Chapter 2 Soils

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652.0204 State Supplement

(a) General

Soils are discussed in NEH Part 652 Chapter 2 and there is a more extensive explanation of soils with respect to irrigation in NEH, Section 15, Chapter 1 “Soil-Plant-Water Relationships.” The data and discussion in this supplement points out a few differences and expands on certain irrigation related soil properties as they apply to South Carolina.

(b) Soil Limitations and Suitability for Irrigation

(1) General

South Carolina soils share many of the limitations for irrigation with other regions of the country [described in NEH, Part 652.01 (c) and Exhibit 2-1]. While salinity, sodicity and other high pH chemical factors are seldom a problem in the state, low pH soils do present management issues. In the Piedmont and Upper Coastal Plain (Fig SC1-11), many of the highly weathered soils are very acidic. When subsoil pH is below 3.6, crops are rarely successful, and irrigation is less valuable. While lime and/or gypsum application can ameliorate aluminum toxicity and low calcium, the high costs for adequate materials to create a deep root zone conducive to successful water management make these less desirable sites.

Root restricting layers – fragipans, plinthite, and bedrock – are common in South Carolina. Cementing agents in fragipans and plinthite, primarily iron and silica, form dense layers that restrict root exploration into cracks and interfaces between polygonal structures in the subsoil and substratum. Bedrock also acts as a confining layer restricting root exploration. While root restricting layers are often deep enough to allow moderate rooting above them, they may restrict vertical water flow and create perched water tables in the root zone.

Perhaps more important than the restrictive layers are the highly leached E horizons in Coastal Plain soils. By definition, E horizons are leached of clay and other iron and aluminum compounds. These leached layers occur just below the topsoil and are left with sand and silt or certain low reactive clays that have little iron or other cementing agents necessary to form stable soil structural units (peds). They compact easily into dense zones that restrict root penetration. Even if the layers are broken up by deep tillage, the pans reform under high precipitation and saturated soil moisture conditions prevalent in the southeastern U.S. These soils are unsuitable for deep subsurface drip irrigation and other irrigation designs should consider the root zone limitations in these soils.

Many highly weathered soils formed in high silica parent materials (granite, gneiss) have few silt sized soil particles. Silt is associated with high available water storage, good aeration, and stable aggregate formation. Without silt, soils with high sand and clay and organic matter will form naturally high bulk densities. Uncompacted sandy loam and loamy sand surface soils will typically have bulk densities about 1.6 to 1.65 grams per cubic centimeter. At these densities, many would assume the soils are highly compacted and root restrictive.

However soils in the Southeast can compress further under traffic to densities as high as 1.7 to 1.8 grams per cubic centimeter. In these soils, porosity and aeration are decreased and irrigation in these soils is frequently a problem. Only high permeable soils that move water rapidly through the soils allow air to re-enter before plants suffer. Sandy surface soils with weak structure and low organic matter are subject to formation of thick crusts. When irrigation or rainfall occurs before seedling emergence, plant stands may suffer. As the growing season progresses the crusts reduce the maximum rate of infiltration and increase the potential for runoff. Fortunately, formation of crusts and their negative effects may be minimized with high amounts of surface residues and minimum tillage.

(2) USDA Land Capability Classification

The USDA 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. There is a tendency to disregard land capability classification in favor of specific soil properties when considering conservation or irrigation design. However, the Land Capability Classification provides a useful overview of the land and soils that can guide the selection of appropriate irrigation practices and the conservation practices to make irrigation feasible.

Land Capability Classes for all soils in South Carolina are available in the electronic Field Office Technical Guide (eFOTG), Section II /Soils information/ eFOTG Soils Information with the county documents listing soils with their Land Capability Class (column 8) and other conservation related classifications and values (http://efotg.sc.egov.usda.gov/efotg_locator.aspx). The USDA Land Capability Classification System is a general guide in the selection of sites suitable for irrigation systems. The capability groupings are based on the soil limitations, the risk of damage, and how soils respond to treatment when used for cropland.

Soils are grouped into eight capability classes from I through VIII. Class I soils have the fewest limitations, widest range of uses and the least risk of damage when continuously row cropped. Soils in higher classes have progressively greater natural limitations. Within each class of II to VIII, there are three subclasses designated by letters, as follows:

- **e** – Risk of erosion unless a close growing plant cover is maintained.
- **w** – Water in or on the soil interferes with plant growth or cultivation; artificial drainage may eliminate or reduce wetness problems.
- **s** – Soils are limited by shallowness, droughty or stony conditions.

The subclasses can be further divided into capability units. The capability units are similar groups of soils that are suited to the same crops and forage plants. These soils require similar management and have similar yields.

Land used for irrigation and continuous row crops is best suited to Class I - III soils. Erosion control measures are needed on Class II and Class III soils with a subclass of "e." Planning and installation for erosion control practices should be done prior to installation of an irrigation system. Wetness problems can be expected on soils with a subclass of "w." Surface and/or subsurface drainage may partially correct wetness problems. Droughty conditions occur on many soils with a subclass of "s." Irrigation will reduce this limitation in many cases. Low fertility, excessive leaching, and erosion problems may also occur on these soils.

Soils with marginal or very little potential for crop production are in Classes IV through VIII. These soils have severe natural limitations and may produce low yields even under the best management. However, irrigation on some Class IV-s soils has been successful in the Coastal Plain. This land requires more intensive management, making the cost per unit of production generally higher. A careful site by site evaluation is needed before irrigating Class IV-s land.

Land in Classes IV through VIII is normally better suited for hayland, pasture, woodland, wildlife areas or other uses where a permanent cover can be maintained. While some soil limitations may be overcome through aggressive crop management or soil modification, crops grown on these soils would not generally be economically feasible for commercial production.

The USDA Land Capability Classification System is a useful tool for general planning. Site specific information is necessary to plan the best irrigation system.

(3) Suitability for Selected Crops

In addition to Land Capability Classes, soils of South Carolina have been classified by their suitability for economical production of the State’s primary agronomic and horticultural crops. These classifications are available on the South Carolina eFOTG, Section II /Soils Information/Soil Interpretations/Suitability for Selected Crops. They are based on yield data and knowledge of inherent yield potential under good management practices for the desired crop. These statewide documents have tables grouped by vegetable/ fruit crops, field crops, and forage crops.

(4) Evaluating Site Suitability for Irrigation

Once a potential irrigation site has been located on a soils map (Web Soil Survey), properties of that soil can help identify potential limits, if any, which would affect irrigation feasibility, design, or management. Table SC2-16 outlines the most common soil restrictive features and limitations. Restrictive features do not necessarily preclude irrigation, but they may affect the choice of irrigation method or require alteration of the drainage, slope, or soil to accommodate irrigation. Siting for center pivots can be particularly challenging because covering most of the more productive parts of a field may require inclusion of some soil or area that is generally unsuitable or less desirable for irrigation.

In noting the soil present in the mapped area, remember that most map units contain unlabeled "soil inclusions" that may have less desirable properties. Commonly encountered “inclusions” may be identified in the map unit description, or there may be visible indications of less desirable soils in a farmed field. Different soil colors seen in aerial images of plowed fields may be evidence of drainage, erosion, or even previous manipulation of the soil for terraces, waterways, or pipelines.

Patches of weeds, weedy shrubs, or even trees may be an indication of a farmer's recognition of a problem area. Areas where water collects after runoff may have worse problems after irrigation is installed. Often these can be identified in a time series of aerial images. Whenever possible a site visit and discussion with the farmer will better serve to identify problem areas of fields.

A general site evaluation can be obtained using the USDA – NRCS Web Soil Survey (WSS) website (http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm) - create AOI/Soil Data Explorer tab/Soil Report tab/Water Management Report. Options include General, Micro (above & below ground), Sprinkler (general and close spaced drops), and Surface. The rating class and limiting features point out conditions that may limit the effectiveness of irrigation. The rating value, 0.01 to 1.00, indicates the degree of the limitation, with high numbers indicating more severe limitations. Many of this report's limits for irrigation are shown in Table SC2-16

Table SC2–16 Irrigation restrictive features and limits and location of the data within current NRCS Web Soil Survey (WSS) and other reports.

