. Sample Design
 - a. Independent
 - b. Stratified
 - c. Random
 - d. Clustered

2. Provisional Correlation

Preliminary assessment of validation points (and cross-tabulated confusion matrix from training dataset) identified several class concepts with limited observations, poor discrimination in modeling, limited extent in hardened classification, or difficulty distinguishing from similar or associated soil concepts. Therefore, an initial pass of correlation decisions assigned specific classes into logical grouping with associated concepts, reducing the total number for classes from 21 to 14. Some classes that appeared to be poorly discriminated were retained if a class rendered a meaningful representation of a landscape associated concept that was inherently highly variable.

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Field Symbol (ID)	Hardened Classification Field Name	Approved Symbol (ID)	Approved Correlation
1	Beseman	3	Cathro Approved Raster Class
2	Bowstring	1	Bowstring Approved Raster Class
3	Brennyville	2	Brennyville Approved Raster Class
4	Cathro	3	Cathro Approved Raster Class
5	Cebana	4	Cebana Approved Raster Class
6	Freeon	8	Milaca Approved Raster Class
7	Freer	5	Freer Approved Raster Class
8	Giese	6	Giese or Twig Approved Raster Class
9	Greenwood	7	Greenwood Approved Raster Class
10	Milaca	8	Milaca Approved Raster Class
11	Millward	9	Millward Approved Raster Class
12	Mora	10	Mora Approved Raster Class
13	Parent	4	Cebana Approved Raster Class
14	Rifle	11	Rifle Approved Raster Class
15	Ronneby	12	Ronneby Approved Raster Class
16	Santiago	8	Milaca Approved Raster Class
17	Seelyeville	13	Seelyeville Approved Raster Class
18	Amery	8	Milaca Approved Raster Class
19	Tacoosh	3	Cathro Approved Raster Class
20	Twig	6	Giese or Twig Approved Raster Class
21	Water	21	Water

3. Final Accuracy Assessment

Contemporary Field Observation – 90 pedons

Set Aside Historical Documentation – 41 (Minnesota DNR Organic Soil Cores)

Remote Sensing and Ancillary Data – 20 (Water and Alluvial Concepts)

Total Valid Points: 151

ID	Approved Correlation	Raster Value	Map Symbol	Correlated Map Unit Name
21	Water	3108525	2lthb	Water
1	Bowstring Approved Raster Class	3108534	2z19n	Bowstring muck and Fluvaquents, loamy, 0 to 2 percent slopes, frequently flooded
2	Brennyville Approved Raster Class	3108535	2z586	Brennyville silt loam, 1 to 6 percent slopes, stony
3	Cathro Approved Raster Class	3108536	2z58p	Cathro muck, 0 to 1 percent slopes, frequently ponded
4	Cebana Approved Raster Class	3108537	2z588	Cebana-Giese, frequently ponded complex, 0 to 2 percent slopes, stony
5	Freer Approved Raster Class	3108538	2z589	Freer silt loam, 1 to 3 percent slopes, stony
6	Giese or Twig Provisional	3108539	2z58b	Giese, stony-Cathro complex, 0 to 1 percent slopes, (430-648-H, 1 st Ed., Amend. 40, June 2023)

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ID	Approved Correlation	Raster Value	Map Symbol	Correlated Map Unit Name
	Raster Class			frequently ponded
7	Greenwood Provisional Raster Class	3108540	2z19t	Greenwood mucky peat, 0 to 1 percent slopes
8	Milaca Provisional Raster Class	3108541	2z58d	Milaca loam, 1 to 9 percent slopes, stony
9	Millward Provisional Raster Class	3108542	2z58f	Milaca and Millward soils, 3 to 20 percent slopes, stony
10	Mora Provisional Raster Class	3108543	2z58g	Mora silt loam, 1 to 6 percent slopes
11	Rifle Provisional Raster Class	3108544	2z1b0	Rifle mucky peat, 0 to 1 percent slopes, occasionally ponded
12	Ronneby Provisional Raster Class	3108546	2z58j	Ronneby silt loam, 1 to 4 percent slopes, stony
13	Seelyeville Provisional Raster Class	3108545	2z1b1	Seelyeville, occasionally ponded-Cathro, frequently ponded, complex, 0 to 1 percent slopes

Error Matrix

ID	21	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
21	6	2	0	2	0	0	0	0	0	0	0	0	0	0	10
1	0	8	0	0	0	0	2	0	0	0	0	0	0	0	10
2	0	0	7	0	1	0	0	0	0	2	0	0	0	0	10
3	0	0	0	6	0	0	0	0	0	0	1	0	0	0	7
4	0	0	0	0	9	1	3	1	0	0	2	0	1	1	17
5	0	0	0	0	0	6	0	0	0	0	1	0	0	0	7
6	0	0	0	1	0	0	6	0	0	0	0	1	0	2	10
7	0	0	0	2	0	0	0	14	0	0	0	4	0	0	20
8	0	0	1	0	0	1	0	0	21	2	2	0	0	0	27
9	0	0	0	0	0	0	0	0	2	0	1	0	0	0	3
10	0	0	0	0	0	0	0	0	1	0	6	0	3	0	10
11	0	0	0	5	0	0	0	0	0	0	0	6	0	0	11
12	0	0	0	0	1	0	1	0	0	0	0	0	4	0	6
13	0	0	0	2	0	0	0	0	0	0	0	0	0	1	3
Total	6	10	8	18	11	8	12	15	24	2	12	14	7	4	151

ID Producer Accuracy User Accuracy

21	100%	60%
1	80%	80%
2	88%	70%
3	33%	86%
4	82%	53%
5	75%	86%

ID Producer Accuracy User Accuracy

6	50%	60%
7	93%	70%
8	88%	78%
9	0%	0%
10	50%	60%
11	43%	55%
12	57%	67%
13	25%	33%

Overall Accuracy 66 percent

Area Weighted Accuracy 67 percent

Khat (Kappa Coefficient) 63 percent

Spatial Tolerance +/- 10 m

Uncertainty:

Shannon Entropy:

Data Development

1. SSURGO Vector Data Development and Correlation

Input: Project Classification Output (Mille Lacs Uplands) – Output from VI.2 Extent: MLRA SSURGO Map Unit Extent – Proposed Correlation footprint evaluated through geographic analysis and field investigations and buffered by one cell.

Local Process of Line Projection and Segmentation following the concept of the most important line, and subsequent map unit correlation. Additional information about tabular data development and taxons are contained in the project correlation.

A. Segmentation

Sequence of Majority Filters (filter for the class not represented as other) Each Line is Identified if the value (5 m) OR Majority at any neighborhood radius (15/30/45/60/75 m) represents the most important classification identified.

Line 0xx – Exclusion Water (End)

- Water

Line 1xx – Histosol (intermediate)

- Line 11x Alluvial (End)
 - Bowstring
- Line 12x – Other – Histosol (Intermediate)
 - Line 120 – Deep Histosol (Intermediate)
 - Line 120 – Dysic Deep Histosols (End)
 - Greenwood
 - Line 121 – Other – Euic Deep Histosols (End)
 - Rifle
 - Seelyeville
 - Line 122 – Other – Terric Histosols (End)
 - Cathro
 - Beseman
 - Tacoosh

Line 2xx – Other – Mineral (Intermediate)

- Line 21x – Mineral Hydric (End)

- Twig
- Giese
- Line 22x – Other – Mineral (Intermediate)
 - Line 220 – Other – Mineral Matrix – Not Silt Capped
 - Santiago
 - Milaca
 - Mora
 - Ronneby
 - Parent
 - Line 221 – Mineral Matrix – Silt Capped
 - Amery
 - Freeon
 - Brennyville
 - Freer
 - Cebana
 - Line 222 – Mineral Dry (End)
 - Millward

B. Reconstitution

Sequence of Eliminate as Grouped by Major Breaks

- Group 1 – Non-alluvial Histosols and Hydric Soils (21, 120, 121, 122) Vectorized
 - Greenwood, Rifle, Seelyville, Twig, Giese
 - Iterative Eliminate 0.5 to 15 acres
- Group 2 – Other mineral Soils (220, 221, 222) Vectorized
 - Santiago, Milaca, Mora, Ronneby, Parent, Amery, Freeon, Brennyville, Freer, Cebana, Millward
 - Iterative Eliminate 0.5 to 6 acres
- Group 3 – Exclusions (No Elimination) Water and Alluvial (0,11) Vectorized
 - Water, Bowstring
- Merge Group 1, 2, 3
 - Iterative Eliminate 0.1 to 3.5 acres

C. Cartography and Correlation

Remove Narrow Delineation

Soil Lines Buffered by 20 m

Erase Buffered Zones from Rasterized Version of Soil Polygons 1

Euclidean Allocation and Re-Vectorize

Iterative Eliminate 0.1 to 3.5 acres

Soil Polygon Composition

- Tabulate Percentage of Classes (Project Classification Output (Mille Lacs Uplands)) Per Polygon
- Project Map Unit Name of each polygon assuming all components > 10 percent are named component
- Pare 861 projected map unit names down to 17 tentative Provisional Concepts

Dissolve polygons based on Provisional Concepts

Smooth Lines (PAEK 30 m)

Clip based on MLRA SSURGO Map Unit Extent

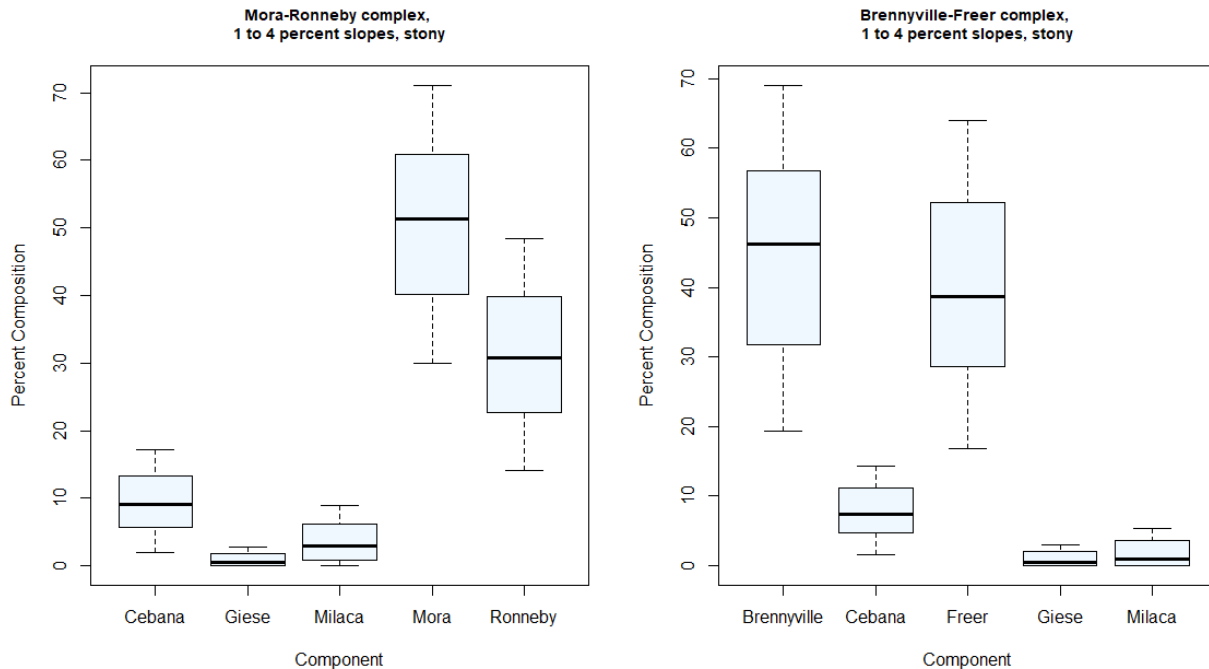
One Additional Pass of Dissolve and Eliminate following smoothing

Tabulate Percentage of Classes (Project Classification Output (Mille Lacs Uplands)) Per Map Unit

Revise Provisional Concepts into Provisional Map Units

Statistical Analysis was performed on the percentage of each component modeled within each individual map unit delineation. The image below illustrates the percent composition of the dominant components modeled within that map unit. The lower and upper whiskers of the box plot show the 10th and 90th percentile break, respectively.

Figure 2: Box and Whisker Plot Showing Map Unit Percent Composition



In NASIS

Provisional Map Unit Name = Major Component from analysis considering similar and dissimilar etc.

Field Symbol = Project Mapunit Record ID (1–17) with slope phase

Field Symbol (ID)	Former or Field Name	Published Map Symbol	National Symbol	Correlated Soil Name
1	Bowstring muck	C211	2z19n	Bowstring muck and Fluvaquents, loamy, 0 to 2 percent slopes, frequently flooded
2B	Brennyville-Freer complex	C10B	2z19m	Brennyville-Freer complex, 1 to 4 percent slopes, stony
16	Seelyeville-Greenwood-Cathro complex	C104A	2z1b2	Cathro, frequently ponded-Seelyeville, occasionally ponded-Greenwood complex, 0 to 1 percent slopes
3	Cathro-Twig complex	C28A	2z19p	Cathro-Twig, stony complex, 0 to 1 percent slopes, frequently ponded
4	Cathro, Beseman and Twig Soils	C28A	2z19p	Cathro-Twig, stony complex, 0 to 1 percent slopes, frequently ponded
5A	Cebana-Freer-Giese complex	C126A	2z19q	Cebana-Giese, frequently ponded-Freer complex, 0 to 3 percent slopes
13	Parent-Ronneby-Giese complex	C4A	2z19z	Cebana-Giese, frequently ponded-Ronneby complex, 0 to 3 percent slopes
8	Greenwood mucky	C101A	2z19t	Greenwood mucky peat, 0 to 1 percent slopes

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Field Symbol (ID)	Former or Field Name	Published Map Symbol	National Symbol	Correlated Soil Name
	peat			
7C	Freeon-Santiago complex	C73C	2z19s	Milaca loam, 1 to 7 percent slopes, stony
9C	Milaca-Amery complex	C73C	2z19s	Milaca loam, 1 to 7 percent slopes, stony
6C	Freeon-Brennyville complex	C1C	2z19r	Milaca-Brennyville complex, 1 to 7 percent slopes, stony
10D	Milaca-Millward complex	C72D	2z19w	Milaca-Millward complex, 2 to 20 percent slopes, stony
11C	Milaca-Mora complex	C71C	2z19x	Milaca-Mora complex, 1 to 7 percent slopes, stony
12B	Mora-Ronneby complex	C9B	2z19y	Mora-Ronneby complex, 1 to 4 percent slopes, stony
14	Rifle and Seelyeville soils	C158	2z1b0	Rifle mucky peat, 0 to 1 percent slopes, occasionally ponded
15	Seelyeville-Cathro complex	C75A	2z1b1	Seelyeville, occasionally ponded-Cathro, frequently ponded, complex, 0 to 1 percent slopes

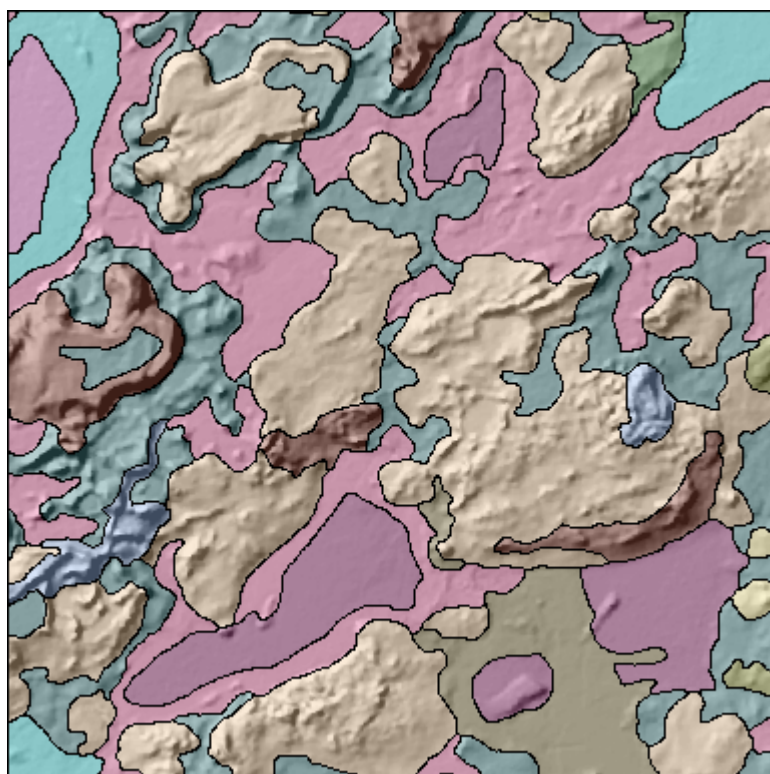
New MLRA map units certified through this project replace previous correlations. This project aligns with standards related to MLRA field project strategies (National Soil Survey Handbook 610.3.2). MLRA field projects produce seamless coverage of attribute and spatial data across political boundaries. Exact joins are achieved in all MLRA map units correlated through this MLRA field project. See Project Correlation: MLRA 90A – Mille Lacs Uplands Coarse-Loamy Basal Till Investigation – Final Correlation in NASIS for more information on classification and correlation.