Property	Limits	Restrictive Factor	Data Source(s)
Slope	> 6%, > B slope	Steep site, erosion, runoff, steeper sites require pressure control for uniform irrigation	Map Unit Symbol; WSS Map Unit Description Report; eFOTG Soils Information
	> 3%	Water runoff potential	WSS Map Unit Description Report; eFOTG Soils Information
	> 2%, > A slope	Limits to surface irrigation	Map Unit Symbol; WSS Map Unit Description Report; eFOTG Soils Information
USDA Texture (Surface Layer)	CS, S, FS, VFS, LS, LFS, LVFS,	Fast intake, limitation for surface irrigation	Map Unit name; WSS Map Unit Description Report; WSS Engineering Properties Table; eFOTG Soils Information
	SL, FSL, VFSL, L, SIL	Medium intake, few limitations for traveler and pivot sprinkler irrigation	
	SCL, CL, SICL, SC, SIC, C	Slow intake, limitation for traveler and center pivot sprinkler irrigation	
Land Capability Class (non-irrigated)	> 3	Limitations for most irrigated crop production	WSS Map Unit Description Report; eFOTG Soils Information (county reports); WSS Land Capability Classifications Report
Land Capability Class (non-irrigated)	> 4	Unsuitable for most irrigated crop productions, though irrigated pastures, vineyards, and orchards are possible on some slopes	
	e, w, s subclass	Erosion risk, water in soil, or shallow, droughty, stony conditions	
Fraction > 3 in.	> 25 (wt %)	Large stones, reduced plant root zone AWC	WSS Map Unit Description Report
Depth to bedrock	< 40 inches	Depth to rock; restricted plant root zone	WSS Map Unit Description Report; WSS Soil Features Report
Depth to cemented pan	< 40 inches	Cemented Pan; restricted plant root zone	WSS Soil Features Report

Property	Limits	Restrictive Factor	Data Source(s)
Fragipan (Great Group)	All (Fragi-)	Rooting depth (Depth of Moisture Replacement - DMR)	WSS Soil Features Report
Bulk density (0-40in. layer)	> 1.7 g/cc	Rooting depth (DMR)	WSS Physical Soil Properties Report
Erosion factor (Kw) – (Surface layer)	> 0.35	Erodes easily	WSS Physical Soil Properties Report; eFOTG Soils Information
Wind Erodibility Group	1, 2, 3	Soil Blowing damages young plants, reduces crop yield and quality	WSS Physical Soil Properties Report
Sodium Absorption Ratio (Great Group)	> 13 (Natric, Halic)	Excess sodium ions	WSS Chemical Soil Properties Report
Salinity	> 8 mmho/cm, 1 dS/m	Excess calcium and magnesium ions	WSS Chemical Soil Properties Report
Calcium carbonate equivalent (% in thickest layer, 10-60 in. depth)	> 40	Excess lime	WSS Chemical Soil Properties Report
Soil Reaction (pH) at any depth 10 to 60 in.	< 5.0 or > 8.0	Too acid or too alkaline	WSS Chemical Soil Properties Report
Flooding	Occasional or Frequent	Soil air is removed, plants damaged	WSS Water Features Report
Ponding	Occasional or Frequent	Seasonal surface ponding; Soil air is removed	WSS Water Features Report
Drainage class	Very poorly, Poorly, somewhat poorly	Depth to seasonally high water table creates restrictions to plant root zone	eFOTG Soils Information (county reports)
Depth to High Water Table	< 3 feet	Restrictions to plant root zone; Wetness; Ponding	WSS Water Features Report
Saturated Hydraulic Conductivity – (0-60 micro meters/sec.)	< 1.4	Percolates slowly	WSS Physical Soil Properties Report
	< 0.14	Water percolates and redistributes slowly	
Saturated Hydraulic Conductivity of most restrictive layer	< 0.14	When below the surface layer, restricts maximum amount before surface saturation	WSS Physical Soil Properties Report
Available Water Capacity	< 0.10 in/in	Droughty	WSS Physical Soil Properties Report
	< 0.05 in/in	Limited water storage for plant growth	WSS Physical Soil Properties Report

(c) Soil Parameters for Irrigation

(1) General

Irrigation design pulls soil and site data from several sources. The first group might be considered basic soil properties. A second group would be considered derived soil parameters. Basic soil properties are those typically described through field observations and laboratory tests. They are the parameters that make up soil classification systems and data tables for soils in agriculture, geology, and engineering. Soil texture, structure, soil layer thickness, 15 bar (wilting point) water retention, depth to fragipans, cation exchange capacity, etc. are examples of basic soil properties.

Derived soil parameters are often use-oriented, calculated or estimated values for soils. For irrigation, values like initial and final infiltration rates, maximum drip application rates, and others consider both static and dynamic properties to aid in the design and management of irrigation systems. While soils of South Carolina have been fully described for basic soil properties, there are fewer data sets for derived design parameters.

(2) Basic Soil Properties

(i) Soil Texture –

Soil texture describes the size distribution of the particles that make up the fabric of the soil. It is considered a static or unchanging property of the soil, as opposed to dynamic – constantly changing – properties like soil infiltration rate or soil water content. Many conservation and management practices and designs are dependent upon or affected by soil texture.

Unfortunately no single textural classification system has emerged. Three find widespread use in the U.S., although each has a different audience (USDA, USCS, AASHTO). A breakdown of the USDA and USCS soil groups are shown in Table SC2-17.

The USDA classification emphasizes the soil texture's role in productivity. Water and nutrient holding capacity are closely related to clay and silt sized particles. Stable aggregate formation that improves soil aeration, allows easy root exploration, and improves permeability of water in soil is linked to silt sized particles. Workability, rapid drainage, and trafficability of soil are linked to sand content. Conversely, very coarse sand and gravel provide little benefit to crop production, and these sizes are mostly ignored in the USDA system.

The USDA system breaks soil, defined as particles passing 10 mesh sieve (< 2 mm), into three size groups – sand, silt, and clay. Then using a standard graph – the texture triangle – one of twelve basic textural classes is assigned to the soil mixture (Fig. SC2-10). The sand fraction may be further subdivided into very coarse, coarse, medium, fine, and very fine sizes, and the descriptor added to basic textural classes that contain sand. A list of the textural classes and their abbreviations, as well as sizes of soil separates can be found in NEH Part 652, Chapter 2, Table 2-5.

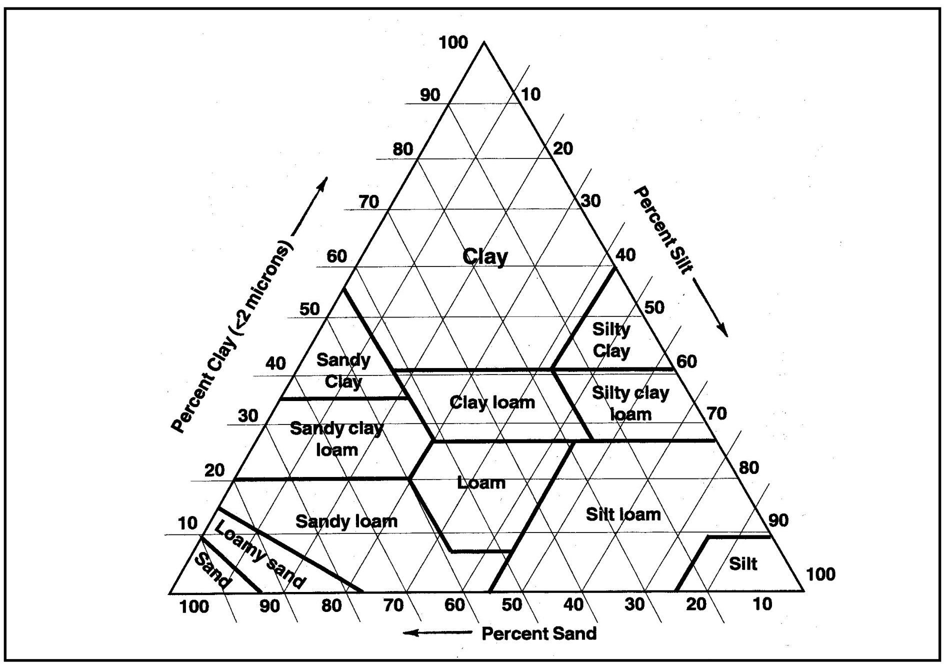


Figure SC2-10 Soil Texture Triangle

The Unified Soil Classification System (USCS) is used by engineers and geologists. It isn't specifically related to soils but is used for many types of materials from earthworks, mining, crushing, milling, etc. It emphasizes handling and workability of the materials. It has been related to suitability of these materials to form earthen structures like dams and levees or to be moved by dredging, conveyors, etc.

The USCS is not solely a particle size classification. It also relies upon the plasticity imparted when fines (passing 200 mesh sieves) make up more than 50% of the soil material. As such, the USCS cannot be directly inferred from the USDA texture. Uniformity of sizes is also expressed in the USCS when the soil is predominantly coarse. Two letters designate the soil size. The first and/or second refers to size: G – gravel; S – sand; M – silt; C – clay; and O – organic. The second designates grading or plasticity: P – poorly graded (groups of uniform sizes); W – well-graded (diversified sizes); H – high plasticity; and L – low plasticity.

The American Association of State Highway and Transportation officials (AASHTO) uses their Soil Classification System for highway construction purposes. It finds less use in design of agricultural irrigation than either the USDA or Unified systems. However, for wheeled systems like center pivots and linear move system, the ability of the soil to withstand traffic without bogging down or deeply rutting can be related to the AASHTO classification.