MLRA 90A – Mille Lacs Uplands Coarse-Loamy Basal Till Investigation
Acreage and Proportionate Extent of the Soils (MLRA Map Units)

Parts of the following subsets: Aitkin County, Minnesota; Benton County, Minnesota; Carlton County, Minnesota; Isanti County, Minnesota; Kanabec County, Minnesota; Mille Lacs County, Minnesota; Morrison County, Minnesota; Pine County, Minnesota; Sherburne County, Minnesota

Map Symbol	Soil Name	Acres	Percent
C1C	Milaca-Brennyville complex, 1 to 7 percent slopes	16,115	1.3
C4A	Cebana-Giese, frequently ponded-Ronneby complex, 0 to 3 percent slopes	74,527	5.9
C9B	Mora-Ronneby complex, 1 to 4 percent slopes, stony	258,251	20.5
C10B	Brennyville-Freer complex, 1 to 4 percent slopes	245,035	19.5
C28A	Cathro-Twig, stony complex, 0 to 1 percent slopes, frequently ponded	126,489	10.1
C71C	Milaca-Mora complex, 1 to 7 percent slopes, stony	47,801	3.8
C72D	Milaca-Millward complex, 2 to 20 percent slopes, stony	70,258	5.6
C73C	Milaca loam, 1 to 7 percent slopes, stony	105,593	8.4
C75A	Seelyeville, occasionally ponded-Cathro, frequently ponded, complex, 0 to 1	78,494	6.2

Map Symbol	Soil Name	Acres	Percent
	percent slopes		
C101A	Greenwood mucky peat, 0 to 1 percent slopes	45,326	3.6
C104A	Cathro, frequently ponded-Seelyeville, occasionally ponded-Greenwood complex, 0 to 1 percent slopes	5,125	0.4
C126A	Cebana-Giese, frequently ponded-Freer complex, 0 to 3 percent slopes, stony	66,848	5.3
C158	Rifle mucky peat, 0 to 1 percent slopes, occasionally ponded	63,578	5.1
C211	Bowstring muck and Fluvaquents, loamy, 0 to 2 percent slopes, frequently flooded	54,070	0.4
	Total	1,257,510	100.0

Figure 3: SSURGO Mapping**2. Raster Soil Survey Correlation**

Minnesota (MN) RSS Area

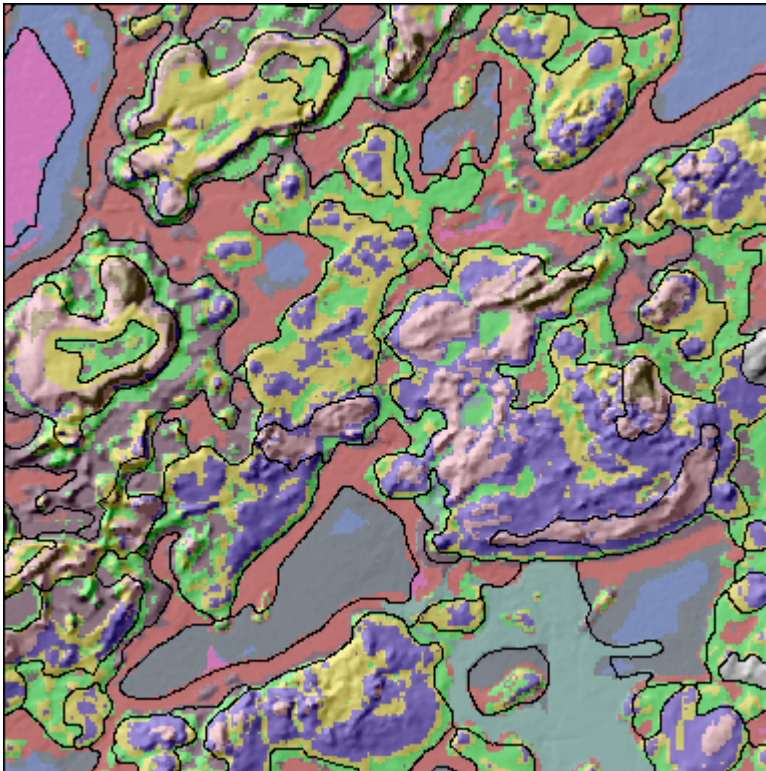
RSS Project: MLRA 90A – Mille Lacs Uplands Coarse-Loamy Basal Till Investigation

Acreage and Proportionate Extent of the Soils

Map Symbol	Soil Name	Acres	Percent
2z19n	Bowstring muck and Fluvaquents, loamy, 0 to 2 percent slopes, frequently flooded	45,089	3.6
2z586	Brennyville silt loam, 1 to 6 percent slopes, stony	139,178	11.0
2z58p	Cathro muck, 0 to 1 percent slopes, frequently ponded	126,639	10.0
2z588	Cebana-Giese, frequently ponded complex, 0 to 2 percent slopes, stony	160,985	12.7
2z589	Freer silt loam, 1 to 3 percent slopes, stony	112,773	8.9
2z58b	Giese, stony-Cathro complex, 0 to 1 percent slopes, frequently ponded	61,988	4.9

Map Symbol	Soil Name	Acres	Percent
2z19t	Greenwood mucky peat, 0 to 1 percent slopes	42,402	3.3
2z58f	Milaca and Millward soils, 3 to 20 percent slopes, stony	13,811	1.1
2z58d	Milaca fine sandy loam, 1 to 9 percent slopes, stony	176,007	13.9
2z58g	Mora silt loam, 1 to 6 percent slopes, stony	159,241	12.6
2z1b0	Rifle mucky peat, 0 to 1 percent slopes, occasionally ponded	50,504	4.0
2z58j	Ronneby silt loam, 1 to 4 percent slopes, stony	99,463	7.9
2z1b1	Seelyeville, occasionally ponded-Cathro, frequently ponded, complex, 0 to 1 percent slopes	69,400	5.5
2zthb	Water	8,766	0.7
	Total	1,266,246	100.0

Figure 4: Raster Mapping with SSURGO Lines



Results

1. Seamless Spatial Data – seamless SSURGO product across political lines

Scale, management focus, base materials, and mapping tools have changed through the course of county-based progressive soil survey. Digital soil survey products from SSURGO reflect this variability in resulting products. Following the completion of MLRA field projects, soil survey interpretive results seamlessly follow natural landforms and, thus, flow across county or state lines and land management boundaries.

Figure 5: SSURGO 2019. The image below illustrates county subset-based inconsistencies as rendered prior to project completion. Example of inconsistencies along a county boundary and throughout the project area prior to completion of MLRA field project. Image represents Depth to Restrictive Layer (depth range: green = 200 cm to orange = 100 cm)

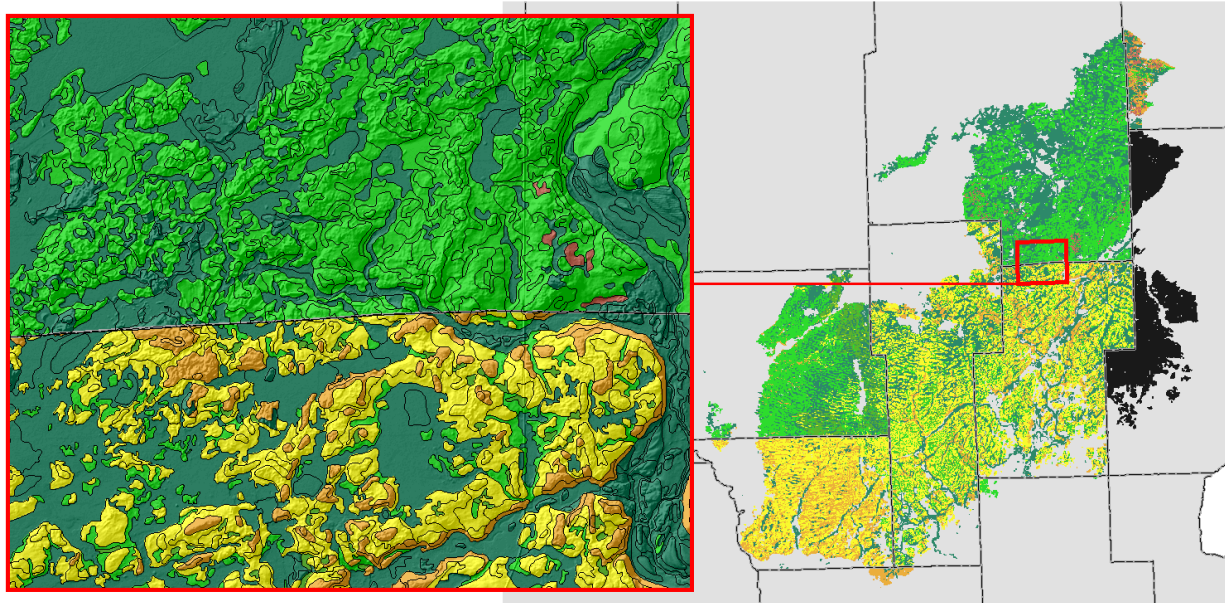
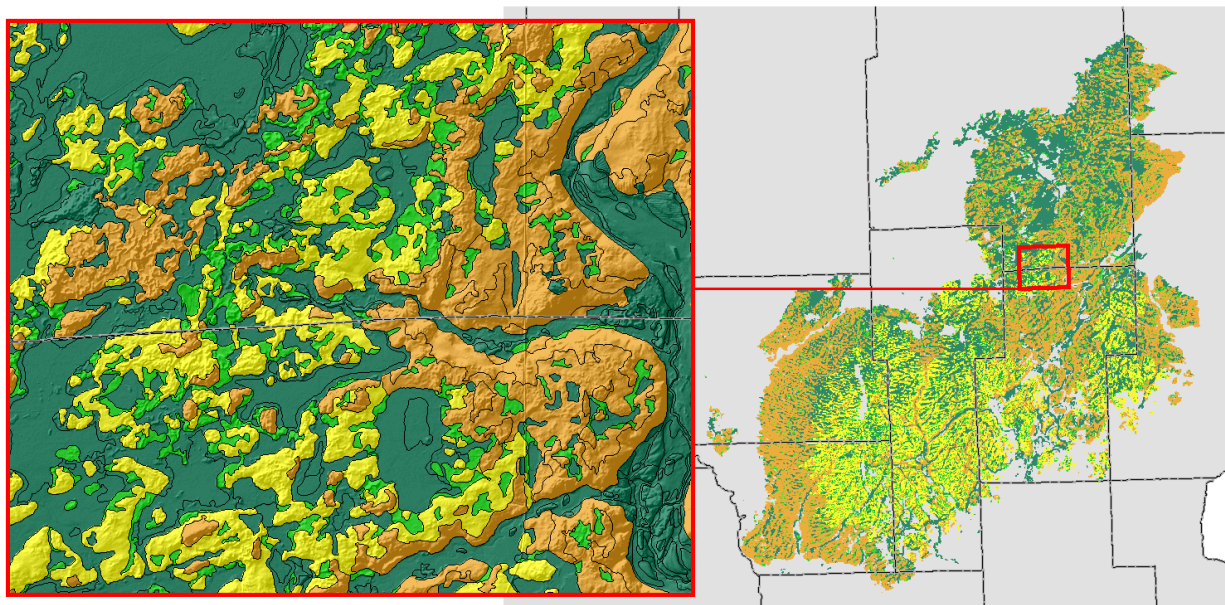


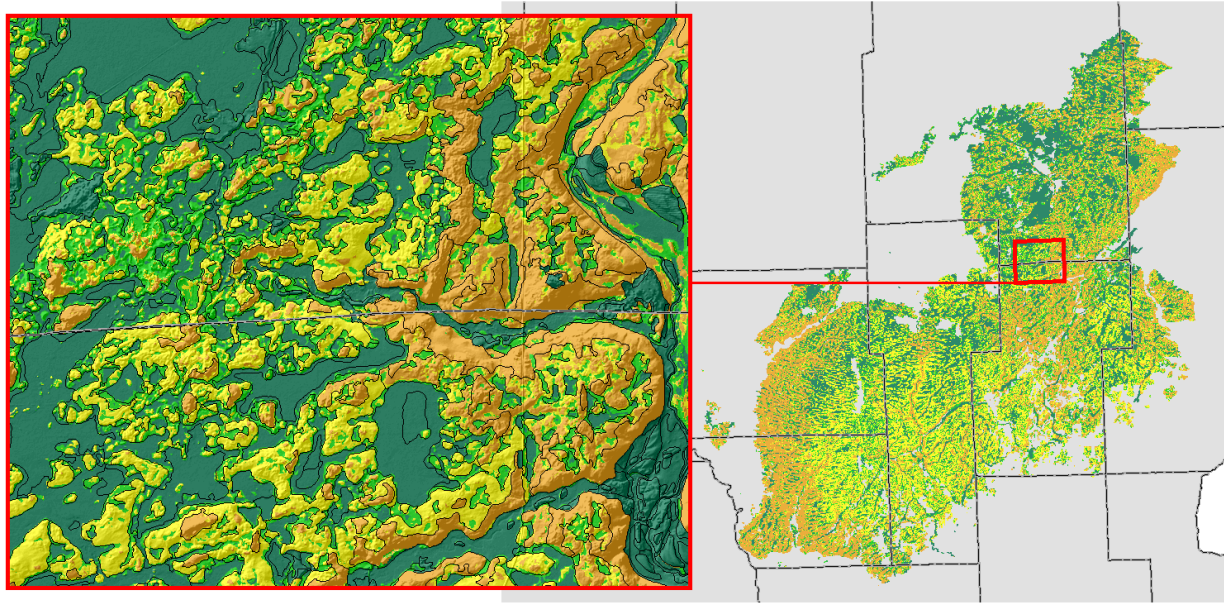
Figure 6: SSURGO 2020. The image below illustrates results of applied mapping conventions (outlined VIII.1.b and VIII.1.c above) through the MLRA field project. Results display the consistent mapping of Depth to Restrictive Layer (depth range: green = 200 cm to orange = 100 cm)



2. Raster Soil Survey

RSS products provide consistent soil information using digital soil mapping methods to exploit the relationship of environmental data to soil variability. Resulting products are spatially refined (10m resolution) representations of soil knowledge in comparison to traditional SSURGO products represented above.

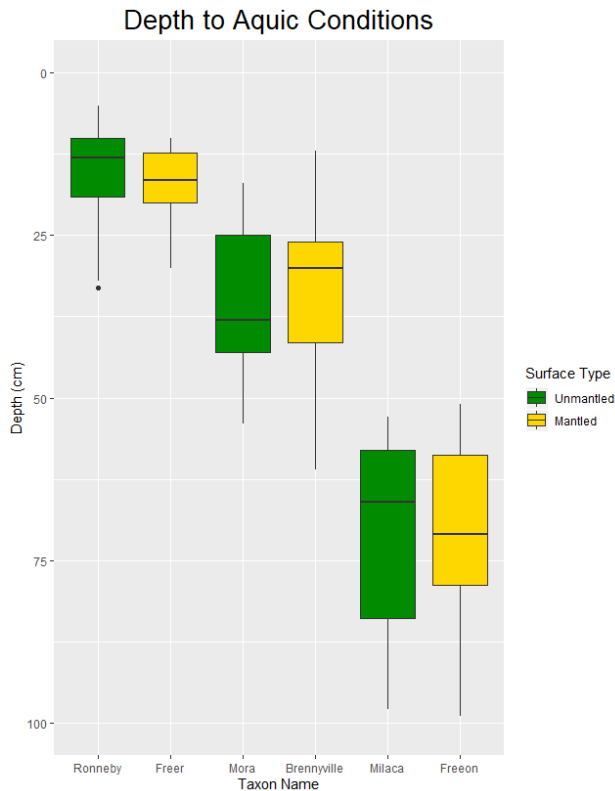
Figure 7: Raster Soil Survey 2020. The image below is a spatial representation of Depth to Restrictive Layer illustrating 50–250x the amount of detail in comparison with vector delineations from SSURGO. Results render uniquely from SSURGO at small and large scales while providing complimentary data.



3. Complete and Consistent Tabular Data

Supporting tabular data for SSURGO and RSS populated to the common and current standard for MLRA map units and components.

Tabular data was developed through the review and analysis of 479 descriptions collected in the project area, including 50 pedons containing laboratory analysis. Trends in property depths were statistically analyzed on all the historically collected data and data collected during the initial training point and validation point collection phase. This data was then used to aid in the population of the components in the soils database. Figure 8 illustrates the trends observed in depth to observed aquic conditions of the upland soil components in the Mantled and Unmantled Catenas.

Figure 8: Box and Whisker Plot Showing Depth to Aquic Conditions of Upland Soils

MLRA map units and associated component concepts designed to capture +/- 80 percent of the observed variability in soil properties, qualities, and diagnostic features.

Headnote for Project Raster Soil Survey

Data is published at 10 m resolution covering identical spatial extent of MLRA map units in SSURGO correlated through this MLRA field project. MLRA raster data published in the Minnesota (MN) RSS Area is complimentary to the data found in SSURGO and was foundational to the published SSURGO updates in parts of Aitkin County, Minnesota (MN001); Benton County, Minnesota (MN009); Carlton County, Minnesota (MN017); Isanti County, Minnesota (MN059); Kanabec County, Minnesota (MN065); Mille Lacs County, Minnesota (MN095); Morrison County, Minnesota (MN097); Pine County, Minnesota (MN115); Sherburne County, Minnesota (MN141) through the project (MLRA 90A – Mille Lacs Uplands Coarse-Loamy Basal Till Investigation). Certain map unit acreage (2lthb; 2z19n) was confined to project extent where appropriate.

The acreage of 1,266,246 represents the Land Category Acreage of raster data (Water acreage confined to project footprint). Total Land Category Acreage of this project is 1,257,510 representing MLRA Map Units and Anthropogenic MLRA Map Units updated through the project, excluding Water. Additional Information can be found in the document "Project Correlation: MLRA 90A – Mille Lacs Uplands Coarse-Loamy Basal Till Investigation - Final Correlation," stored in the National Soil Information System (NASIS) Database. This document is available upon request by contacting the NRCS-Minnesota State Soil Scientist.

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Variables, Software and Methods:

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Spatial Data

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Footnotes

1. Mucky modified layers are considered 0.5 X horizon depth to illustrate relative trends
2. Observations contain enough relevant information to be used in model training and correlation, but have high spatial uncertainty relative to landform position
3. Observations contained insufficient documentation for model training, but adequate descriptive data to confirm the soils as pertinent to the project
4. Observations contained insufficient documentation for model training, but adequate descriptive data to confirm the soils as pertinent to the project
5. Observations contained insufficient documentation for model training, but adequate descriptive data to confirm the soils as pertinent to the project
6. Observations contained insufficient documentation for model training, but adequate descriptive data to confirm the soils as pertinent to the project
7. Observations contain enough relevant information to be used in model training and correlation, plot radius was documented to establish a spatial footprint of a polypedon to assist in class modeling
8. Observations contain enough relevant information to be used in model training and correlation, plot radius was documented to establish a spatial footprint of a polypedon to assist in class modeling
9. Observations contained insufficient documentation for model training, but adequate descriptive data to confirm the soils as pertinent to the project
10. Observations contain enough relevant information to be used in model training and correlation, but have high spatial uncertainty relative to landform position
11. Observations contain enough relevant information to be used in model training and correlation, but have high spatial uncertainty relative to landform position
12. Observations contain enough relevant information to be used in model training and correlation, but have high spatial uncertainty relative to landform position
13. Observations contain enough relevant information to be used in model training and correlation, plot radius was documented to establish a spatial footprint of a polypedon to assist in class modeling

648.15 Metadata

Example metadata

MapunitRaster 10 m – Minnesota
File Geodatabase Raster Dataset

Tags

Minnesota, USA, RSS, geoscientific information, Soil Survey, GDG, soils, United States of America, environment, Raster Soil Survey, gridded, farming, raster, Geospatial Data Gateway, SSURGO

Summary

The 202209 RSS Map Unit Raster was created for use in national, regional, and state-wide resource planning and analysis of soils data. The raster map layer data can be readily combined with other national, regional, and local raster layers (e.g., National Land Cover Database (NLCD), the National Agricultural Statistics Service (NASS) Crop Data Layer, or the National Elevation Dataset (NED)).

Description

This layer represents the soil map unit classes in a raster format. Raster datasets are efficient for modeling with other raster datasets such as landcover, landuse or elevation. Each cell value is represented by the integer version of the map unit key (MUKEY), a unique identifier within the associated tabular SSURGO data containing soil properties and interpretations. The standard character map unit key (MUKEY) is also included to facilitate table joins to the SSURGO tables that contain these soil properties and interpretations.

Credits

Soil Survey Staff. Raster Soil Survey (RSS) Database for Minnesota. United States Department of Agriculture, Natural Resources Conservation Service. Available on the USDA Geospatial Data Gateway. 20220901 (202209 official release).

Use limitations

The U.S. Department of Agriculture, Natural Resources Conservation Service, should be acknowledged as the data source in products derived from these data. This dataset is not designed for use as a primary regulatory tool in permitting or siting decisions but may be used as a reference source. This is public information and may be interpreted by organizations, agencies, units of government, or others based on needs; however, they are responsible for the appropriate application. Federal, State, or local regulatory bodies are not to reassign to the Natural Resources Conservation Service any authority for the decisions that they make. The Natural Resources Conservation Service will not perform any evaluations of these maps for purposes related solely to State or local regulatory programs. Digital data files are periodically updated. Users are responsible for obtaining the latest version of the data.

Extent

West -97.248378 East -89.365641
North 49.387564 South 43.359233

Scale Range

Maximum (zoomed in) 1:5,000
Minimum (zoomed out) 1:150,000,000

ArcGIS Metadata - Topics and Keywords - Themes or categories of the resource farming, geoscientific information, environment

* Content type Downloadable Data

Place keywords Minnesota, USA, United States of America

Thesaurus: Title Codes for the Identification of the States, the District of Columbia and the Outlying Areas of the United States, and Associated Areas (Fips Pub 5-2)

Theme keywords RSS, geoscientific Information, Soil Survey, GDG, soils, environment, Raster Soil Survey, gridded, farming, raster, Geospatial Data Gateway, SSURGO

Citation -Title MapunitRaster 10 m - Minnesota

Presentation formats digital map

FGDC geospatial presentation format raster digital data

Citation Contacts -Responsible party

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center

Contacts role originator

Resource Details -Dataset languages English (UNITED STATES)

Spatial representation type * grid

Processing environment Empty

Credits

Soil Survey Staff. Raster Soil Survey (RSS) Database for Minnesota. United States Department of Agriculture, Natural Resources Conservation Service. Available on the USDA Geospatial Data Gateway. 20220901 (202209 official release).

ArcGIS item properties

* Name MapunitRaster_10m_MN_202209

* Access protocol Local Area Network

Extents -Extent

Geographic extent

Bounding rectangle

Extent type Extent used for searching

* West longitude -97.248378

* East longitude -89.365641

* North latitude 49.387564

* South latitude 43.359233

* Extent contains the resource Yes

Extent in the items coordinate system

* West longitude -91935.000000

* East longitude 489345.000000

* South latitude 2278455.000000

Title 430 – National Soil Survey Handbook

* North latitude 2930755.000000

* Extent contains the resource Yes

Resource Points of Contact -Point of contact

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Geospatial Center of Excellence

Contacts role point of contact

Contact information: Phone

Voice 800 672 5559

Fax 817 509 3469

Address

Type postal

Delivery point 501 West Felix Street

City Fort Worth

Administrative area TX

Postal code 76115

Country US

Point of contact

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center

Contacts role point of contact

Contact information: Address

Type postal

Delivery point 100 Centennial Mall North

Delivery point Federal Building, Room 152

City Lincoln

Administrative area NE

Postal code 68508-3866

Country US

e-mail address SoilsHotline@lin.usda.gov

Resource Maintenance -Resource maintenance

Update frequency annually

Resource Constraints -Legal constraints

Limitations of use

See access and use constraints information.

Other constraints

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the bases of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, or all or part of an individual's income is derived from any public assistance program, or protected genetic information in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases will apply to all programs and/or employment activities.) To file a complaint of discrimination, complete, sign and mail the USDA Program Discrimination Complaint Form (PDF) or at any USDA office, or call (866) 632-9992 to request the form. Send your completed complaint form or letter to us by mail at: USDA Office of the Assistant Secretary for

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Civil Rights 1400 Independence Avenue, S.W. Washington, D.C. 20250-9410 Or by email at
program.intake@usda.gov.

Individuals who are deaf, hard of hearing or have speech disabilities and you wish to file either an EEO or program complaint please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish). Persons with disabilities who wish to file a program complaint, please see information above on how to contact us by mail directly or by email. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.) please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

Constraints

Limitations of use

The U.S. Department of Agriculture, Natural Resources Conservation Service, should be acknowledged as the data source in products derived from these data. This dataset is not designed for use as a primary regulatory tool in permitting or siting decisions but may be used as a reference source. This is public information and may be interpreted by organizations, agencies, units of government, or others based on needs; however, they are responsible for the appropriate application. Federal, State, or local regulatory bodies are not to reassign to the Natural Resources Conservation Service any authority for the decisions that they make. The Natural Resources Conservation Service will not perform any evaluations of these maps for purposes related solely to State or local regulatory programs. Digital data files are periodically updated. Files are dated, and users are responsible for obtaining the latest version of the data.

Spatial Reference -ArcGIS coordinate system

- * Type Projected
- * Geographic coordinate reference GCS_North_American_1983
- * Projection NAD_1983_Contiguous_USA_Albers
- * Coordinate reference details

Projected coordinate system

Well-known identifier 5070
X origin -16901100
Y origin -6972200
XY scale 266467840.99085236
Z origin -100000
Z scale 10000
M origin -100000
M scale 10000
XY tolerance 0.001
Z tolerance 0.001
M tolerance 0.001
High precision true
Latest well-known identifier 5070

Well-known text

PROJCS[NAD_1983_Contiguous_USA_Albers,GEOGCS[GCS_North_American_1983,DATUM[D_North_American_1983,SPHEROID[GRS_1980,6378137.0,298.257222101]],PRIMEM[Greenwich,0.0],UNIT[Degree,0.0174532925199433]],PROJECTION[Albers],PARAMETER[False_Easting,0.0],PARAMETER[False_Northing,0.0],PARAMETER[Central_Meridian,-96.0],PARAMETER[Standard_Parallel_1,29.5],PARAMETER[Standard_Parallel_2,45.5],PARAMETER[Latitude_Of_Origin,23.0],UNIT[Meter,1.0],AUTHORITY[EPSG,5070]]

Title 430 – National Soil Survey Handbook

Reference system identifier

* Value 5070

* Codespace EPSG

* Version 7.4.6(10.1.0)

Spatial Data Properties -Georectified Grid: Number of dimensions 2

Cell geometry area

Data Quality -Scope of quality information: Resource level dataset

Lineage Process Step: Date 2019-09-19

Description

The Project: Boundary Waters Canoe Area Wilderness - Initial was certified in 2017 adding 1,239,528 acres to Raster Soil Survey Area: Minnesota.

I. Tabular Reference - Legend Area Overlap

Tabular Reference (Legend Area Overlap):

Legend Area Overlap Type: Raster Soil Survey Project

Legend Area Overlap Symbol: BWCA_10-DUL17

Legend Area Overlap Name: Boundary Waters Canoe Area Wilderness - Initial

Conversion Legend:

ID	Raster	Map	Correlated
	Value	Symbol	Map Unit Name
1	3108517 2xfqh		Eveleth-Wahlsten-Eaglesnest complex, 3 to 18 percent slopes, bouldery
2	3108518 2xfqj		Conic-Insula complex, 8 to 35 percent slopes, bouldery
3	3108520 2xfqm		Aquepts, Babbitt and Wahlsten soils, 0 to 5 percent slopes
4	3108519 2xfqk		Quetico-Insula, bouldery-Rock outcrop complex, 3 to 35 percent slopes
5	3108521 2xfqn		Aquepts, very rubbly-Babbitt, bouldery complex, 0 to 4 percent slopes
6	3108522 2xfqq		Canthook, Baudette, Spooner and Voyageurs soils, 0 to 8 percent slopes
7	3108524 2xfqr		Rollins very gravelly sandy loam, 3 to 45 percent slopes, stony
8	3108525 2lthb		Water
9	3108526 2xfqs		Wahlsten, Eaglesnest and Babbitt soils, 1 to 8 percent slopes, bouldery
10	3108527 2xfqv		Rifle, Greenwood and Tacoosh soils, 0 to 1 percent slopes
11	3108528 2xfqw		Greenwood peat, 0 to 1 percent slopes
14	3108531 2xfqy		Tacoosh, Merwin and Rifle soils, 0 to 1 percent slopes
15	3108532 2xfqz		Daisybay and Tacoosh soils, 0 to 1 percent slopes
12	3108529 2xfqt		Bowstring muck, 0 to 1 percent slopes, frequently flooded
13	3108530 2xfqx		Fluvaquents mucky peat, 0 to 2 percent slopes, frequently flooded

II. Raster Soil Survey Level: Level C

III. Model Development

Data referenced for model training: 207 pedons (Contemporary Field Observations).