Like the USCS, the AASHTO soil classification depends upon particle size separation, plasticity, and to some extent, uniformity of the sands. Plasticity is a particular problem in road subgrade material, and in general, soils with > 35% clay can create unstable traffic beds when wet.

The Texture Group No. in Table SC 2-17 looks to relate textures based on the vertical and horizontal water movement through the depth of moisture replacement (DMR) zone. The textures are shown in approximate order of increasing proportions of fine particles

Table SC2-17 USDA and USCS Soil Classification System and Interpolation of Group Symbol

	USDA Classification System and interpretation of Group Symbols		
	Soil Texture	**Group Name**	**Texture Group No.**
Sandy Soils 2/	**CS**	course sand	**1**
	S	sand	**2**
	FS	fine sand	**2**
	LS	loamy sand	**3**
	LFS	loamy fine sand	**3**
	LVFS	loamy very fine sand	**3**
	SL	sandy loam	**4**
	FSL	fine sandy loam	**4**
	VFSL	very fine sandy loam	**4**
	L	loam	**5**
	SIL	silt loam	**5**
	SCL	sandy clay loam	**5**
	CL 1/	clay loam	**6**
	SICL 1/	silty clay loam	**6**
Clayey Soils 2/	**SC**	sandy clay	**7**
	SIC 1/	silty clay	**7**
	C 1/	clay	**7**

Unified Soil Classification System and interpretation of Group Symbols	
Group Symbol	**Group Name**
GW	well-graded gravel, fine to coarse gravel
GP	poorly graded gravel
GM	silty gravel
GC	clayey gravel
SW	well-graded sand, fine to coarse sand
SP	poorly graded sand
SM	silty sand
SC	clayey sand
ML	silt of low plasticity
CL	clay of low plasticity
OL	organic silt, organic clay
MH 1/	silt of high plasticity, elastic silt
CH 1/	clay of high plasticity, fat clay
OH	organic clay, organic silt
Pt	peat

1/ Generally textures with > 35% clay
2/ Sandy soils - higher flow rates and/or closer emitter spacing; Clayey soils - lower flow rates and/or wider emitter spacing

Soil textural classes of the USDA system are provided for each soil horizon of each map unit in the Web Soil Survey (WSS). Since these map units are described separately for each county, the horizon depths and USDA textures may differ for the same soil series from county to county.

When designing irrigation systems or planning other management practices related to soil texture, utilize the actual map unit(s) at the project site and design based upon the values reported for that county. Additional field investigations will help verify the accuracy of the mapped series or lead to more specific soil description or in-situ measurement of texture.

In the WSS, after locating the county and selecting the Area of Interest (AOI), select the "Physical Soil Properties" report to get available USDA particle size data for described horizons. Also the "Map Unit Description" report will provide the textural class name for the topsoil layer.

Both the Unified and AASHTO soil textural classification are provided by soil name and horizon for most soils. In WSS, after locating the county and selecting the AOI, select the "**Engineering Properties**" report to get available USDA texture, Unified Classification, AASHTO classification.

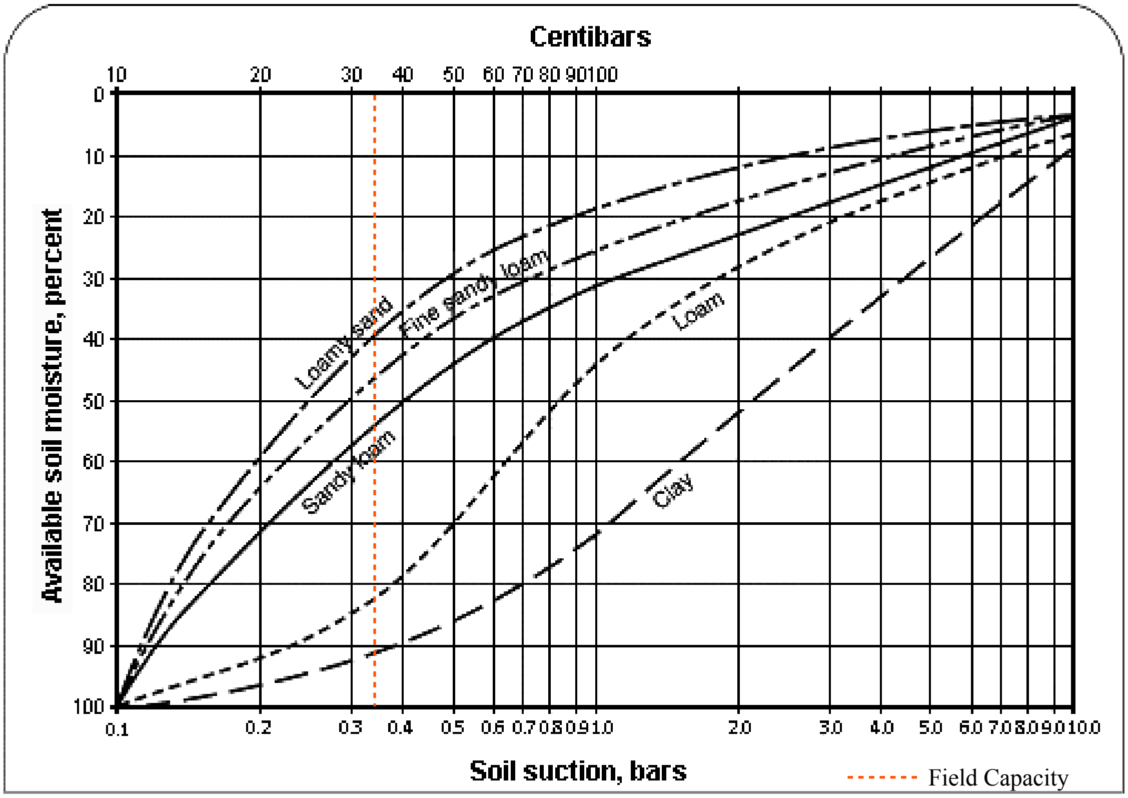
(ii) Available Water Capacity –
The AWC – available soil moisture – of a soil is a measure of its capacity to make water available for plant growth. The AWC is the amount of water held between field capacity at 0.33 bars (33 centibars) and the permanent wilting point at 15 bars (1500 centibars). It varies with other soil properties, especially soil texture (Figure SC2-11), so it is measured or calculated separately for each soil horizon. Generally, AWC is considered a static soil property, but soil compaction can slightly reduce the water content at field capacity, and some long term improvements in soil organic matter and aeration can slightly increase that upper limit for AWC. Consult Chapter 3 (Table SC3-8) for MAD values during various critical growth stages. NRCS recommends 85 - 70 percent AWC (15 - 30% MAD) for Seasonal High Tunnels (Hoop Houses) or for plasticulture operations.

The AWC is often the starting point of a design for an irrigation system. In effect it is the maximum amount of water that could be added to a very dry soil layer. Any additional water could drain vertically, largely unused, or if the soil layer was underlain by a water table or impermeable layer, the excess water could displace air needed for root and plant health.

Values for available water content were determined in the laboratory on samples taken from each soil layer. Water retained against drainage at a tension (or pressure) equivalent to 15 bars (1500 kiloPascals) was taken as the lower limit or wilting point. Water retained against drainage at a tension (or pressure) equivalent to 0.33 bars (33 kiloPascals) for clays or 0.10 bars (10 kiloPascals) for sands was taken as the upper limit or field capacity (Exhibit SC2-3). The difference between those limits, AWC, is often expressed as inches of water available in an inch (depth) of soil. <u>By adding up the inches of water layer by layer from the surface to the planned depth of moisture replacement, an AWC can be calculated for the planned irrigation system</u>.

If the site of the planned irrigation is mapped, AWC for each soil layer for each map unit in the field can be found in the NRCS WSS. Once the county and AOI are located, the AWC values can be found in the "**Physical Soil Properties**" report.

Figure SC2-11 Approximate potential (tension) levels for general soil textures:



Source: Ministry of Agriculture, Food and Rural Affairs, Ontario, Canada

Note: 1 kpa = 1 centibar; 100 centibars = 1 bar

The AWC of a soil layer can also be estimated from the soil texture. NEH Part 652, Chapter 2, Tables 2-1, 2-2 and 2-4 will provide typical ranges for AWC by texture class, and they allow modification of those values for soils with various amounts of coarse fragments or salinity.

Field investigations can be used to improve values for AWC. The “Drained Upper Limit” of a field soil is the water content remaining after a soaking rain or excessive irrigation has been allowed to drain away under minimal evaporation or root uptake for a period of 24 to 48 hours. It is generally greater than the laboratory measured upper limit, and it represents a more realistic value of plant useable water in an irrigated soil. The 15 bar lower limit is usually retained in calculating a field measured AWC.