Sample design: cLHS

Digital environmental data: Terrain, Vegetation Height, and Hydrology Derivatives from LIDAR; PRISM Climate Data; Spectral Indices from LANDSAT 7; Spectral Indices from LANDSAT 5

Title 430 – National Soil Survey Handbook

Number of covariates evaluated for use: 38

Data resolution: 10 m

Modeling methods: Knowledge-based fuzzy logic; random forest; logistic regression; tacit-knowledge oriented rulesets; heads-up feature identification

IV. Map Accuracy

Error Matrix:

ID	1	2	3	4	5	6	7	9	10	11	14	15	12	13	Total
1	6	2	0	2	0	0	0	0	0	0	0	0	0	0	10
2	0	8	0	0	0	0	2	0	0	0	0	0	0	0	10
3	0	0	7	0	1	0	0	0	0	0	2	0	0	0	10
4	0	0	0	6	0	0	0	0	0	0	0	1	0	0	7
5	0	0	0	0	9	1	3	1	0	0	0	2	0	1	17
6	0	0	0	0	0	6	0	0	0	0	1	0	0	0	7
7	0	0	0	1	0	0	6	0	0	0	0	1	0	2	10
9	0	0	0	2	0	0	0	14	0	0	0	4	0	0	20
10	0	0	1	0	0	1	0	0	21	2	2	0	0	0	27
11	0	0	0	0	0	0	0	0	2	0	1	0	0	0	3
14	0	0	0	0	0	0	0	0	1	0	6	0	3	0	10
15	0	0	0	5	0	0	0	0	0	0	0	6	0	0	11
12	0	0	0	0	1	0	1	0	0	0	0	0	4	0	6
13	0	0	0	2	0	0	0	0	0	0	0	0	0	1	3
Tot	6	10	8	18	11	8	12	15	24	2	12	14	7	4	151

Validation data source: Contemporary Field Observation - 253 pedons (Contemporary Field Observations).

Sample design: External validation, multi-stage stratified random

Considerations of confidence and precision: Results published targeting 90 percent confidence (map accuracy)/10 percent precision (acceptable error)

Spatial Tolerance: - +/- 30 m

Overall Accuracy 67 percent

Area Weighted Accuracy 66 percent

Khat (Kappa Coefficient) 61 percent

More details on Raster Soil Survey projects may be found on the NRCS DSM Landing page for Raster Soil Surveys.

Process contact

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center

Contacts role point of contact

Contact information: Address

Type postal

Delivery point 100 Centennial Mall North

Delivery point Federal Building, Room 152

City Lincoln

Administrative area NE

Postal code 68508-3866

Country US

Process step: Date 2019-10-08

Description

The Project: MLRA 90A – Mille Lacs Uplands Coarse-Loamy Basal Till Investigation was certified in 2017 adding 1,266,246 acres to Raster Soil Survey Area: Minnesota.

I. Tabular Reference - Legend Area Overlap

Legend Area Overlap Type: Raster Soil Survey Project

Legend Area Overlap Symbol: MLCU_10-DUL19

Legend Area Overlap Name: MLRA 90A - Mille Lacs Uplands Coarse-Loamy Basal Till Investigation

Conversion Legend:

ID	Raster Value	Map Symbol	Correlated Map Unit Name
8	3108525	2lthb	Water
16	3108534	2z19n	Bowstring muck and Fluvaquents, loamy, 0 to 2 percent slopes, frequently flooded
17	3108535	2z586	Brennyville silt loam, 1 to 6 percent slopes, stony
18	3108536	2z58p	Cathro muck, 0 to 1 percent slopes, frequently ponded
19	3108537	2z588	Cebana-Giese, frequently ponded complex, 0 to 2 percent slopes, stony
20	3108538	2z589	Freer silt loam, 1 to 3 percent slopes, stony
21	3108539	2z58b	Giese, stony-Cathro complex, 0 to 1 percent slopes, frequently ponded
22	3108540	2z19t	Greenwood mucky peat, 0 to 1 percent slopes
23	3108541	2z58d	Milaca loam, 1 to 9 percent slopes, stony
24	3108542	2z58f	Milaca and Millward soils, 3 to 20 percent slopes, stony
25	3108543	2z58g	Mora silt loam, 1 to 6 percent slopes, stony
26	3108544	2z1b0	Rifle mucky peat, 0 to 1 percent slopes, occasionally ponded
28	3108546	2z58j	Ronneby silt loam, 1 to 4 percent slopes, stony
27	3108545	2z1b1	Seelyeville, occasionally ponded-Cathro, frequently ponded, complex, 0 to 1 percent slopes

II. Raster Soil Survey Level: Level B

III. Model Development

Data referenced for model training: 131 pedons (82 Contemporary Field Observations/397 Historical Observations). Additional virtual observations were utilized within a field observed radius relating to soil classes to augment knowledge-based classification.

Sample design: cLHS with purposive and offset descriptions

Digital environmental data: Terrain and Hydrology Derivatives from LIDAR; PRISM Climate Data; Spectral Indices from LANDSAT 7; Spectral Indices from LANDSAT 5; Spectral Indices from LANDSAT 8; LANDFIRE Biophysical Settings; Derivatives from the National Wetland Inventory; GLO - PLSS Bearing Tree Data; Derivatives

from Published Soils and Geologic Data

Number of covariates evaluated for use: 29

Data resolution: 5 m

Modeling methods: Knowledge-based fuzzy logic; linear regression; inverse-distance weighting; logistic regression; random forest

IV. Map Accuracy

Error Matrix:

ID	8	16	17	18	19	20	21	22	23	24	25	26	28	27	Total
8	6	2	0	2	0	0	0	0	0	0	0	0	0	0	10
16	0	8	0	0	0	0	2	0	0	0	0	0	0	0	10
17	0	0	7	0	1	0	0	0	0	2	0	0	0	0	10
18	0	0	0	6	0	0	0	0	0	0	1	0	0	0	7
19	0	0	0	0	9	1	3	1	0	0	2	0	1	1	17
20	0	0	0	0	0	6	0	0	0	0	1	0	0	0	7
21	0	0	0	1	0	0	6	0	0	0	0	1	0	2	10
22	0	0	0	2	0	0	0	14	0	0	4	0	0	0	20
23	0	0	1	0	0	1	0	0	21	2	2	0	0	0	27
24	0	0	0	0	0	0	0	0	2	0	1	0	0	0	3
25	0	0	0	0	0	0	0	0	1	0	6	0	3	0	10
26	0	0	0	5	0	0	0	0	0	0	6	0	0	0	11
28	0	0	0	0	1	0	1	0	0	0	0	0	4	0	6
27	0	0	0	2	0	0	0	0	0	0	0	0	0	1	3
Tot	6	10	8	18	11	8	12	15	24	2	12	14	7	4	151

Validation data source: Contemporary Field Observation - 131 pedons (90 Contemporary Field Observations/41 Historical Peatland Cores); Remote Sensing and Ancillary Data - 20 random points (ID 8 Water; ID 16 Bowstring muck and Fluvaquents, loamy, 0 to 2 percent slopes, frequently flooded)

Sample design: External validation, stratified random

Considerations of confidence and precision: Results published targeting 95 percent confidence (map accuracy)/10 percent precision (acceptable error)

Spatial Tolerance: - +/- 10 m

Overall Accuracy 66 percent

Area Weighted Accuracy 67 percent

Khat (Kappa Coefficient) 63 percent

More details on Raster Soil Survey projects may be found on the NRCS DSM Landing page for Raster Soil Surveys.

Process contact

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center

Contacts role point of contact

Contact information: Address

Type postal

Delivery point 100 Centennial Mall North

Delivery point Federal Building, Room 152

City Lincoln

Administrative area NE

Postal code 68508-3866

Country US

e-mail address SoilsHotline@lin.usda.gov

Title 430 – National Soil Survey Handbook

Process step: Date 2019-10-11

Description

The Project: MLRA 102A – Fergus Falls Till Plain Formdale Catena Study, Re-correlation and Investigations was certified in 2019 adding 825,291 acres to Raster Soil Survey Area: Minnesota.

I. Tabular Reference - Legend Area Overlap

Legend Area Overlap Type: Raster Soil Survey Project

Legend Area Overlap Symbol: FFTP_10-FAR19

Legend Area Overlap Name: MLRA 102A – Fergus Falls Till Plain Formdale Catena Study, Re-correlation and Investigations

Conversion Legend:

ID	Raster	Map	Correlated
	Value	Symbol	Map Unit Name
8	3108525	2lthb	Water
38	3108566	2yw67	Langhei clay loam, 10 to 30 percent slopes
31	3108572	2yw6f	Buse clay loam, 5 to 15 percent slopes
30	3108573	2yw6g	Balaton clay loam, 0 to 4 percent slopes
36	3108568	2yw69	Hokans clay loam, 2 to 9 percent slopes
34	3108564	2yw65	Formdale clay loam, 0 to 4 percent slopes
29	3108574	2yw6h	Aazdahl clay loam, 0 to 3 percent slopes
41	3108565	2yw66	Svea silty clay loam, 2 to 9 percent slopes
32	3108571	2yw6d	Darnen silty clay loam, 5 to 15 percent slopes
35	3108569	2wy6b	Hamerly-Vallers clay loams, 0 to 2 percent slopes
33	3108570	2wy6c	Flom silty clay loam, 0 to 2 percent slopes
37	3108567	2yw68	Lakepark-Wyard silty clay loams, 0 to 4 percent slopes
40	3108562	2z955	Quam silty clay loam, 0 to 1 percent slopes, occasionally ponded
39	3108563	2z954	Quam and Cathro soils, 0 to 1 percent slopes, frequently ponded

II. Raster Soil Survey Level: Level B

III. Model Development

Data referenced for model training: 443 pedons (158 Contemporary Field Observations/285 Historical Observations). Additional virtual observations were utilized within a field observed radius relating to soil classes to augment knowledge-based classification.

Sample design: Stratified cLHS with purposive and offset descriptions

Digital environmental data: Terrain and Hydrology Derivatives from LIDAR; Derivatives from the National Wetland Inventory, National Land Cover Dataset; NASS Cropland

Number of covariates evaluated for use: 19

Data resolution: 5 m

Modeling methods: Knowledge-based fuzzy logic; logistic regression; random forest

IV. Map Accuracy

Error Matrix:

ID	8	38	31	30	36	34	29	41	32	35	33	37	40	29	Tot
8	10	0	0	0	0	0	0	0	0	0	0	0	0	0	10
38	0	7	0	0	0	0	0	0	0	0	0	0	0	0	7

Title 430 – National Soil Survey Handbook

31 0 2 11 0 0 0 0 0 0 0 0 0 0 0 13
30 0 0 1 14 0 1 0 0 0 0 0 0 0 0 16
36 0 0 1 2 6 0 0 0 0 0 0 0 0 0 9
34 1 0 0 0 1 10 1 0 0 0 0 0 0 0 13
29 0 0 0 1 0 0 5 0 1 1 0 1 0 0 9
41 0 0 0 0 1 0 3 5 0 1 0 0 0 0 10
32 0 0 0 0 0 0 1 0 12 0 0 0 0 0 13
35 0 0 0 1 1 0 0 0 0 13 0 4 0 0 19
33 0 0 0 1 0 0 0 0 0 1 13 1 0 0 16
37 0 0 0 0 0 0 0 0 0 0 0 0 4 1 0 5
40 0 0 0 0 0 1 0 0 0 1 3 2 9 0 16
39 2 0 0 0 0 0 0 0 0 0 0 0 3 7 12
Tot 13 9 13 19 9 12 10 5 13 17 16 12 13 7 168

Validation data source: Contemporary Field Observation - 148 pedons; Remote Sensing and Ancillary Data - 20 random points (ID 8 Water and ID 39 Quam and Cathro soils, 0 to 1 percent slopes, frequently ponded)

Sample design: External validation, stratified random

Considerations of confidence and precision: Results published targeting 95% confidence (map accuracy)/10% precision (acceptable error)

Spatial Tolerance: - +/- 10m

Overall Accuracy 75%

Area Weighted Accuracy 70%

Khat (Kappa Coefficient) 73%

More details on Raster Soil Survey projects may be found on the NRCS DSM Landing page for Raster Soil Surveys (<https://tinyurl.com/rwbbgj2>).

Process contact

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center

Contacts role point of contact

Contact information: Address

Type postal

Delivery point 100 Centennial Mall North

Delivery point Federal Building, Room 152

City Lincoln

Administrative area NE

Postal code 68508-3866

Country US

e-mail address SoilsHotline@lin.usda.gov

Process step: Date 2019-10-11

Description

The Project: MLRA 88 – Glacial Lake Plain Baudette Catena was certified in 2019 adding 143,317 acres to Raster Soil Survey Area: Minnesota.

I. Tabular Reference - Legend Area Overlap

Legend Area Overlap Type: Raster Soil Survey Project

Legend Area Overlap Symbol: BAUD_10-BEM19

Legend Area Overlap Name: MLRA 88 – Glacial Lake Plain Baudette Catena

Conversion Legend:

ID	Raster Value	Map Symbol	Correlated Map Unit Name
42	3184646	2yd0n	Baudette silt loam, 0 to 6 percent slopes
43	3184647	2yd0p	Littleswan silt loam, 0 to 3 percent slopes
45	3184645	2yd0m	Spooner silt loam, 0 to 2 percent slopes
44	3184644	2yd0l	Sax muck, 0 to 1 percent slopes, frequently ponded

II. Raster Soil Survey Level: Level A

III. Model Development

Data referenced for model training: 83 pedons (46 Contemporary Field Observations/37 Historical Observations). Additional virtual observations were utilized within a field observed radius relating to soil classes to augment knowledge-based classification.

Sample design: Stratified purposive

Digital environmental data: Terrain and Hydrology Derivatives from LIDAR; LANDFIRE Biophysical Settings; Derivatives from National Hydrologic Dataset; Derivatives from the National Wetland Inventory; National Land Cover Dataset

Number of covariates evaluated for use: 17

Data resolution: 5 m

Modeling methods: Knowledge-based fuzzy logic

IV. Map Accuracy

Error Matrix

ID	42	43	45	45	Tot
42	8	0	0	0	8
43	0	7	0	1	8
45	0	2	11	1	14
55	0	0	1	8	9
Tot	8	9	12	10	39

Validation data source: Contemporary Field Observation - 39 pedons

Sample design: External validation, stratified random

Considerations of confidence and precision: Results published targeting 85 percent confidence (map accuracy)/15 percent precision (acceptable error)

Spatial Tolerance: - +/- 10 m

Overall Accuracy 87 percent

Area Weighted Accuracy 87 percent

Khat (Kappa Coefficient) 83 percent

More details on Raster Soil Survey projects may be found on the NRCS DSM Landing page for Raster Soil Surveys.