(iii) Managed Allowable Depletion (MAD) –

Managed Allowable Depletion is more of a plant property than a soil property, and it may be considered a derived value in that respect. However, it is described here so that available water capacity (AWC) will not be confused with MAD. AWC is a measure of the soils capacity to make water available for plant growth, were MAD (usually expressed as a percentage) is the soil-water available for crop use before the crop begins to suffer detrimental effects.

Those effects include afternoon wilting (stomatal closure), cessation of carbon fixation, shedding of flowers or fruit, and other growth and yield reducing impacts. These effects differ by crop type and even by time in the growing season, so MAD must be based on crop and growth stage.

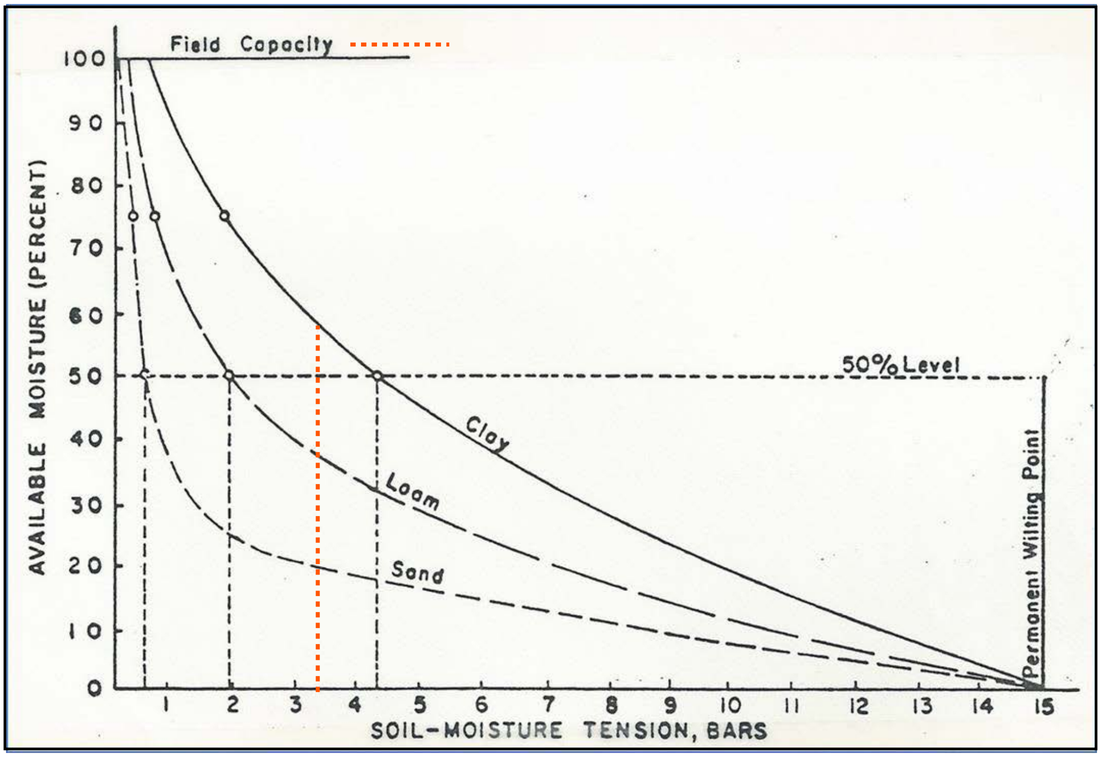


Exhibit SC2–3 Soil Tension curves relating soil-water pressure to percent of Available Water Capacity

(iv) Soil Stratification –
Stratification - abrupt changes in texture - of soil layers can affect water and air movement in irrigated soils, as well as water retention.

In Soil Taxonomy, a family name lists two soil textures when there are strongly contrasting particle size classes within the control section or the horizon. Examples would be soil series that have a family particle size class of sandy over loamy, fine loamy over sandy, coarse loamy over clayey, etc. These are considered stratified soils.

Only four soil series in South Carolina meet the "stratified" definition – Johns, Kalmia, Lumbee, and Seagate. These four series only occur in selected Coastal Plain counties. All other SC soils would be considered "homogeneous" for this property. The soil series can be found in the WSS "Taxonomic Classification of the Soils" report.

(v) Other Soil Properties –
Other soil properties important in irrigation are discussed in NEH Part 652, Chapter 2 "Soils". Charts and data in that document may be usful in the design of South Carolina irrigation systems.

(3) Derived Soil Parameters

(i) Maximum Irrigation Application Rates –
Sprinkler irrigation application rates and amounts should be related to the temporary surface storage and soil intake rate – the capacity of a soil to absorb irrigation water from the surface and move it into and through the soil before runoff occurs. Soils classified in the intake families of 0.1, 0.3, 0.5, and 1.0 are generally those that are suited for sprinkler irrigation but have a potential for runoff. Some sandy soils are classified into higher intake families such as 1.5 and these soils rarely have runoff problems.

The amount of moisture already in the soil greatly influences the rate at which water enters the soil. The soil takes in and absorbs irrigation water rapidly when water is first applied to the field surface – the initial intake rate. As the irrigation application continues, the surface soil gradually becomes saturated and the intake rate decreases until it reaches a nearly constant value – the final intake rate. If the total irrigation application depth is low, all of the applied water can infiltrate before the final intake rate. This is reflected in Table SC2-18 on maximum design rates for sprinklers.

Water not immediately infiltrating the soil accumulates for a period of time in large soil pores (at water content above the drained upper limit) near the surface and in surface depressions. When this temporary storage is filled to capacity, runoff begins. Proper management can increase retention time by increasing surface storage capacity on or near the soil surface. A greater amount of excess water is stored, and more time is allowed for water to enter the soil profile. This can be accomplished by several practices including surface residue cover, tillage induced surface roughness (such as furrow diking), and contour or cross slope farming. These measures also help to improve infiltration rates and to slow velocity of surface runoff.

The intake of any soil is limited by restrictions to the flow of water into or through the soil profile. The soil layer within the soil-water control zone with the lowest transmission rate, either at the surface or directly below it, usually has a major effect on the intake rate. Important factors that influence intake rates and application rates are the physical properties of the soil and, in sprinkler irrigation, the plant and residue cover.

(a) Intake Rates for Solid-Set Sprinkler –

Solid-set sprinkler systems, both permanent and portable, are designed specifically to consider minimum intake rates of soil. Design of sprinkler systems involves trade offs between minimizing the number of lateral lines and maximizing the uniformity of application. Laterals contain most of the capital costs (ditches, plastic tubing, riser tubes, and sprinkler heads), and incur opportunity costs when the lateral position cannot be used for crop production. Semi-permanent alleys also incur costs for weed control. Minimizing these costs is one design goal for solid-set systems. Spacing may also be affected by desired multiples of rows for efficient equipment operation (planters, sprayers, harvesting equipment). Sprinkler heads from small plastic wobblers and spinners to rotating impact sprinklers to high volume big guns can be used to meet spacing needs in a solid-set system.

Higher pressures and nozzle discharge rates are balanced against the spacing needed to throw water over distances between widely spaced laterals. Higher pressures typically increase energy costs for pumping, and high pressure sprays are often subject to significant water losses through drift and evaporation during irrigation. Wherever the design balance falls, the maximum sprinkler application rate must fall below the soil intake rate.

Application rate is fixed in solid-set sprinkler systems; net application depth is dependent upon duration of irrigation. The soil intake rate for solid-set is greatest during the beginning of the application of irrigation water, but as the topsoil layer becomes saturated additional intake may be limited by percolation rates of subsoil horizons. If the total or net application depth per irrigation event is low, a higher sprinkler application rate can be used. However, when net application exceeds one-half inch, the sprinkler application rate must be lowered.

The approximate application rate (AR) for solid-set, hand move or wheel line may be calculated, as follows:

$$AR = \frac{96.3 \text{ x } GPM}{Area}$$

where: ***AR*** = Application Rate (inches/hour);
GPM = flow through the sprinkler nozzle (gpm);
Area = distance between sprinkler on the lateral x distance between laterals (sq. feet); and
96.3 = units conversion constant = (12 inches/feet) × (60 min/hour) / (7.48 gallons/cubic foot).

When application rate exceeds the infiltration rate, water ponds on the surface and, depending on slope and traffic/tillage patterns, runoff or redistribution of water may occur. The result is less water in the root zone and/or more uneven water distribution. Typical maximum sprinkler application rates for various soil textures are given in Table SC2-18.

Table SC2-18 Maximum Sprinkler Irrigation Application Rates (inches/hour) for row crops as related to soil texture in the surface layer [1/]

Irrigation Texture Group	Soil Textures	Land Slope	Net Irrigation Application (inches) 0.5	1.0	1.5	2.0
		%	inches/hour			
1	CS	< 2	2/	2/	3.0	2.0
		2 to 5	2/	2/	2.5	1.5
		> 5	2/	3.0	2.0	1.0
2	S and FS [3/]	< 2	2/	3.0	2.0	1.5
		2 to 5	2/	2.5	1.5	1.0
		> 5	3.0	2.0	1.0	0.8
3	LS, LFS, LVFS	< 2	2/	2.0	1.5	1.0
		2 to 5	3.0	1.5	1.0	0.8
		> 5	2.5	1.0	0.8	0.6
4	SL, FSL, VFSL [4/]	< 2	3.0	1.5	1.0	0.7
		2 to 5	2.5	1.2	0.8	0.5
		> 5	2.0	0.8	0.5	0.4
5	L, SIL, SCL	< 2	2.0	1.2	0.8	0.6
		2 to 5	1.5	0.8	0.5	0.4
		> 5	1.0	0.6	0.4	0.3
6	CL and SICL	< 2	1.5	1.0	0.6	0.5
		2 to 5	1.0	0.6	0.5	0.4
		> 5	0.8	0.5	0.4	0.3
7	SC, SIC, C	< 2	1.2	0.6	0.5	0.4
		2 to 5	0.8	0.5	0.4	0.3
		> 5	0.5	0.4	0.3	0.2

1/ Irrigation application rates in this Table are to be used as a guide in arriving at maximum application rates for sprinkler applications in South Carolina. The values are estimates based upon data published in S.C. Agricultural Experiment Station Tech. Bulletin. 1022, recommendations from NEH, Section15, Chapter 11, and results and observations obtained from irrigation evaluation tests made in South Carolina. Higher application rates may be used with smaller applications due to the higher initial intake rate and surface storage, etc. Runoff is usually a concern during the last portion of the irrigation cycle when soils are nearing saturation and intake rates are lowest.

Footnotes for Table SC2-18 (continued)

Use of some cultural practices such as bedding and contouring, row diking, and possibly others may warrant that application rate not be a limiting factor in design. These practices shall be documented to support planning and design.

For grasses or minimum tillage crops with approximately 50% or more ground cover, tabular values may be increased 25%.

2/ For soils with these textures, slopes, and application depths, soil intake rates are usually not the limiting factor in system design. Other factors including crop type and droplet impact should be considered to arrive at an application rate. For upper limit values in this table, a value of 4.0 inches per hour may be used except for gun sprinklers.

For some crops and gun sprinklers, factors other than soil texture, slope, and application depth may dictate that application rates be less than shown. These include but are not limited to crop type, lack of ground cover, droplet impact, and hydrologic condition of the soil. As a guide, use approximately 0.8 inch/hour as the maximum allowable gun sprinkler application rate. Adjust lesser values downward as experience dictates. Net Irrigation Application (NIA) can be determined as shown on page 4-12.

3/ If the spodic horizon appears to impede water movement through the soil, reduce the shown value by 0.50.

4/ If these soils have sandy clay loam sub horizons between 20 to 40 inches, the designer shall adjust the values to ensure no runoff.

Table SC2-18 could also be applied to microirrigation. Runoff from a microirrigation system would be a very rare situation for Texture Groups 1 – 5 (Table SC2-17). Runoff potential and surface ponding should be considered for Groups 6 & 7 and if a potential design issue, reduce Table SC2-18 application rates to an appropriate value.

(b) Intake Rates for Travelers –

Big guns or travelers operate, in one respect, like big sprinklers or guns in solid-set systems. A single big gun moves along the "lateral" or traveler run (towpath). It takes the place of many sprinklers or guns fixed along a lateral in solid-set arrangement. The larger volume and reach of these nozzles requires a larger water delivery system, typically on the order of 400 to 450 gallons per minute for systems with typical wetted diameters of 400 to 425 feet (NEH Part 652, Chapter 6, Table 6-6). To reach those distances travelers typically operate at high pressure – from 60 to 120 pounds per square inch. Overlap of sprinkler patterns (towpath to towpath) is often a lower percentage than for solid-set systems, as these big guns are designed to deliver a relatively "flat" net application depth over much of the spray radii.

With higher volume and pressure, travelers create a spray that is more similar to a thundershower than a gentle rainfall. Droplet impact may disrupt bare soil creating a crust that reduces subsequent infiltration of both rainfall and irrigation. Soil may be splashed onto crops making this method of application less desirable where high value crops like strawberries and vegetables are concerned. On the other hand, it is ideal for forage and pastures which may need rescue irrigation during extended dry weather.

Although the instantaneous application rate of a traveler is fixed, the effective application rate and net application depth are determined by the speed at which the big gun is moving along a run or towpath. The speed should be set so that the maximum application rate of the traveler is 0.8 inch/hour, or less as experience with runoff indicates. Speed of modern travelers can usually be set to stay within a narrow range over the entire towpath.

c) Intake Rates for Center Pivots –

Center pivots create the greatest challenges for designs that must keep application rates below soil intake rates (NEH Part 652, Chapter 2, Table 2-6). Figure SC2-4 is a graphical procedure to estimate the required wetted diameter of the sprinkler package based on the application depth, available surface storage and system capacity.

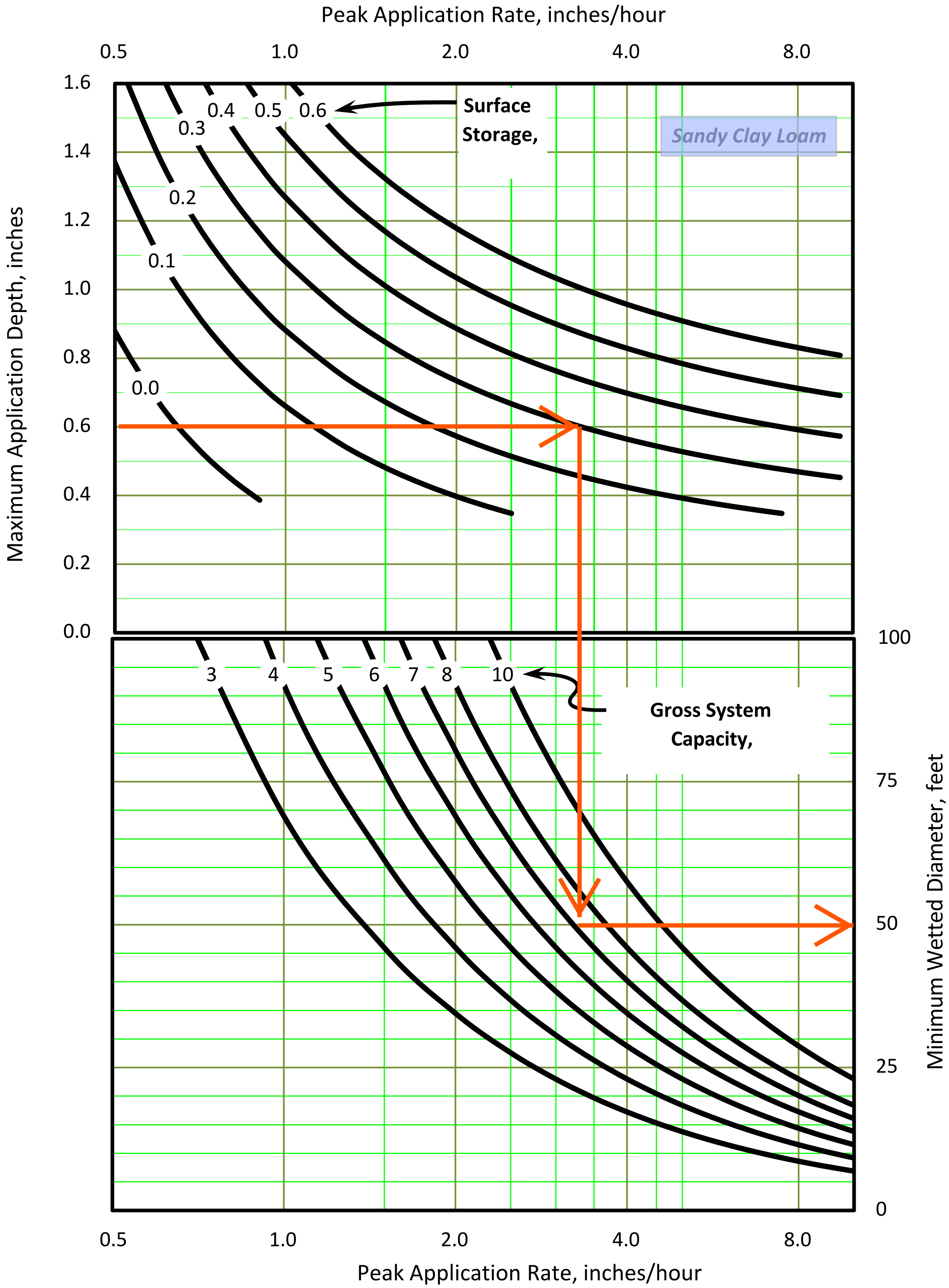


Exhibit SC2-4 Graphical procedure to determine required Wetted Diameter for Center Pivot (Courtesy of University of Nebraska - see Center Pivot Irrigation Management Handbook for other soil textures)

The radial operation leaves soil areas close to the pivot under sprinklers for as much as an hour or more while areas covered by the end section may have the full application depth applied in a few minutes.