Process contact

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center

Contacts role point of contact

Title 430 – National Soil Survey Handbook

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Delivery point Federal Building, Room 152
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Administrative area NE
Postal code 68508-3866
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e-mail address SoilsHotline@lin.usda.gov

Process step: Date 2022-09-01

Description

On 2022-09-01, a 10 m raster layer was imported into a file geodatabase displaying the results from Raster Soil Survey (RSS) project(s). This raster layer was aligned to the CONUS gSSURGO-mukey.tif layer. A single attribute

MUKEY was added to the raster attribute table to facilitate joins with the attribute data.

Process contact

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Geospatial Center of Excellence
Contacts role processor

Contact information: Phone

Voice 800 672 5559
Fax 817 509 3469

Address

Delivery point 501 West Felix Street
City Fort Worth
Administrative area TX
Postal code 76115

Process step: Date 2022-09-01

Description

The Raster Soil Survey SSURGO dataset is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared using digital soil mapping methodologies, incorporating remotely sensed and field collected samples. This dataset consists of georeferenced digital map data and computerized attribute data. The map data are in a soil survey area extent format and include a detailed, field verified inventory of soils and miscellaneous areas that normally occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped. The soil classes are linked to attributes in the National Soil Information System (NASIS) relational database, which gives the proportionate extent of the component soils and their properties.

Process contact

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center
Contacts role processor

Contact information: Phone

Voice 402 437 5499

Title 430 – National Soil Survey Handbook

Address

Delivery point Federal Building, Room 152
Delivery point 100 Centennial Mall North
City Lincoln
Administrative area NE
Postal code 68508-3866
e-mail address SoilsHotline@lin.usda.gov

Source data: Relationship to the process step produced

Source citation: Alternate titles Soil Survey Geographic (SSURGO) Database for Soil Survey Areas

Process step: Date 2022-08-11

Description

The Project: MLRA 88 – Agassiz Lake Plain Effie Till and Clayey Lacustrine Catenas was certified in 2022 adding 612,626 acres to Raster Soil Survey Area: Minnesota.

I. Tabular Reference - Legend Area Overlap

Legend Area Overlap Type: Raster Soil Survey Project

Legend Area Overlap Symbol: AGLP_10-BEM22

Legend Area Overlap Name: MLRA 88 – Agassiz Lake Plain Effie Till and Clayey Lacustrine Catenas

Conversion Legend:

ID	Raster	Map	Correlated
	Value	Symbol	Map Unit Name
66	3314481	30890	Taylor silty clay loam, 8 to 25 percent slopes
66	3314482	30891	Taylor silty clay loam, 3 to 8 percent slopes
67	3314483	30892	Alango silty clay loam, 1 to 4 percent slopes
68	3314484	30893	Indus silty clay loam, 0 to 2 percent slopes
69	3314485	30894	Wildwood-Dora complex, 0 to 1 percent slopes, frequently ponded
71	3314486	30895	Suomi loam, 8 to 35 percent slopes
71	3314487	30896	Suomi loam, 3 to 8 percent slopes
72	3314488	30897	Ashlake loam, 1 to 4 percent slopes
73	3314489	30898	Effie loam, 0 to 2 percent slopes
74	3314490	30899	Hamre-Tacoosh complex, 0 to 1 percent slopes, frequently ponded
75	3314494	3089b	Effie mucky loam, frequently ponded, 0 to 1 percent slopes
76	3314492	3089c	Indus mucky silty clay loam, frequently ponded, 0 to 1 percent slopes

II. Raster Soil Survey Level: Level A

III. Model Development

Data referenced for model training: 181 pedons (131 Contemporary Field Observations/50 Historical Observations). Additional virtual observations were utilized within a field observed radius relating to soil classes to augment knowledge-based classification.

Sample design: cLHS with purposive and offset descriptions

Digital environmental data: Terrain and Hydrology Derivatives from LIDAR; LANDFIRE Biophysical Settings; Derivatives from National Hydrologic Dataset; Derivatives from the National Wetland Inventory

Title 430 – National Soil Survey Handbook

Number of covariates evaluated for use: 20

Data resolution: 5 m

Modeling methods: Knowledge-based fuzzy logic; trend surface; logistic regression; random forest

IV. Map Accuracy

Error Matrix:

ID	66	67	68	69	71	72	73	74	75	76	Tot
66	5	0	0	0	1	0	1	0	0	0	7
67	0	10	1	1	0	0	1	0	0	0	13
68	0	0	7	0	0	0	0	0	0	2	9
69	0	0	0	10	0	0	0	1	0	2	13
71	0	0	0	0	6	0	0	1	0	0	7
72	1	1	0	0	0	8	0	0	0	0	10
73	1	1	0	1	0	1	5	1	0	0	10
74	0	0	0	1	0	0	1	5	1	0	8
75	0	0	0	0	0	0	0	1	7	0	8
76	0	0	0	0	0	0	0	1	2	5	8
Tot	7	12	8	13	7	9	8	10	10	9	93

Validation data source: Contemporary Field Observation - 93 pedons

Sample design: External validation, stratified random

Considerations of confidence and precision: Results published targeting 80 percent confidence (map accuracy)/10 percent precision (acceptable error)

Spatial Tolerance: - +/- 10 m

Overall Accuracy: 73 percent

Area Weighted Accuracy 70 percent

Khat (Kappa Coefficient) 70 percent

More details on Raster Soil Survey projects may be found on the NRCS DSM Landing page for Raster Soil Surveys.

Process contact

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center

Contacts role point of contact

Contact information: Address

Type postal

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Delivery point Federal Building, Room 152

City Lincoln

Administrative area NE

Postal code 68508-3866

Country US

e-mail address SoilsHotline@lin.usda.gov

Process step: Date 2022-08-11

Description

The Project: MLRA 90A – Duxbury Moraine Coarse-Loamy Basal Till Investigation was certified in 2022 adding 209,123 acres to Raster Soil Survey Area: Minnesota.

Title 430 – National Soil Survey Handbook

I. Tabular Reference - Legend Area Overlap

Legend Area Overlap Type: Raster Soil Survey Project

Legend Area Overlap Symbol: DUXB_10-DUL22

Legend Area Overlap Name: MLRA 90A – Duxbury Moraine Coarse-Loamy Basal Till Investigation

Conversion Legend:

ID	Raster Value	Map Symbol	Correlated Map Unit Name
8	3108525	2lthb	Water
16	3108534	2z19n	Bowstring muck and Fluvaquents, loamy, 0 to 2 percent slopes, frequently flooded
18	3108536	2z58p	Cathro muck, 0 to 1 percent slopes, frequently ponded
27	3108545	2z1b1	Seelyeville, occasionally ponded-Cathro, frequently ponded, complex, 0 to 1 percent slopes
58	3314473	308xm	Milaca silt loam, 5 to 30 percent slopes, stony
58	3314474	308xv	Milaca-Mora complex, 1 to 7 percent slopes, stony
59	3314475	308y1	Minocqua, occasionally ponded and Giese, frequently ponded, soils, 0 to 2 percent slopes
60	3314476	308y9	Oesterle silt loam, 0 to 3 percent slopes
61	3314477	308xh	Loxley and Beseman soils, 0 to 1 percent slopes
62	3314478	308y0	Mora-Ronneby complex, 1 to 4 percent slopes, stony
63	3314479	308xy	Millward-Mora complex, 2 to 20 percent slopes, stony
64	3314480	308y8	Milaca and Greysolon soils, 2 to 20 percent slopes, stony

II. Raster Soil Survey Level: Level C

III. Model Development

Data referenced for model training: 164 pedons (160 Contemporary Field Observations/4 Historical Observations).

Additional virtual observations were extracted from ancillary sources to augment some classifications.

Sample design: cLHS with purposive and offset descriptions

Digital environmental data: Terrain and Hydrology Derivatives from LIDAR; PRISM Climate Data; Spectral

Indicies from LANDSAT 7; Spectral Indicies from LANDSAT 5; Derivatives from National Hydrologic Dataset;

Derivatives from the National Wetland Inventory; Derivatives from Published Soils and Geologic Data

Number of covariates evaluated for use: 33

Data resolution: 5 m

Modeling methods: Knowledge-based fuzzy logic; logistic regression; random forest

IV. Map Accuracy

Error Matrix:

ID	8	16	18	27	58	59	60	61	62	63	64	Tot
8	9	0	0	1	0	0	0	0	0	0	0	10
16	0	7	0	1	0	0	0	0	0	0	0	8
18	0	0	7	2	0	0	0	2	0	0	0	11
27	0	0	0	1	0	0	0	0	0	0	0	1
58	0	0	1	0	20	0	0	0	0	2	0	23
59	0	0	4	0	1	8	0	0	1	0	0	14
60	0	0	0	0	2	0	5	0	0	1	0	8
61	0	0	0	0	0	0	0	9	0	0	0	9
62	0	0	1	0	2	0	0	0	4	0	0	7
63	0	0	0	0	7	0	0	0	0	3	0	10

Title 430 – National Soil Survey Handbook

64 0 0 0 0 1 0 0 0 0 1 6 8
Tot 9 7 13 5 33 8 5 11 5 7 6 109

Validation data source: Contemporary Field Observation - 91 pedons; Remote Sensing and Ancillary Data - 18 random points (ID 8 Water and ID 16 Bowstring muck and Fluvaquents, loamy, 0 to 2 percent slopes, frequently flooded)

Sample design: External validation stratified random

Considerations of confidence and precision: Results published targeting 75 percent confidence (map accuracy)/10 percent precision (acceptable error)

Spatial Tolerance: - +/- 10 m

Overall Accuracy 72 percent

Area Weighted Accuracy 70 percent

Khat (Kappa Coefficient) 69 percent

More details on Raster Soil Survey projects may be found on the NRCS DSM Landing page for Raster Soil Surveys.

Process contact

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center

Contacts role point of contact

Contact information: Address

Type postal

Delivery point 100 Centennial Mall North

Delivery point Federal Building, Room 152

City Lincoln

Administrative area NE

Postal code 68508-3866

Country US

e-mail address SoilsHotline@lin.usda.gov

Process step: Date 2022-08-11

Description

The Project: MLRA 90A – Grantsburg Sublobe Investigation was certified in 2022 adding 301,041 acres to Raster Soil Survey Area: Minnesota.

I. Tabular Reference - Legend Area Overlap

Legend Area Overlap Type: Raster Soil Survey Project

Legend Area Overlap Symbol: GBSL_10-DUL22

Legend Area Overlap Name: MLRA 90A – Grantsburg Sublobe Investigation

Conversion Legend:

ID	Raster	Map	Correlated
	Value	Symbol	Map Unit Name
8	3108525	2lthb	Water
18	3108536	2z58p	Cathro muck, 0 to 1 percent slopes, frequently ponded
27	3108545	2z1b1	Seelyeville, occasionally ponded-Cathro, frequently ponded, complex, 0 to 1 percent slopes
46	3314446	307cd	Alstad loam, 0 to 2 percent slopes
47	3314447	307c1	Ricelake, Branstad, and Talmoon soils, 0 to 6 percent slopes
48	3314448	307c2	Bluffton-Hamre complex, 0 to 1 percent slopes, frequently ponded

Title 430 – National Soil Survey Handbook

50	3314449 307c5	Braham loamy sand, 12 to 35 percent slopes
50	3314450 307c0	Braham-Cutaway loamy sands, 0 to 12 percent slopes
51	3314451 307cb	Branstad loam, 2 to 6 percent slopes
51	3314452 307cc	Branstad loam, 6 to 12 percent slopes
54	3314454 307c7	Cushing loam, 15 to 35 percent slopes
54	3314455 307c9	Cushing loam, 2 to 6 percent slopes
54	3314456 307c8	Cushing loam, 6 to 15 percent slopes
56	3314459 307cf	Talmoon-Alstad loams, 0 to 2 percent slopes

II. Raster Soil Survey Level: Level B

III. Model Development

Data referenced for model training: 251 pedons (92 Contemporary Field Observations/159 Historical Observations). Additional virtual observations were utilized within a field observed radius relating to soil classes to augment knowledge-based classification.

Sample design: cLHS with purposive and offset descriptions

Digital environmental data: Terrain and Hydrology Derivatives from LIDAR; PRISM Climate Data; Spectral Indices from LANDSAT 7; Spectral Indices from LANDSAT 5; Spectral Indices from LANDSAT 8; LANDFIRE Biophysical Settings; Derivatives from National Hydrologic Dataset; Derivatives from the National Wetland Inventory

Number of covariates evaluated for use: 45

Data resolution: 5 m

Modeling methods: Knowledge-based fuzzy logic; linear regression; trend surface; logistic regression; random forest

IV. Map Accuracy

Error Matrix:

ID	8	18	27	46	47	48	50	51	54	56	Tot
8	10	0	0	0	0	0	0	0	0	0	10
18	0	10	0	0	0	3	0	0	0	0	13
27	0	1	3	0	0	2	0	0	0	0	6
46	0	0	0	11	0	0	2	2	1	0	16
47	0	0	0	5	2	0	3	1	0	3	14
48	0	3	0	3	0	9	0	0	0	2	17
50	0	0	0	0	2	0	9	2	2	1	16
51	0	1	0	2	0	1	1	16	0	0	21
54	0	0	0	0	0	0	0	3	10	0	13
56	0	0	0	5	0	1	0	0	0	6	12
Tot	10	15	3	26	4	16	15	24	13	12	138

Validation data source: Contemporary Field Observation - 128 pedons; Remote Sensing and Ancillary Data - 10 random points (ID 8 Water)

Sample design: External validation, stratified random

Considerations of confidence and precision: Results published targeting 90 percent confidence (map accuracy)/10 percent precision (acceptable error)

Spatial Tolerance: - +/- 10 m

Overall Accuracy 62 percent

Area Weighted Accuracy 67 percent

Khat (Kappa Coefficient) 58 percent

Title 430 – National Soil Survey Handbook

More details on Raster Soil Survey projects may be found on the NRCS DSM Landing page for Raster Soil Surveys.

Process contact

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center

Contacts role point of contact

Contact information: Address

Type postal

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Delivery point Federal Building, Room 152

City Lincoln

Administrative area NE

Postal code 68508-3866

Country US

e-mail address SoilsHotline@lin.usda.gov

Distribution -Distributor: Contact information

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Geospatial Center of Excellence

Contacts role distributor

Contact information: Phone

Voice 800 672 5559

Fax 817 509 3469

Address

Type postal

Delivery point 501 West Felix Street

City Fort Worth

Administrative area TX

Postal code 76115

Country US

Available format

Name ESRI File Geodatabase

Version 10.0

Ordering process

Terms and fees The charge is \$250 for an external hard drive that contains one or more datasets. A dataset is one state that includes both spatial and attribute data.

Instructions

Call or write to organizations listed under Distributor.