Almost all center pivots in South Carolina are designed by the equipment manufacturers using software that optimizes for uniformity of application depth over the pivot coverage area. They achieve this by changing the spacing of sprinklers and/or the discharge rate of sprinklers nozzles.

As long as the original sprinkler package remains in place, and worn and clogging nozzles are kept at a minimum, the uniformity of application will remain near design specifications regardless of the speed at which the pivot is operated. Because of the greater travel speed of the end tower than those near the pivot, the uniform application is achieved by increasing the application rate per foot of pivot pipe length from pivot to end tower. Average and instantaneous application rates will increase for parts of the field covered by outer reaches of the system.

Early high pressure systems utilized impact spray heads or sprinklers on top of the boom. Most of the center pivot systems delivered since the early 2000's are designed to operate with low pressure discharge at the spray (drop) nozzle. The sprinklers are mounted on tubes hanging below the boom. Pressure regulators are most commonly used with these systems to assure each head is operating at its optimum design pressure.

Low pressure in the system reduces energy consumption by the pump, and low pressure spray (drop) nozzles release larger and more uniform droplets. These droplets reduce travel time in air (reducing droplet evaporation), and eliminate small droplets to reduce water losses to wind and spray drift. The trade off, however, is smaller wetter diameters for individual sprinklers along the pivot. This too increases average and instantaneous application rates. While water is conserved during application, if care isn't taken to keep the highest (end tower) instantaneous application rate below soil infiltration rates, redistribution or runoff will reduce the net application depth and reduce uniformity over the field.

The average application rate (AAR_{cp}) may be calculated as follows:

$$\boldsymbol{AAR_{cp}} = \frac{96.3 \text{ x } \boldsymbol{r} \text{ x } \boldsymbol{Q}}{\boldsymbol{L}^2 \times w}$$

where: $\boldsymbol{AAR_{cp}}$ = Average Application Rate (inches/hour);
r = distance out from the pivot to last tower (feet);
Q = discharge rate of the sprinkler package (gallons/minute);
L = the total wetted radius of the pivot to last tower (feet); and
w = wetted radius of the sprinkler of interest, typically last sprinkler on base pivot (feet).

If we assume the maximum peak rate (based on an elliptical pattern) is going to occur at the end of the pivot, which it will, that will cancel out the **r** and one of the **L** values, leaving the following equation for peak application rate::

$$\boldsymbol{PAR_{cp}} = \frac{\frac{4}{\boldsymbol{\pi}} \text{ x } 96.3 \text{ x } \boldsymbol{Q}}{\boldsymbol{L} \times w}$$

Evaluate $\boldsymbol{PAR_{cp}}$ against the maximum sprinkler application rate for the appropraite soil texture in Table SC2-18. If there is any potential for redistribution or runoff of the applied irrigation water then address the issue by a system redesign or increase of surface storage.

Typically, center pivot manufacturers' sprinkler printouts calculate average gpm/acre at each tower but not peak application rate (PAR_{cp}). Although the concept is not difficult to understand, most pivot designs have not had an evaluation of PAR_{cp} vs soil intake rate. When you hear the farmer say "water is running off the field" it usually means that the PAR_{cp} is too high and another sprinkler package should have been considered. Figure SC2-12 shows examples when the PAR_{cp} is greater than the soil intake rate.

Figure SC2-12 Runoff from center pivot irrigation systems (Source: stock images)

(d) Data Sources for Design Parameters –
Once site suitability and soils at the project location are known, the irrigation system can be designed. Basic soil properties can be pulled from multiple reference materials. The reference materials are summarized in Table SC2-19.

Soil texture and AWC in the *depth of moisture replacement* (DMR) zone are important soil properties when determining an irrigation schedule. Water movement within the soil profile (i.e., through DMR) are used to determine a maximum irrigation cycle to "not waste water" past the DMR, even if multiple cycles are needed to meet the daily ETc.

Table SC2 – 19 Required Data and Source location for design of typical irrigation systems.[1/]

Data Requires	Needed for	Related to	Data Source
Map unit (Series, Surface Soil Texture, Slope)	Site evaluation	Soil and site limitations	WSS, County Soil Survey maps
Suitability of Soils for Selection of Crops	Site evaluation	Crop type, Soil Series	eFOTG Suitability of Soils for Selected Crops
Available Water Capacity, Saturated Hydraulic Conductivity by soil layer	Limits and water in the irrigation management zone	Map Unit Layers	**WSS Physical Soil Properties Report**; NEH Part 652 (Tables 2-1 to 2-4)
USDA, AASHTO and Unified **soil texture** class by depths	Evaluation of AWC	Map Unit Layers	**WSS Engineering Properties Report**
Stratified vs Homogeneous Soil family	ENTSC Drip Irrigation Design worksheet	Soil texture uniformity of horizons in Series	WSS Taxonomic Classification of the Soils Report; SCIG section 0204 (c)(2)(iv)(pg. 2-49)
Depth of Moisture Replacement (Effective Rooting Depth)	Irrigation Water Scheduling	Crop type; (root-limiting soil layer)	SCIG Chapter 3 (Table SC3-9)
Soil Permeability	Intake rates	Saturated hydraulic conductivity, permeability classification	WSS Physical Soil Properties Report
Maximum recommended application rate	Sprinkler Systems	Topsoil texture; slope	Center Pivot, NEH Part 652 (Table 2- 7); Sprinklers, NEH Part 652 (Table 2-8), SCIG (Table 2-19)
Maximum surface storage (above soil) to prevent runoff	Furrow diking, soil roughness for erosion control	Topsoil texture & depth, permeability, intake rate	NEH Part 652 (Tables 2-10a to 2-10g, 2- 11 to 2-13; Figures 2-5a and b)
Soil intake rates by texture	Evaluation of pivot design; Design of solid-set and surface irrigation	Topsoil texture, structure,	NEH Part 652 (Table 2-6, Table 2-8, Table 2-9)

1/ WSS – Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm);
eFOTG – Electronic Field Office Technical Guides (http://efotg.sc.egov.usda.gov/efotg_locator.aspx);
NEH Part 652 – NRCS Irrigation Guide national sections

Soil suitability is based on the number and type of "limitations" to the practice of irrigation. Table SC2-20 shows the main limitations and rating from several Web Soil Survey reports.

To determine map symbol and Hydric soil status - (http://efotg.sc.egov.usda.gov/efotg_locator.aspx). Pick State/ County/Section II/Soils Information/eFOTG Soils Information/County, then open report to find soil(s).

Map units that consist of more than 1 soil series - complexes/associations - are not included in this list. *Complexes* are too difficult to separate and *Associations* are not different enough to separate out.

Table SC2–20 Irrigation Limitations / Notes and Ratings for South Carolina Soils

Soil Series Name	Limitations / Notes for use with Irrigation System	Ratings
Ailey	Low AWC, Slow water movement	
Alaga	Low AWC, Seepage, Slope	
Alamance	Depth to soft bedrock, Depth to Sat zone, slope	
Albany	Depth to Sat zone, Low AWC, Seepage	
Alpin	Low AWC, Seepage, Slope	
Altavista	Depth to Sat zone, Seepage	
Angie	Slow water movement, Seepage, Too acid	SL Sprinkler
Appling	Slope, Too acid	
Argent	Drained, Depth to Sat zone, Slow water movement	
Armenia	Frequent flooding, Slow water movement, Depth to Sat zone	
Ashe	Slope, Erosion, Soil Creep, Mostly Forested	
Autryville	Seepage, Low AWC	
Badin	Slope, Depth to restrictive layer, Low AWC	
Baratari	Depth to Sat zone, Seepage	VH RO, VL Irr
Barnwell	Seepage, Slope, Too acid	SL Sprinkler
Bayboro	Drained, Depth to Sat zone, Slow water movement	
Beaches [3/]	Not suitable for irrigation	
Bertie	Depth to Sat zone, Seepage, Too acid	
Bethera	Drained, Depth to Sat zone, Slow water movement	
Bethlehem	Slope, Depth to bedrock	
Bibb	Depth to Sat zone, Frequent flooding, Seepage	
Bladen	Drained, Depth to Sat zone, Slow water movement	
Blaney	Low AWC, Slow water movement	
Blanton	Low AWC, Seepage, Slope	
Bohicket [2/]	Not suitable for irrigation	
Bonneau	Seepage, Slope	
Brevard	Slope, Erosion, Mostly Forested	
Brewback	Drained, Depth to Sat zone, Slow water movement	
Brogdon	Seepage	SL Sprinkler
Brookman	Drained, Depth to Sat zone, Slow water movement	
Buncombe	Frequent flooding, Low AWC, Slope	