Transfer options

Online source

Location Geospatial Data Gateway

Transfer options

Medium of distribution

Medium name DVD

Limitations for using the medium

Recording Format UDF 2.5

Distribution format

* Name File Geodatabase Raster Dataset

Fields -Details for object VAT_MapunitRaster_10m_MN_202209 -* Type Table

* Row count 76

Field Count -* Alias Count

* Data type Double

* Width 8

* Precision 0

* Scale 0

Field OBJECTID -* Alias OBJECTID

* Data type OID

* Width 4

* Precision 0

* Scale 0

Field description

Internal feature number.

Description source

ESRI

Description of values

Sequential unique whole numbers that are automatically generated.

Field Value -* Alias Value

* Data type Integer

* Width 4

* Precision 0

* Scale 0

Field description

The raster cell value is the same as MUKEY, but in integer form.

Field MUKEY -* Alias MUKEY

* Data type String

* Width 30

* Precision 0

* Scale 0

Field description

The MUKEY is used to join to the Map unit or Muaggatt tables.

Description source

USDA SSURGO/STATSGO2 Metadata web page

Overview Description: Entity and Attribute Overview

Raster cell locations are based on map unit delineations which are closed polygons that may be dominated by a single soil or nonsoil component plus allowable similar or dissimilar soils, or they can be geographic mixtures of groups of soils or soils and nonsoil areas. The map unit symbol uniquely identifies each closed delineation map unit.

Title 430 – National Soil Survey Handbook

Each symbol corresponds to a map unit name. The map unit key is used to link to information in the National Soil Information System (NASIS) tables.

Metadata Details -Metadata language English (UNITED STATES)

Metadata character set utf8 - 8 bit UCS Transfer Format

Scope of the data described by the metadata dataset

Scope name * dataset

* Last update 2022-09-29

ArcGIS metadata properties

Metadata format ArcGIS 1.0

Standard or profile used to edit metadata FGDC

Created in ArcGIS for the item 2014-10-02 14:41:25

Last modified in ArcGIS for the item 2022-09-29 12:37:02

Automatic updates

Last update 2022-09-29 12:37:02

Metadata Contacts -Metadata contact

Organizations name U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center

Contacts role point of contact

Contact information: Address

Type postal

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Country US

e-mail address SoilsHotline@lin.usda.gov

Thumbnail and Enclosures -Enclosure

FGDC Metadata (read-only) -

Spatial Data Organization -Raster Object Information

Raster Object Type Pixel

Row Count 65230

Column Count 58128

Vertical Count 1

Spatial Reference -Horizontal Coordinate System Definition

Planar

Planar Coordinate Information

Planar Coordinate Encoding Method row and column

Coordinate Representation

Abscissa Resolution 10.000000

Ordinate Resolution 10.000000

Entities and Attributes -Detailed Description

Entity Type

Entity Type Label VAT_MapunitRaster_10m

Attribute

Attribute Label Count

Attribute

Attribute Label OBJECTID

Attribute Definition

Internal feature number.

Attribute Definition Source Esri

Attribute Domain Values

Unrepresentable Domain

Sequential unique whole numbers that are automatically generated.

Attribute

Attribute Label Value

Attribute Definition

The raster cell value is the same as MUKEY, but in integer form.

Attribute

Attribute Label MUKEY

Attribute Definition

The MUKEY is used to join to the Map unit or Muaggatt tables.

Attribute Definition Source

USDA SSURGO/STATSGO2 Metadata web page

Overview Description

Entity and Attribute Overview

Raster cell locations are based on map unit delineations which are closed polygons that may be dominated by a single soil or nonsoil component plus allowable similar or dissimilar soils, or they can be geographic mixtures of groups of soils or soils and nonsoil areas. The map unit symbol uniquely identifies each closed delineation map unit. Each symbol corresponds to a map unit name. The map unit key is used to link to information in the National Soil Information System (NASIS) tables.

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- H. Soil Science Division Staff. 2017. *Soil Survey Manual*. Edited by C. Ditzler, K. Scheffe, and H.C. Monger. Washington, D.C.: Government Printing Office.

Part 649 – Land Resource Areas

Subpart A – General Information

649.0 Definition and Purpose

A. Land resource areas are a hierarchal segmentation of the Earth's surface based primarily upon natural resource attributes and properties that influence use and management. The seven resource attributes used in defining land resource units are climate, geology, soils, vegetation, water resources, physiography, and land use. The role each attribute plays in the determination and naming of a resource area varies, and its importance depends upon the level within the hierarchy. Some resource areas exhibit a high degree of uniformity across the entire landscape. Other resource areas are characterized by a high degree of variation that occurs in a predictable and repeatable pattern. Still other resource areas represent significant or unique environments.

B. The land resource region (LRR) is the highest level of the hierarchy and represents broad landscape divisions at a small scale. The major land resource area (MLRA) is the second-highest level and generally represents broad landforms or a geologic region at a small scale. In many cases, it represents broad areas with similar potentials or limitations for use, such as forestland, or areas with similar resource limitations, such as arid climate. The third level of the hierarchy is the land resource unit (LRU). The land resource unit represents related landforms that make up the landscape. Land resource units are defined primarily by significant differences between one or two of the resource attributes. These differences affect land use and land management decisions at the landscape scale.

C. LRRs are defined by their resource attributes. They are delineated on maps at a continental scale. They are used in describing regional attributes of the natural resources at a national scale. MLRAs are typically presented on maps at a national scale and used for State and regional planning. Examples are large river basin watersheds, forest regions, deserts, and expansive uniform areas of cropland. The LRU is typically delineated on State or regional maps and used at the State or local level.

D. Information and maps of LRRs and MLRAs are published in Agriculture Handbook 296. This information is not appropriate for site-specific conservation planning or application. The maps are generalized. The lines are smoothed and are not intended to represent a point of change on the ground. Small areas may exist within the LRR or MLRA near transitions where inliers and outliers of adjacent MLRAs or LRUs occur that are not delineable on the map at the publication scale.

649.1 Policy and Responsibilities

A. State Office

- (1) Works with cooperators or partners, or independently, to propose changes to LRRs, MLRAs, and LRUs to be presented to the soil survey regional office
- (2) Reviews soil survey map units to verify assignment to the appropriate MLRA and LRU in the National Soil Information System

B. Soil Survey Office

Works with cooperators or partners, or independently, to propose changes to LRRs, MLRAs, and LRUs to the soil survey regional office

C. Soil Survey Regional Office

- (1) Works with cooperators or partners, or independently, to propose changes to LRRs, MLRAs, and LRUs

- (2) Submits and coordinates proposed changes from other disciplines and States that share the LRR, MLRA, or LRU
- (3) Maintains the boundary, description, and documentation for each MLRA or LRU to which it is assigned
- (4) Ensures that the maps displaying LRRs or MLRAs are joined and coordinated across boundaries
- (5) Submits proposed changes to LRRs, MLRAs, and LRUs to the National Soil Survey Center's national leader for soil survey standards
- (6) Provides the National Soil Survey Center with the appropriate publication scale copy of the MLRA and LRU maps for the area of responsibility

D. National Soil Survey Center

- (1) Receives and reviews proposed changes for the center director's approval
- (2) Keeps the maps, descriptions, and digital layers of land resource areas current
- (3) Maintains the area symbols, area names, and area acres for land resource areas in the National Soil Information System
- (4) Publishes Agriculture Handbook 296, which contains resource area descriptions and maps
- (5) Provides the NRCS Resource Inventory Division an official copy of the geographic data layers of land resource areas
- (6) Works with soil survey regional offices to resolve disputed lines or concepts

E. Soil Science Division

- (1) Director reviews and approves proposed changes
- (2) Director provides the final decision on any disputed lines or concepts of land resource areas

F. National Water and Climate Center

Provides the most recent Parameter-elevation Regression on Independent Slopes Model (PRISM) data for new and/or subdivided land resource areas to the National Soil Survey Center to facilitate revision of Agriculture Handbook 296. (Climate parameters to consider are the mean annual precipitation, mean annual air temperature, and frost-free days.)

G. NRCS Resource Inventory Division

Provides updated land use descriptions of land resource areas to the National Soil Survey Center to facilitate revision of Agriculture Handbook 296.

H. NRCS Resource Assessment Division

Provides supporting data for the modified or newly established LRRs and MLRAs to the National Soil Survey Center, as requested, for use in their descriptions.

I. National Technology Support Centers

Review and comment on the descriptions of land resource areas.

649.2 Descriptions

A. Land resource areas are subdivided by their landscape characteristics. Both soil surveys and ecological site surveys utilize this characterization to place information within a hierarchical system. The soil survey hierarchy consists of land resource regions, major land resource areas, land resource units, STATSGO2, and SSURGO as described below. The ecological site hierarchy consists of land resource regions, major land resource areas, land resource units, land resource unit subsets, and ecological sites, but does not include STATSGO2 or SSURGO. See section 649.6 for an example.

B. Land Resource Regions

Land resource regions (LRRs) are concepts of unique, mostly continuous broad landscapes. They are delineated on small-scale national maps used in national planning. LRRs are geographical regionalization of the United States and its Territories. They consist mainly of broadly related patterns of geology, soil, climate, physiography, vegetation, water resources, and land use based on publication scale.

C. Major Land Resource Areas

MLRAs are geographical concepts based on subdivisions within a land resource region. They identify areas with similar physiography, geology, climate, water resources, soils, biological resources, and land use based on publication scale. MLRAs are typically used in regional multistate or individual State planning processes.

D. Land Resource Units

- (1) LRUs are subdivisions of an MLRA that have one or more unique features within the MLRA criteria that make them more homogenous. LRUs are based on identifiable differences in physiography, geology, climate, water resources, soils, biological resources, or land use or other natural resource conditions that make them unique within the MLRA.
- (2) The LRU concepts, descriptions, and maps are used primarily for ecological sites, conservation planning, soil carbon assessments, and land management subdivisions within MLRAs. LRUs can be developed and documented in NASIS and other data management systems and managed at the level of the soil survey region. Descriptions and delineations of LRUs are not included in U.S. Department of Agriculture Handbook 296, “Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin.”

E. State Soil Geographic (STATSGO2) Database

STATSGO2 map units represent a broad-based inventory of soils and nonsoil areas. The general soil map in traditional county soil surveys represents this scale characterized by map units based on distinctive patterns of soils, drainage, and landforms. The STATSGO2 database has been used to make the general soil maps of the United States (See part 644, subpart A, section 644.7, of this handbook). The STATSGO2 map units are based on shared soil properties and related features aggregated or summarized from SSURGO-level mapping.

F. Soil Survey Geographic (SSURGO) Database

The SSURGO database provides detailed maps and data for soils in the United States and its Territories, Commonwealths, and Island Nations (Section 649.4). SSURGO map units are designed to show soil components (i.e., polypedons) that include soil series, taxa above the series, taxadjuncts, miscellaneous areas, and phases (Soil Survey Manual, 2017, p. 249).

G. Land Resource Unit Subset

The LRU subset is determined locally based on soil moisture, soil temperature, precipitation, geology, aspect, physiography, or some other factor that explains vegetative variations within an LRU. The LRU Subset typically exists at a broader scale than ecological sites.

H. Ecological Site

An ecological site is a conceptual division of the landscape. It is a distinctive kind of land based on recurring soil, landform, geological, and climate characteristics that differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its ability to respond similarly to management actions and natural disturbances.

649.3 Land Resource Area Attributes

Land resource areas are defined by dominant land use, physiography, geology, climate, water, soil, and biological resources. These attributes are used to define the concepts and geography of each resource area (LRR, MLRA, and LRU). Resource area size and delineation are determined using the appropriate publication map scales.

(1) Land Use

Common land use potentials include the arrangement, activities, and inputs used to produce, change, or maintain land cover type. Information on the extent of land used for cropland, pasture, rangeland, forestland, industrial and urban development, and other special purposes is provided by the most recent National Resource Inventory (NRI) or the USGS National Land Cover map (Homer et al., 2012). Summary statistics are provided for the whole resource area unless otherwise stated. Also included is a list of the principal crops grown and the type of farming practiced. The relative extent of federally owned land based on NRI data is also reported if relevant.

(2) Physiography

Common physical geographic features include topography, landforms, and elevation ranges. Summary reports of the ranges in height above sea level and relief, including significant exceptions if applicable, are provided for the area as a whole. Physiographic section, province, and division are described for each resource area (Fenneman and Johnson, 1946). The extent of the hydrologic unit areas within each resource area (Seaber et al., 1987; eight-digit HUC for LRU, four-digit HUC for MLRA, two-digit HUC for LRR) is reported as a percent. The major rivers and streams identified by the National Wild and Scenic Rivers System that drain each resource area are also listed.

(3) Geology

Common geologic features include the geologic material (rock type) and geologic age. Summary descriptions of surficial and bedrock geology are reported for each resource area. This information is derived from a wide variety of State and Federal maps and other reports.

(4) Climate

Common climatic properties include the average annual precipitation, seasonal distribution of precipitation, average annual temperature, and average number of frost-free days. Summary reports of mean annual precipitation ranges for the driest and the wettest parts of the resource area and of the range of the seasonal distribution of precipitation are given. Also given are the range of the mean annual air temperature and the average frost-free period characteristic of the resource area. The mean annual precipitation, mean annual air temperature, and average frost-free period should be referenced according to weather station and to a specific collection of most recent 30-year normal period (e.g., 1981 to 2010), as summarized by the National Water and Climate Center. These data are derived from Parameter-elevation Regression on Independent Slopes Model data (<http://www.prism.oregonstate.edu/>) by the National Water and Climate Center, located in Portland, OR.

(5) Water

Water resource characteristics are commonly defined by water source, quantity, and quality. Defining features should include surface stream flow, ground-water characteristics, irrigation availability, and dependency upon neighboring resource areas for water. Summary reports of the resource area include surface stream flow, ground water, and the source of water for municipal use and irrigation. In addition, the dependency upon neighboring resource areas for

water supply or the ability to provide water to neighboring resource areas is described. Extent and number of irrigation districts in the resource area are given if pertinent.

(6) Soils

Common soil resources are the nature and properties of the soils. Soils are identified according to the principal taxonomic great groups as referenced in the SSURGO database or the STATSGO2 database (if SSURGO data are not available). Representative soil series of individual resource areas can further define resource area extents. Summary reports of common soil great groups, representative soil series, and the relationship of soils to landscape position are given.

(7) Biological Resources

Biological resources are commonly defined by vegetation species, type, and phenology. Summary reports of major plant communities within the resource areas are described by dominant species, identified by common plant names (Kuchler, 1985). Fish and wildlife species common within the resource area are also listed.

649.4 Cartographic Standards

The cartographic standards for land resource areas include the concepts of minimum mappable area and minimum management. The minimum mappable area concept is a concrete assignment applied by cartographers to the smallest area that can be presented on the map with a map unit symbol inside the polygon drawn at the published map scale. The minimum management concept is an abstract assignment applied by resource managers that reflects both the concrete parameters of the map scale and the inherent characteristics of the resource area. Although the published map scale allows for a minimum polygon size, the hierarchy of nesting resource areas requires acre limitations for the minimum mappable area concept.

(1) Land Resource Regions

LRRs are delineated on national maps at small scales—1:7,500,000 for the conterminous United States and 1:10,000,000 for Alaska. These maps are most useful for national program planning. For maps at a scale of 1:7,500,000, the delineation of the minimum mappable area is approximately 1 cm by 1 cm (0.4 inch by 0.4 inch), or about 560,000 hectares (1,400,000 acres).

(2) Major Land Resource Areas

MLRAs are delineated on national maps at small scales—1:5,000,000 for the conterminous United States and the Pacific and Caribbean Islands and 1:7,500,000 for Alaska. These maps are most useful for national, regional, and State program planning. The delineation of the minimum mappable area is approximately 1 cm by 1 cm (0.4 inch by 0.4 inch), or about 250,000 hectares (620,000 acres). Minimum linear delineations are at least 0.3 cm (0.1 inch) in width and 2.5 cm (1 inch) in length. (Note: The Pacific and Caribbean Islands, which have land areas less than 600,000 hectares, or 1,600,000 acres, in size are excluded from the minimum delineation rule due to individual island sizes and distribution.)

(3) Land Resource Units

LRUs may occur as single delineations but commonly occur as several separate delineations. LRUs are delineated on national maps at small scales—1:1,000,000 for the United States and the Pacific and Caribbean Islands and 1:5,000,000 for Alaska. LRU maps often depict areas that are cartographically too small to be delineated at an MLRA map scale (i.e., 1:5,000,000). These maps are most useful for State and watershed-level program planning. The delineation of the minimum mappable area is approximately 1 cm by 1 cm (0.4 inch by 0.4 inch), or about 10,000 hectares (25,000 acres). Minimum linear delineations are at least 0.3 cm (0.1 inch) in

width and 2.5 cm (1 inch) in length. (Note: The Pacific and Caribbean Islands are excluded from the minimum delineation rule due to individual island sizes and distribution.)

(4) State Soil Geographic (STATSGO2) Database

The STATSGO2 soil map units occur as single delineations and depict areas on national maps at larger scales—1:250,000 for the conterminous United States and the Pacific and Caribbean Islands and 1:500,000 for Alaska. The delineation of the minimum mappable area is approximately 1 cm by 1 cm (0.4 inch by 0.4 inch), or about 625 hectares (1,545 acres). Minimum linear delineations are at least 0.3 cm (0.1 inch) in width and 2.5 cm (1 inch) in length.

(5) Soil Survey Geographic (SSURGO) Database

The SSURGO database provides detailed soil maps and data for most areas in the United States and its Territories, Commonwealths, and Island Nations. The minimum polygon area is approximately 1 hectare (2.5 acres). This minimum delineation is represented on a 1:12,000- or 1:24,000-scale map by an area approximately 1 cm by 1 cm (0.4 inch by 0.4 inch). Minimum delineation size is governed by mapping scale and the order of the soil survey. In the Caribbean Area, the minimum delineation is represented on a 1:20,000-scale map for Puerto Rico and a 1:12,000-scale map for the U.S. Virgin Islands.

649.5 Names and Symbols

Traditionally, the names of LRRs, MLRAs, and LRUs reflect unique relationships in agriculture, native plant communities, and landscape features.

(1) Land Resource Regions

The symbols for LRRs are capital letters, and the names are combinations identifying broad physiographic provinces and predominant land use. An example is “M—Central Feed Grains and Livestock Region.” LRRs also may be represented by a capital letter followed by an additional character.

(2) Major Land Resource Areas

The symbols for MLRAs are Arabic numbers or number-letter combinations. If an existing MLRA is subdivided into two or more new MLRAs, the numbers are followed by an alphabetical character, beginning with “A.” Examples include 55A, 55B, and 55C. The names commonly consist of associated physiographic areas, landforms, and natural geographic areas, such as “108—Illinois and Iowa Deep Loess and Drift”; “7—Columbia Basin”; “4A—Sitka Spruce Belt”; and “161A—Lava Flow and Rock Outcrops.”

(3) Land Resource Units

LRUs are represented by two numeric characters following the MLRA symbol. If the MLRA has no LRU subdivisions, it is represented as a “01,” indicating that the MLRA and LRU are the same polygon. Descriptive or geographic context terms are included in the LRU name, such as “70A02—Canadian River Plains and Valleys - Volcanic Plateaus.”

649.6 Coding System for Hierarchical Land Resource Areas for Ecological Sites

A. The following coding system is used to organize the relationships of land resource areas from LRRs to ecological sites. The code consists of 12 alphabetical and numeric characters that combine labels for LRRs, MLRAs, LRUs, LRU subsets, and ecological sites to achieve the following four objectives:

(1) Represent the land resource area hierarchy

- (2) Provide flexibility for expanding and contracting subdivisions within each hierarchy level
- (3) Provide a code that retains current and familiar symbols and provide for future expansion
- (4) Be intuitive and easily discernable at a quick glance

B. In the example “GX070A02B001,” the positions in following 12-digit code are as follows:

- (1) *GX*—Land Resource Region.—Every LRR is represented by two characters—its current alphabetical character and an uppercase “X,” which serves as a place holder. Exceptions to the insertion of an X are the Alaskan LRRs, which would be coded as XA, XB, WA, WB, rather than their current X1, X2, W1, W2. In addition, if current LRRs were to be subdivided (for example, LRR D), an uppercase letter, beginning with “A,” would be added (e.g., DA, DB).
- (2) *070A*—Major Land Resource Area.—Every MLRA is represented by four characters—numeric and an uppercase alphabetical. If a current MLRA has no alphabetical character, an “X” is inserted (e.g., 035X, 002X, 143X).

If two or more MLRAs are combined (e.g., 38 and 39), one is chosen, e.g., 039X. If MLRAs are subdivided, as in the case in Montana where 43A, B, and C might be split six ways, the new subdivisions would start with the “D” modifier. Thus, the six new MLRAs would be: 043D, 043E, 043F, 043G, 043H, and 043I. This scheme keeps track of old versus new MLRAs.

- (3) *02*—Land Resource Unit.—Every LRU is represented by two numeric characters. This allows an MLRA to be subdivided into 99 LRUs. If the MLRA has no LRU subdivisions, it is represented as a “01,” indicating that the MLRA and LRU are the same polygon. A second LRU subdivision would be “02,” and the third “03.”
- (4) *B*—LRU Subset.—Every LRU subset is represented by one alphabetical character. This allows an LRU to be subdivided into 26 LRU subsets. If there are no subsets, an “X” is inserted.
- (5) *001*—Ecological Site Identification (ESID).—Every ESID is represented by three numeric characters. This allows 999 ecological sites to be identified within an LRU subset.

649.7 Establishing or Revising Land Resource Areas

A. Any agency office or National Cooperative Soil Survey (NCSS) partner can make a proposal to modify the maps or descriptions of existing land resource areas (LRR, MLRA, or LRU) or to establish a new land resource area. Proposals are submitted to the soil survey regional office responsible for the specific area.

B. The SSR—

- (1) Reviews, vets, and compiles the proposals and forwards them to the National Soil Survey Center for consideration in the revision of Agriculture Handbook 296.
- (2) Coordinates suggested changes with the national leader for standards at the National Soil Survey Center and with regional members of the NCSS.
- (3) Submits the following information to the national leader for standards:
 - (i) Documentation and justification for the requested changes.
 - (ii) The draft land resource area map, in support of the suggested changes, printed to the appropriate publication scale to verify cartographic standards.
 - (iii) The GIS shape file used to create the land resource area printed map and the portable document format (PDF) that presents the original land resource area boundaries and symbols in black with an overlay showing the proposed land resource area boundaries and symbols in red.
 - (iv) A complete draft of the appropriate land resource area descriptions, including needed revisions to previously existing descriptions impacted by the proposal.
 - (v) Letters from the SSRs and State conservationists of areas that share the land resource area. The letters will show concurrence on the changes and document a correct join if the changes affect the areas that share the land resource area.

- (vi) Descriptions of changes that affect land resource area boundaries.

C. The National Soil Survey Center—

- (1) Reviews and concurs on the justification and complete documentation prior to final approval by the director of the Soil Science Division.
- (2) Digitally incorporates approved changes into the existing LRR, MLRA, and LRU documentation and maps and produces and releases new map products for official use.
- (3) Sends a 1:7,500,000-scale LRR proof plot, a 1:5,000,000-scale MLRA proof plot, and a 1:1,000,000-scale LRU proof plot, along with the appropriate map unit descriptions reflecting the revisions, to the originating SSR for review and concurrence.
- (4) Integrates the concurred changes to LRR and MLRA maps and descriptions into the most recent version of Agriculture Handbook 296, “Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin.”
- (5) Provides copies of the updated maps and documentation to the appropriate NRCS users, NCSS cooperators, and others as requested.
- (6) Archives all documentation supporting approved changes.

649.8 Publication

USDA Agriculture Handbook 296, “Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin,” is an assemblage of current information about land use, including farming, ranching, forestry, engineering, recreational development, and other uses. It is published as both a hard-copy and a digital product on the National Soil Survey Center’s website. This assemblage consists of LRR and MLRA maps and the supporting map unit descriptions for each. This land resource area information is used at national, regional, and State levels—

- (1) As a basis for making decisions about agricultural issues.
- (2) As a framework for organizing and operating resource conservation programs.
- (3) For the geographic organization of research and conservation needs and the data derived from these activities.
- (4) For coordinating technical guides within and between States.
- (5) For organizing, displaying, and using data in physical resource inventories.
- (6) For aggregating natural resource data.

Part 649 – Land Resource Areas

Subpart B – Exhibits

649.10 References

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- E. Soil Science Division Staff. 2017. Soil survey manual. U.S. Department of Agriculture Handbook 18. Government Printing Office, Washington, DC.
- F. U.S. Department of Agriculture, Natural Resources Conservation Service. 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296.

Part 651 – Advance Soil Survey Information

651.0 Definition and Purpose

- A. Advance soil survey information is information that has been gathered but is not yet published to the Web Soil Survey. The purpose of providing advance soil survey information is to furnish users with soil maps, interpretations, and other data prior to final correlation of the data.
- B. Soil data posted to the Web Soil Survey is official soil information, certified for use by the state soil scientist in participation with the State Technical Guide Committee for USDA programs.
- C. Interim reports are considered obsolete with the advent of the Web Soil Survey. Interim reports were defined as reports that were prepared and produced after the final correlation memorandum was signed and before the soil survey is published.
- D. Progressively correlated soil information is now publicly accessed through the Web Soil Survey prior to the completion of the soil survey.

651.1 Policy and Responsibilities

- A. Advance soil survey information for private lands is available for review by the public in NRCS offices and in the appropriate agency for public lands.
- B. The party requesting the data normally bears the cost of preparation or reproduction, or both. The state conservationist or the appropriate head of the lead agency is responsible for determining how to finance and where to reproduce advance soil survey information.

651.2 General

- A. Advance soil survey information is part of the technical assistance provided to conservation district cooperators. Conservation district cooperators are entitled to this technical assistance because of their Cooperative Working Agreement (CWA). Title 180, General Manual, Part 401, Subpart C, Section 401.22, and Subpart F, Section 401.40, provide more information. Soil survey information is encouraged to be correlated progressively and placed on the Web Soil Survey as it is updated or developed. Placing soil survey information onto the Web Soil Survey removes the information from the status of advance soil survey information.
- B. Interested individuals can study and review copies of the field sheets, composite overlays, or digitized copies of field sheets and attribute data from which interpretations or conservation plans are prepared. They may purchase copies of these materials and copies of soil survey spatial and attribute databases according to procedures established in the State.

651.3 Restrictions

- A. A soil map with interpretations that were prepared specifically for use in developing a conservation plan for a district cooperator may not be made available except under certain

circumstances. Title 120, General Manual, Part 408, Subpart C, “Freedom of Information Act and Privacy Act,” provides more information.

B. Advance soil survey information requires special labeling. Section 651.5 discusses the requirements for labeling field sheets. These requirements also apply to composite overlays and digitized products that are provided outside the Web Soil Survey.

C. Information is not provided that is deemed sensitive to national security as identified by the Department of Defense, Homeland Security, or other Federal authority in any directive included in the MOU or other working agreement. See part 606, section 606.1, of this handbook for more information on working agreements.

651.4 Providing Quality Assurance, Quality Control, and Review

To ensure a quality product, map unit names, field sheets, composite overlays, digitized products, and interpretation tables and text are reviewed to ensure the information is legible and easily read and consistent with adjoining areas. An identification legend, a feature and special symbols legend, and supporting explanatory material must accompany all advance soil survey field sheets and digitized soil maps.

651.5 Labeling of Advance Soil Survey Information

A. Advance soil survey information is labeled with the names of the cooperating agencies; the Natural Resources Conservation Service, U.S. Department of Agriculture; the month and year it was prepared, and any necessary precautionary notes. These notes need not follow any specific format or be in finished form, but they must be legible. Part 607, subpart A, section 607.2B, of this handbook provides more information on labeling paper copies of aerial photo field sheets. All field sheets in advance soil survey information are labeled “ADVANCE COPY SUBJECT TO CHANGE.”

B. The text of all advance soil information and the electronic products contain a statement that warns that the information is not official NRCS information. For example, “Information in this report is unofficial data subject to change upon completion, correlation, and publication to the Web Soil Survey; therefore, the user is cautioned that some map units may be discontinued, others combined, or the name of some changed and, as a result, soil suitability ratings and interpretations are likely to change. Advance soil survey information is not valid to determine USDA Farm Bill program eligibility or requirements needed for Farm Bill compliance. These determinations require onsite visits and investigations.

C. Metadata associated with digital advance soil survey information should state the dataset is an advance copy subject to change.

Part 655 – Technical Soil Services

655.0 Definition

Technical soil services are the presentation and application of soil survey information. In addition, technical soil services may include soil scientists providing soils information using onsite investigations to enhance and localize soil survey information for site-level application. Soil scientists help users understand the soil survey, apply soil information to specific needs, and integrate soil survey information with other resources and technology. Technical soil services include the derivation and application of soil information to meet USDA and NRCS policy and program needs. Technical soil services are cooperative efforts of the National Cooperative Soil Survey (NCSS). See the Technical Soil Services Handbook for more detailed information. It is available online at the following URL: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_053400.

655.1 Types of Service

Technical soil services provide five basic types of service: technical policy and program services; planning services; site-specific soil investigations, testing, interpretation, and evaluation; expert services for judicial requests; and information services.

- (1) **Technical Policy and Program Services.**—Technical policy and program services are for Federal agencies, State, Tribal, or local units of government, or private groups or individuals that use technical soil survey information in their policy and programs. These services ensure that those government policies that support improved planning, management, or regulation of lands use current and official soil survey information. The Web Soil Survey provides access to the agency's official soil survey information, which is the source of soil survey information in the Field Office Technical Guide. The Field Office Technical Guide is an interdisciplinary document. Formal agreements that include a general reference to technical soil services provide the operational authority to NRCS when it assists other agencies.
- (2) **Planning Services.**—Planning services are the technical interpretation of soil survey information for the development of plans that include conservation practices and systems. Soil conservation district cooperators and USDA program participants are the primary recipients of these planning services. Recipients also include Federal agencies, State governments, or local governments. Planning services involve recommendations on specific tracts of land. Formal agreement with the soil conservation district as a cooperator or a formal agreement with NRCS that includes specific reference to technical soil services provides the operational authority for NRCS.
- (3) **Site-Specific Soil Investigations, Testing, Interpretation, and Evaluation.**—Site-specific soil investigations, testing, interpretation, and evaluation are services that support the design and installation of works and structures or the implementation of agricultural practices or that test and evaluate research predictions. These technical soil services are part of NRCS technical assistance to individual cooperators or units of government that have signed agreements specifying the services. The intention of services to individual cooperators is usually to help apply a conservation plan. These services are described in general terms in district agreements with NRCS. They are very site specific and often result in design and practice specifications.
- (4) **Expert Services for Judicial Requests.**—Expert services related to judicial requests are technical soil services that originate as a result of legal actions affecting Federal, State, or

local governments involved with soil resource data. Agency policy requires agency advice and authority from NRCS management and USDA legal counsel before these services are provided. Contact your supervisor if you are subpoenaed by a court, are requested to be an expert witness, or if legal services are requested by any means. Also refer to 7 CFR Section 1.210 and subsequent sections through 7 CFR Section 1.219 (also known as subpart K). Part 635 of the Technical Soil Services Handbook provides detailed guidance and recommendations on acting as an expert witness:

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_053396.