Table SC2–20 Irrigation Limitations / Notes and Ratings for South Carolina Soils

Soil Series Name	Limitations / Notes for use with Irrigation System	Ratings
Bush River	Depth to Sat zone, Depth to bedrock, Slow water movement, Slope	
Butters	Seepage, Low AWC	
Byars	Drained, Depth to Sat zone, Slow water movement	
Cahaba	Slope, Low AWC, Seepage	
Cainhoy	Low AWC, Seepage, Slope	
Callison	Slope, Depth to Sat zone, Depth to restrictive layer	
Candor	Slope, Low AWC, Seepage	
Cantey	Depth to Sat zone, Low AWC	VH RO, VL Irr
Cape Fear	Drained, Depth to Sat zone, Slow water movement	
Capers [2/]	Not suitable for irrigation	VH RO, VL Irr
Caroline	Seepage, Too acid, Slope	
Cartecay	Depth to Sat zone, Seepage, Occasional flooding	VH RO, VL Irr
Cataula	Slope, Seepage, Slow water movement, Low AWC	SL Sprinkler
Cecil	Slope	
Centenary	Low AWC, Seepage	
Chandler	Slope, Erosion, Soil Creep, Mostly forested	
Charleston	Low AWC, Seepage	
Chastain	Depth to Sat zone, Ponding & Frequent flooding, Seepage	
Chenneby	Frequent flooding, Depth to Sat zone, Too acid	
Chewacla	Frequent flooding, Depth to Sat zone, Too acid	
Chipley	Depth to Sat zone, Low AWC, Seepage	
Chisolm	Seepage, Slope, Low AWC	SL Sprinkler
Clarendon	Depth to Sat zone, Too acid, Slow water movement	SL Sprinkler
Claycreek	Slow water movement, Depth to Sat zone, Slope	
Clayham	Seepage, Water erosion	SL Sprinkler
Cleveland	Slope, Erosion, Soil Creep, Mostly forested	
Colfax	Frequent flooding, Depth to Sat zone, Slope	
Congaree	Frequent flooding, Too acid	
Coosaw	Seepage, Depth to Sat zone	SL Sprinkler
Coronaca	Slope, Water Erosion	
Cowarts	Seepage, Slope	

Table SC2–20 Irrigation Limitations / Notes and Ratings for South Carolina Soils

Soil Series Name	Limitations / Notes for use with Irrigation System	Ratings
Coxville	Drained, Depth to Sat zone, Seepage	
Craven	Slope, Depth to Sat zone, Too acid & Slow water movement	
Crevasse [3/]	Not suitable for irrigation	VL Irr
Daleville	Drained, Depth to Sat zone	
Dasher [1/]	Not suitable for irrigation	
Davidson	Slope, Water Erosion	
Dawhoo	Depth to Sat Zone, Seepage, Frequent flooding, Low AWC, Too acid	VH RO, VL Irr
Deloss	Depth to Sat zone, Drainage	
Dorian	Depth to Sat Zone	
Dorovan [3/]	Not suitable for irrigation	
Dothan	Seepage, Slope	
Duckbottom	Depth to Sat zone, Ponding & Frequent flooding, Seepage	
Dunbar	Drained, Depth to Sat zone, Seepage	
Duplin	Depth to Sat zone, Seepage	
Durham	Seepage, Slope	
Echaw	Low AWC, Seepage, Too acid	
Eddings	Seepage, Low AWC, Slope	SL Sprinkler
Edisto	Seepage, Depth to Sat zone	SL Sprinkler
Elloree	Depth to Sat zone, Seepage, Very frequent flooding, Low AWC	VH RO, VL Irr
Emporia	Low AWC, Too acid	
Enon	Slope, Water Erosion	
Enoree	Depth to Sat zone, Seepage, Frequent flooding	VH RO, VL Irr
Eulonia	Depth to Sat zone, Seepage	VH RO, VL Irr
Eunola	Depth to Sat zone, Seepage	VH RO, SL Sprinkler
Eustis	Seepage, Low AWC	SL Sprinkler
Evard	Slope, Erosion, Soil Creep, Mostly forested	
Exum	Depth to Sat zone, Too acid	
Faceville	Slope, Seepage	
Fannin	Slope, Erosion, Soil Creep, Mostly forested	
Foreston	Seepage, Low AWC	
Foxworth	Seepage, Low AWC	SL Sprinkler

Table SC2–20 Irrigation Limitations / Notes and Ratings for South Carolina Soils

Soil Series Name	Limitations / Notes for use with Irrigation System	Ratings
Fripp [3/]	Not suitable for irrigation	
Fuquay	Low AWC, Seepage, Slow water movement	
Georgeville	Slope, Water erosion	
Gilead	Slope, Depth to Sat zone, Seepage	
Gills	Depth to Sat zone, Cemented Pan, Low AWC, Slope, Erosion	VL Irr
Goldsboro	Depth to Sat zone, Seepage, Too acid	
Goldston	Depth to bedrock, Low AWC, Slope	
Gourdin	Depth to Sat zone, Seepage, Low AWC, Too acid	VL Irr
Grady	Depth to Sat zone, Seepage	VH RO, VL Irr
Greenville	Seepage	
Grifton	Depth to Sat zone, Frequently flooded	
Gundy	Slope, Water erosion	VL Irr
Gwinnett	Slope	
Handsboro [2/]	Not suitable for irrigation	
Hard Labor	Seepage, Slow water movement, Slope	SL sprinkler
Hayesville	Slope, Erosion	
Haywood	Seepage, Slope, Water erosion	VL Irr
Helena	Depth to Sat zone, Slow water movement, Slope	
Herndon	Slope, Slow water movement, Too acid	
Hiwassee	Slope, Water erosion	
Hobcaw	Drained, Depth to Sat zone, Too acid	
Hobonny [1/]	Not suitable for irrigation	
Hockley	Seepage, Depth to Sat zone, Slope	SL Sprinkler
Hornsville	Drained, Depth to Sat zone, Too acid	
Hyde	Drained, Depth to Sat zone, Too acid	
Iredell	Drained, Depth to Sat zone, Slow water movement	
Izagora	Depth to Sat zone, Seepage, Too acid	SL Sprinkler
Jedburg	Depth to Sat zone, Seepage	
Johns (**)	Depth to Sat zone, Seepage	
Johnston	Drained, Depth to Sat zone, Frequently flooded	
Kalmia (**)	Low AWC, Seepage, Too acid	
Kenansville	Low AWC, Seepage	

Table SC2–20 Irrigation Limitations / Notes and Ratings for South Carolina Soils

Soil Series Name	Limitations / Notes for use with Irrigation System	Ratings
Kershaw	Seepage, Low AWC, Slope	VL Irr
Kiawah	Depth to Sat zone, Seepage, Low AWC, Too acid	VL Irr
Kinston	Depth to Sat zone, Ponding & Frequent flooding, Seepage	
Kirksey	Slope, Too acid, Depth to bedrock	
Lakeland	Low AWC, Seepage, Slope	
Leaf	Drained, Depth to Sat zone, Slow water movement	
Lenoir	Drained, Depth to Sat zone, Slow water movement	
Leon	Depth to Sat zone, Low AWC, Drainage, Seepage	
Levy [2/]	Not suitable for irrigation	VL Irr
Lignum	Slope, Depth to Sat zone, Slow water movement	
Lockhart	Slope	
Louisburg	Slope, Depth to bedrock, Low AWC	
Lucknow	Low AWC, Seepage	
Lucy	Seepage, Slope, Low AWC	
Lugoff	Seepage	VL Irr
Lumbee (**)	Depth to Sat zone, Low AWC, Drained	
Lynchburg	Depth to Sat zone, Seepage	
Lynn Haven	Depth to Sat zone, Too acid, Drained	
Madison	Slope, Too acid	
Mantachie	Frequently flooded, Depth to Sat zone, Too acid	
Manteo	Low AWC, Depth to bedrock, Slope, Erosion	VH RO, VL Irr
Marlboro	Seepage, Slope, Too acid	
Marvyn	Slope, Low AWC, Seepage	
Masada	Slope, Too acid	
Mayodan	Slope, Water erosion, Seepage	
McColl	Depth to Sat zone, Low AWC, Drained	
Mecklenburg	Slope, Slow water movement	
Meggett	Drained, Depth to Sat zone, Slow water movement	
Mimms	Depth to Sat zone, Ponding & Frequent flooding, Seepage	
Molena	Seepage, Low AWC, Slope	SL Sprinkler
Montonia [6/]	Not suitable for irrigation	
Mouzon	Depth to Sat zone, Flooding, Slow water movement, Too acid	VL Irr