- (5) Information Services.—Information services are the distribution and explanation of National Cooperative Soil Survey procedures and standards, including the technical content and use of soil survey products. Delivery of these services does not require a formal agreement.

655.2 Policy

A. NRCS technical soil services, except for Farmland Protection Policy Act requests and information services, go to or through Federal, State, and local units of government with which there is a memorandum of understanding or a cooperative agreement.

B. Onsite technical assistance to private individuals is provided only through formal agreements with government entities, such as conservation districts, that specify the services. This assistance relates directly to NRCS programs and is defined in the conservation district memorandum of understanding.

655.3 Responsibilities

Soil scientists provide technical soil services both within the framework of NCSS and as part of other programs. The responsibility for providing these services is delegated to resource soil scientists, State soil scientists, the national leader for technical soil services, national technical support centers, and National Headquarters. For more information on these responsibilities, see part 604 of the Technical Soil Services Handbook. The handbook is available online at the following URL:
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_053400.

Part 656 – Coastal Zone Soil Survey (CZSS)

656.0 Definition and Purpose

A. The coastal zone is the area where terrestrial land meets bays, sounds, estuaries, tidal rivers, seas, oceans, or other water bodies. It includes dunes, marshes, beaches, coastlines, and anthropogenic coastal areas. It has shallow, subtidal subaqueous soils (submerged lands) that can support submerged aquatic vegetation. A spatial inventory of basic resources and habitats is essential to effectively study, manage, conserve, and sustain shallow, subtidal ecosystems.

B. A coastal zone soil survey (CZSS) is an order 2 soil survey with a focus in the coastal zone. Once completed, a CZSS provides detailed (1:12,000 scale) spatial soil maps (points, lines, and polygons), a rich database of soil chemical and physical properties, site data, and interpretations for coastal applications. The data and interpretations are useful for marine spatial planning, aquaculture, and coastal and nearshore restoration projects, such as sea-grass planting, oyster reef creation, beach replenishment, and salt marsh restoration.

656.1 Boating Safety

Refer to Title 360 General Manual, Part 420, Subparts AA and BB “Boating Safety in Coastal Zone Soil Survey.” The purpose of those subparts is to establish policy and guidance for safe operation, training, and maintenance of boats operated by NRCS personnel. Subpart AA provides the background, scope, responsibilities, training, equipment, inspections, and vessel records. Subpart BB provides information about regulations, laws, and checklists for float plans, fueling, powerboat operation, trailering, and maintenance.

656.2 CZSS Laboratory Sample Collection Methods

A. Comparable to traditional subaerial soil sampling, the purpose of CZSS sampling is to obtain specific information about a soil and its properties. Sampling in the CZSS environment faces unique challenges, which requires specialized approaches to obtain adequate and viable materials for analysis—traditional Kellogg Soil Survey Laboratory (KSSL) approaches cannot be used because soils are often completely saturated. Accessing sampling locations may be difficult due to challenges such as shifting or fluctuating tides, soft terrain, ditches, and creeks. Therefore, it is critical to establish local estuary partners to aid in site sampling selections. Information from long-term monitoring and research sites, such as Surface Elevation Tables (SET) monitored by local estuary managers, is a good place to start gathering information about a particular area or landform. An array of field sampling methods is required to successfully evaluate and sample each unique site.

B. CZSS Bulk Density Measurement—Bulk density is the measurement of the oven-dried weight per unit volume of soil. Bulk density is important for soil interpretations and calculation of carbon stocks. Because of prevalent saturation in the CZSS environment, the satiated bulk density method is used.

C. The following methods are used to collect samples of satiated bulk density for CZSS projects. For each method, collect three replicate samples for each soil horizon or layer being sampled.

1. Macaulay Peat Sampler Method
 - a. Definition.—A Macaulay peat sampler is pressed into the soil to obtain a sample in the form of a half-cylinder core.
 - b. Usage.—This method is typically used for undisturbed organic soil materials or fluid or highly fluid mineral soils.
 - c. Methodology summary.—
 - (1) Press a Macaulay peat sampler into the soil to the desired depth and rotate the sampler 180 degrees to close the auger “door.”
 - (2) Remove the sampler and open the sampling “door” to expose the core.
 - (3) Samples are most easily obtained by taking segments of the core in whole-number centimeter increments (2 cm and 5 cm are common). Mark the core segments at the desired length, slice with a knife, and carefully remove the samples and place in a plastic bag.
 - (4) Calculate sample volume based on the segment length, keeping in mind that the sample shape is a half cylinder ($V = \frac{1}{2}(\pi r^2 h)$, where r = radius of the core and h = height of the core segment).
 - (5) Three replicate samples should be collected per horizon if enough soil material is available in the Macaulay sampler or can be gathered on site.
2. Vibracore Half Core Method
 - a. Definition.—A metal vibracore tube (typically aluminum irrigation pipe) is vibrated rapidly with a gas or electric vibrating machine, enabling it to penetrate saturated soils and extract a core.
 - b. Usage.—This method is used in saturated soil environments where soils can be nonfluid to fluid but where a Macaulay sampler cannot penetrate the soil or is refused at shallow depths. Samples retrieved with a vibracore may be subject to compaction due to rapid vibration and settlement of the soil materials surrounding the vibracore pipe.
 - c. Methodology summary.—
 - (1) Once the vibracore sample has been collected, record the inside diameter of the vibracore pipe.
 - (2) Split the core in half lengthwise and collect half-cylinder-shaped samples for each horizon. The sample segments should be collected in whole-number centimeter increments for ease of recording and calculation.
 - (3) Note the sample dimensions and volume, keeping in mind that the sample shape is a half cylinder.
 - (4) Replicates of three should be performed on a given horizon if enough soil material is available.
 - (5) Note that an accurate core volume is contingent on a linear, perpendicular split of the core being sampled (i.e., an exact half-cylinder shape; $V = \frac{1}{2}(\pi r^2 h)$, where r = inside radius of the cylinder and h = core segment height).
3. Block or Brownie Method
 - a. Definition.—A very sharp knife or other cutting tool is used to take a three-dimensional sample (a block or cube) of soil.
 - b. Usage.—This method is typically used for surface horizons in subaerial soils (e.g., tidal marshes). Generally, organic soil materials or moderately fluid to nonfluid fine-loamy mineral materials, like silt loam, can be collected using this method. The basic requirement is that the soil material must be sufficiently cohesive to hold together on its own as an intact sample.
 - c. Methodology summary.—
 - (1) Use a sharp knife or blade to cut and carve out blocks of soil. Cut the blocks as

perpendicular as possible to ensure they are true cubes (i.e., not a trapezoidal shape). This will allow for the most accurate volume calculations. Larger samples will provide more accurate data.

(2) Measure and record the length (L), width (W), and height (H) of each block and calculate the volume ($V = L \times W \times H$). A vernier caliper is ideal for accurate dimensional measurements.

(3) Replicates of three are standard when using this bulk density method.

4. Hole Saw Method

a. Definition.—A hole saw tool is used vertically or horizontally to remove a core of defined volume from soils with high amounts of roots and fibers.

b. Usage.—This method is used for organic soils with high amounts of roots or fibers that can maintain an intact sample when removed with the sampling tool. It can be used vertically into the soil surface, horizontally into the soil pit face, or horizontally into a portion of the surface (plug) that has been removed in its unaltered state.

c. Methodology summary.—

(1) Use a standard hole saw drill bit (a tool commonly used for drilling wood or metal) and an attached handle.

(2) To extract the sample, push and twist the sampler into the soil in a circular or ratcheting motion.

(3) Remove the soil core and cut slices of a desired thickness.

(4) Trim roots or fibers with a serrated knife or shears.

(5) Record the hole saw bit diameter (e.g., 3 in. or 4 in. diameter) and sample thickness in the sampling notes.

(6) Calculate and record the volume of the sample ($V = \pi r^2 h$, where r = core radius and h = core segment height).

(7) Three replicate samples should be collected.

5. Field Core Method

a. Definition.—A metal cylinder of a known volume, generally 3 inches in diameter and length, is pressed or driven into the soil.

b. Usage.—This method is used when a core can be pressed, hammered, or vibrated into the soil without interference from rock fragments and without compaction from a coring device. Usage can vary with soil texture type. This method is not practical for sandy soils with loose, moist consistence.

c. Methodology summary.—

(1) Prepare a flat surface, either horizontal or vertical, at the required depth in the sampling pit.

(2) Press or drive the core sampler into the soil. Use caution and proceed slowly to prevent compaction.

(3) If a hammer is required, place a wood block on top of the core tube before striking and strike squarely on the wood block.

(4) Remove the core from the soil by carefully digging out beside and under the metal cylinder, making sure no soil falls out of the core during this process.

(5) Trim the excess soil protruding outside of the coring device and ensure the soil is flush with both ends of the instrument.

(6) Carefully remove the soil from the coring device and place in a sample bag as a loose sample.

(7) Label the volume of the core on the sample bag ($V = \pi r^2 h$, where r = core radius and h = core segment height).

(8) Three replicate samples should be collected.

6. Syringe Method

a. Definition.—The body of a standard syringe is pressed into the soil to obtain a mini-

core.

- b. Usage.—This method is used when samples have been collected in a vibracore tube and the soil materials are too sandy or fluid to collect a half core. It is best suited to very sandy soils but works in almost all mineral soil materials. It is not suitable for fibric or hemic soil materials, as rhizomes often prevent successful penetration of the syringe into the sample.
- c. Methodology summary.—
 - (1) After collecting a vibracore sample, use a plastic syringe from which the end has been removed to subsample horizons, collecting a mini-core from within the vibracore.
 - (2) After the core has been split open, take a syringe sample from the flat inner face of the split core.
 - (3) Fix the plunger at a predetermined mark and gently push the syringe into the vibracore sample to collect that known volume (typically 10cc or 15cc) of the sample.
 - (4) Take three subsamples or replicates of each sampled horizon. Calculate the bulk density of each subsample. Average the values to get the average bulk density of the horizon.

D. CZSS Bulk Sample Collection

- 1. The bulk sampling of a CZSS pedon is done by individual horizons, as in traditional soil sampling. The bulk sampling process is used to gather samples for physical and chemical soil analyses. The process to collect bulk samples of a saturated or subaqueous soil may differ from that of traditional soil sampling.
- 2. The methods and tools used are typically the same as those used to obtain samples for bulk density analysis of saturated and subaqueous soils. They include a Macaulay peat auger, a vibracore tube, or a hand-dug soil pit. Once the sample is collected using one of these methods, traditional bulk sampling techniques can be used to remove samples from the tools noted above.
- 3. Samples for chemical analysis for incubated pH should be collected in the field with a Macaulay peat sampler (when applicable) or directly from the vibracore tube immediately after it is opened. These samples should be placed in the appropriate incubated pH cups provided by KSSL and properly sealed. Prior to shipping to KSSL or performing incubated pH analysis, samples should be frozen to minimize the chemical oxidation process.

656.3 CZSS Laboratory Sample Analysis Methods

A. Laboratory analysis of soil samples are used to obtain an in-depth understanding of a soil's properties and characteristics. To obtain a representative sample, there must be an adequate amount of soil material and the material must be thoroughly mixed. Analysis can also be completed with subsamples; however, the precision of the laboratory results decreases when using only subsamples.

B. CZSS samples to be sent for laboratory analysis have specific characterizations unique to CZSS soils that should be noted before they are sent. All laboratory methods require measurements of dimensions or volume of the samples and instruments. Without these measurements, laboratory calculations cannot be done or may be erroneous.

C. Laboratory analysis can be completed in soil survey field offices if staff are properly trained and equipped or if samples can be sent to KSSL. Soil survey field offices should refer to the appropriate section in the current edition of the Soil Survey Field and Laboratory Methods

Manual, Soil Survey Investigations Report No. 51 (SSIR 51) for field office laboratory procedures. Note that the procedures for laboratory analyses performed at KSSL are published in a separate manual, the Kellogg Soil Survey Laboratory Methods Manual, Soil Survey Investigations Report No. 42.

D. CZSS Bulk Density Laboratory Analyses

1. Use the satiated bulk density field office laboratory method (SSIR 51, version 2, section 3.3.2.1) for samples collected with the Macaulay peat sampler, vibracore half core, block or brownie, hole saw, field core, and syringe sampling methods from subaqueous and other permanently saturated soils.
2. Use the field state field core bulk density field office laboratory method (SSIR 51, version 2, section 3.3.1.5) for samples that are not saturated.
3. If a soil survey field office is not properly trained or equipped to perform bulk density analysis according to the SSIR 51 procedures referenced above, the samples can be submitted to KSSL.

E. CZSS Chemical and Physical Laboratory Analyses

1. Use the Soil Survey Field and Laboratory Methods Manual (SSIR 51, version 2) for detailed field office laboratory methods for chemical and physical soil analyses.
2. Any chemical and physical analyses for which field office staff are not properly equipped and trained to perform should be completed by KSSL.

656.4 CZSS Cartographic Standards

A. The cartographic standards for CZSS projects include the concepts of minimum mappable area and minimum management. The minimum mappable area is decided by cooperators and estuarine land managers. These areas are often very small in acreage on CZSS maps as restoration activities often occur on a small area basis (these types of restoration activities are also very costly).

B. The smallest area that can be represented on a map may likely be smaller than the publication scale and previous guidelines in the NSSH. Most CZSS projects are conducted at a mapping scale of 1:12,000. There are many CZSS natural resource areas within these publications that are and can be represented on a map at approximately 1/4 acre (0.10 hectare) in size. The location and delineation of these CZSS critical features are often performed at a much more precise mapping scale than 1:12,000. Although the published map scale allows for a minimum polygon size and minimum size delineation, the CZSS customer request often dictates the smallest delineation size.

C. Examples of very small map unit delineations could be thin layer deposition projects, living shoreline projects, aquaculture restoration projects, or subaquatic vegetation restoration projects. The minimum size delineations within the CZSS projects could be quite small. As considerable resources were invested in these restoration projects, CZSS products need to be able to identify these map units accurately. These small restoration areas are monitored very intensely for the success of their projects and CZSS assists in their accurate location and delineation.

D. Considerable time and resources are invested in each CZSS project and field observation points must be maximized to ensure inclusion within the respective project. Every effort should be taken to make certain field observation points are included in the published CZSS product.