Table SC2–20 Irrigation Limitations / Notes and Ratings for South Carolina Soils

Soil Series Name	Limitations / Notes for use with Irrigation System	Ratings
Mullers	Depth to Sat zone, Freq flooding, Too acid, Slow water movement	VL Irr
Murad	Seepage, Depth to Sat zone, Low AWC	SL Sprinkler
Musella	Low AWC, Depth to bedrock, Slope, Water erosion	VL Irr
Myatt	Depth to Sat zone, Too acid, Drained	
Nahunta	Depth to Sat zone, Seepage	
Nakina	Drained, Depth to Sat zone, Too acid	
Nankin	Slope, Too acid, Slow water movement	
Nansemond	Depth to Sat zone, Seepage, Low AWC, Too acid	VH RO, VL Irr
Nason	Slope, Water erosion, Depth to bedrock	
Neeses	Slope, Too acid	
Nemours	Depth to Sat zone, Slow water movement, Seepage, Too acid	SL Sprinkler
Newhan [3/]	Not suitable for irrigation	
Noboco	Seepage, Too acid, Low AWC	
Norfolk	Seepage, Too acid	
Ochlockonee	Seepage, Occasional flooding	SL Sprinkler
Ocilla	Depth to Sat zone, Low AWC, Seepage	
Ogeechee	Depth to Sat zone, Low AWC, Too Acid	VH RO, VL Irr
Okeetee	Depth to Sat zone, Ponding, Seepage, Slow water movement	VH RO, VL Irr
Olanta	Seepage, Low AWC	
Onslow	Depth to Sat zone, Seepage	
Orange	Slope, Depth to Sat zone, Depth to bedrock	
Orangeburg	Slope, Low AWC, Seepage	
Osier	Drained, Frequent flooding, Low AWC	
Pacolet	Slope, Seepage, Water erosion	
Pactolus	Depth to Sat zone, Low AWC, Seepage	
Pageland	Depth to Sat zone, Depth to bedrock, Slope, Water erosion, Too acid	VH RO, VL Irr
Pamlico [1/]	Not suitable for irrigation	
Pantego	Drained, Depth to Sat zone	
Paxville	Drained, Depth to Sat zone, Too acid	
Pelham	Depth to Sat zone, Seepage, Low AWC, Too acid	VH RO, VL Irr
Pelion	Slope, Drained, Slow water movement, Too acid	

Table SC2–20 Irrigation Limitations / Notes and Ratings for South Carolina Soils

Soil Series Name	Limitations / Notes for use with Irrigation System	Ratings
Persanti	Depth to Sat zone, Low AWC	VH RO, VL Irr
Pickens	Low AWC, Depth to bedrock, Slope, Stones	VL Irr
Pickney	Depth to Sat zone, Seepage, Frequent flooding, Low AWC, Too acid	VH RO, VL Irr
Plummer	Drained, Depth to Sat zone, Low AWC	
Pocalla	Seepage, Too acid, Low AWC	
Pocomoke	Depth to Sat zone, Seepage, Too acid	VL Irr
Poindexter	Slope	VH RO
Polawana	Drained, Depth to Sat zone, Ponding	
Ponzer [1/]	Not suitable for irrigation	VH RO, VL Irr
Porters	Slope, Seepage, Depth to bedrock, Water erosion	VL Irr
Portsmouth	Drained, Depth to Sat zone, Root zone restriction	
Prosperity	Depth to Sat zone, Depth to bedrock	
Pungo [1/]	Not suitable for irrigation	
Quitman	Depth to Sat zone, Seepage, Low AWC, Too acid	VL Irr
Rains	Drained, Depth to Sat zone	
Rawlings	Slope, Depth to bedrock	
Red Bay	Seepage	SL Irr
Rembert	Ponding, Depth to Sat zone	VL Irr
Ridgeland	Seepage, Depth to Sat zone, Low AWC	SL Sprinkler
Rimini	Low AWC, Too acid	
Rion	Slope, Too acid	
Riverview	Frequently flooded	
Rutlege	Drained, Depth to Sat zone, Low AWC	
Saluda	Slope, Erosion, Mostly forested	
Santee	Ponding, Depth to Sat zone, Seepage, Slow water movement	VL Irr
Santuc	Depth to Sat zone, Slope, Seepage, Too acid	SP Sprinkler
Saw	Slope, Depth to bedrock	
Scranton	Depth to Sat zone, Low AWC, Seepage	VH RO, VL Irr
Seabrook	Seepage, Low AWC, Depth to Sat zone	
Seagate (**)	Seepage, Low AWC, Depth to Sat zone	
Sedgefield	Depth to Sat zone, Slow water Movement, Slope	
Seewee	Seepage, Low AWC, Depth to Sat zone	

Table SC2–20 Irrigation Limitations / Notes and Ratings for South Carolina Soils

Soil Series Name	Limitations / Notes for use with Irrigation System	Ratings
Shellbluff	Occasional flooding	
Smithboro	Depth to Sat zone, Slow water movement, Slope	VH RO, VL Irr
Springhill	Slope, Low AWC, Seepage	
Stallings	Drained, Depth to Sat zone, Too acid	
Starr	Slope, Water erosion, Seepage	
State	Too acid, Seepage	
Stono	Depth to Sat zone, Seepage	VH RO, VL Irr
Suffolk	Slope, Seepage	
Summerton	Low AWC, Slope	SL Sprinkler
Sunsweet	Seepage, slope	VL Irr
Talladega	Slope, Depth to bedrock, Low AWC, Water erosion	VH RO, VL Irr
Tarboro	Low AWC, Seepage, Slope	
Tatum	Slope, Low AWC, Depth to bedrock	
Tawcaw	Depth to Sat zone, Frequent flooding,	VH RO, VL Irr
Tetotum	Depth to Sat zone, Seepage	VH RO, VL Irr
Thomson	No limitation	
Thursa	Seepage, Slope, Low AWC	
Toccoa	Occasional flooding	
Tomahawk	Depth to Sat zone, Low AWC	
Tomotley	Drained, Depth to Sat zone, Too acid	
Torhunta	Drained, Depth to Sat zone, Frequent flooding	
Totness	Depth to Sat zone, Seepage, Frequent flooding, Low AWC, Too acid	VL Irr
Transylvania [4/]	Not suitable for irrigation	
Troup	Low AWC, Seepage	
Turbeville	Slope	
Uchee	Seepage, Slope, Low AWC	
Udorthents [5/]	Not suitable for irrigation	
Vance	Slow water movement, Seepage, Slope	
Varina	Slow water movement, Seepage, Low AWC	
Vaucluse	Seepage, Slope, Low AWC	
Wadmalaw	Ponding, Depth to Sat zone	VH RO, VL Irr

Table SC2–20 Irrigation Limitations / Notes and Ratings for South Carolina Soils

Soil Series Name	Limitations / Notes for use with Irrigation System	Ratings
Wagram	Low AWC, Slope, Seepage	
Wahee	Drained, Depth to Sat zone, Slow water movement	
Wake [7/]	Not suitable for irrigation	
Walhalla	Slope, Erosion, Mostly forested	
Wando	Seepage, Low AWC, Slope	
Watauga	Slope, Erosion	
Wateree	Slope, Low AWC, Seepage	
Wedowee	Slope, Seepage, Water erosion	
Wehadkee	Drained, Depth to Sat zone, Frequent flooding	
Whistlestop	Depth to Sat zone, Seepage	
Wickham	Seepage, Slope	
Wilkes	Depth to bedrock, Slope, Low AWC	
Williman	Depth to Sat zone, Seepage, Low AWC	VH RO, VL Irr
Winnsboro	Slope, Slow water movement	
Witherbee	Depth to Sat zone, Seepage, Low AWC, Too acid	VH RO, VL Irr
Woodington	Depth to Sat zone, Seepage	VH RO, VL Irr
Worsham	Drained, Depth to Sat zone, Slow water movement	
Wynott	Depth to bedrock, Slope, Slow water movement	
Yauhannah	Seepage, Depth to Sat zone	SL Sprinkler
Yemassee	Depth to Sat zone, Seepage, Too acid	VH RO, VL Irr
Yonges	Drained, Depth to Sat zone, Some flooding	

Some soils are "NOT SUITABLE FOR IRRIGATION" and are shown as "N/A" with a number condition: 1/ organic; 2/ marsh; 3/ beach; 4/ USFS only; 5/ cut and fill; 6/ mountains, and 7/ rock outcropping.

SC soil limitations, notes and ratings are per Selected Reports, as shown below:
VH RO – Very High Runoff from Web Soil Survey (WSS) Water Features Report
VL Irr – Limited for all types of irrigation per WMS – Irrigation General. WMS Irrigation, Sprinkler; & WMS Irrigation Micro
SL – Suitable but somewhat limited for sprinkler irrigation per WSS Soils Features Report

AWC – Available Water Holding Capacity; Sat – Saturated

(**) – denotes soil series in South Carolina which meet the "stratified" definition. All other soils are "homogeneous"