PRELIMINARY

ORDINANCE NO. ____

AN ORDINANCE AMENDING THE CODE OF ORDINANCES OF THE CITY OF CLIVE, IOWA, 2008, BY AMENDING PROVISION OF THE CLIVE POST-CONSTRUCTION STORMWATER MANAGEMENT ORDINANCE

Be It Enacted by the City Council of the City of Clive, Iowa:

SECTION 1. INTERNAL REFERENCES. All references to section numbers in this ordinance shall be to sections contained within Title 8, Chapter 4C of the "2008 Clive Code of Ordinances" unless otherwise specified.

SECTION 2. AMENDMENT. In 8-4C-6, entitled "Postconstruction Stormwater Management Plan (PCSWMP)", subsection A. is hereby amended to read as follows:

A. Every property owner or applicant of a project creating 5,000 square feet or more of impervious surface area, shall design, install and maintain postconstruction stormwater management plan (PSCWMP) facilities as approved by the city council during the site plan, construction drawing and/or platting process. PSCWMP facilities may be required for projects that create less than 5,000 square feet of impervious surface area, if the project is part of a larger plan of development that meets the applicability threshold, even though multiple separate and distinct projects may take place at different times on different schedules.

SECTION 3. AMENDMENT. In 8-4C-6, entitled "Postconstruction Stormwater Management Plan (PCSWMP)", subsection B. is hereby amended to read as follows:

B. An Iowa licensed professional engineer or landscape architect shall design PCSWMP facilities in conformance with the guidelines established in the City of Clive Stormwater Manual, the Iowa Stormwater Management Manual and SUDAS. PCSWMP facilities shall be designed with appropriate BMP's, such as detention and retention basins, soil quality restoration, grass swales, buffer strips, bio-retention and other similar types of infiltration basins and riparian areas, that will convey drainage through the property to one or more treatment areas such that no development shall cause downstream property owners, watercourses, channels or conduits to receive stormwater runoff form the proposed development site a peak flow rate greater than that allowed by the standards in effect at the time of approval of the development.

SECTION 4. REPEALER. All parts of the "CODE OF ORDINANCES OF THE CITY OF CLIVE, IOWA, 2008" in conflict herewith are hereby repealed.

SECTION 5. SEVERABILITY CLAUSE. If any section, provision, sentence, clause, phrase or part of this Ordinance shall be adjudged to be invalid or unconstitutional, such adjudication shall not affect the validity of this Ordinance as a whole or any section, subsection, provision, sentence, clause, phrase or part thereof not adjudged invalid or unconstitutional.

SECTION 6. WHEN EFFECTIVE. This Ordinance shall be in effect from and after its final passage, approval and notice of its passage is given as provided by law.

PASSED AND APPROVED by the City Council on the ___ day of __________, 2016.

Joyce Cortum, City Clerk	Scott Cirksena, Mayor

Ordinance No. ________ authenticated this _____ day of ___________, 2016.

Joyce Cortum, City Clerk	Scott Cirksena, Mayor

Officially posted on the _____ day of __________, 2016, at ______ __.m.

CERTIFIED BY:

Joyce Cortum, City Clerk

PRELIMINARY

CLIVE STORMWATER MANUAL

INTRODUCTION:

The U.S. Environmental Protection Agency's National Pollution Discharge Elimination System ("NPDES") permit program ("Program") administered by the Iowa Department of Natural Resources ("IDNR") requires that cities meeting certain demographic and environmental criteria obtain from the IDNR an NPDES permit for the discharge of storm water from a Municipal Separate Storm Sewer System ("MS4") permit. The City of Clive is subject to the Program and is required to obtain, and has obtained, an MS4 permit (Iowa NPDES Permit Number 77-20-0-02).

The permit authorizes all existing and new storm water point source discharges from all areas within the boundaries of the City of Clive to discharge into waters of the State. Authorization under the permit is subject to the City complying with a Storm Water Pollution Prevention and Management Plan which outlines areas of responsibility for the City to implement Best Management Practices (BMP's):

> **Public Education and Outreach-** Implement public education and outreach about the impacts of storm water discharges and measures which the residents can implement to reduce pollutants in storm water runoff.
>
> **Public Involvement and Participation**- Involve local businesses, developers, homeowners and the general public in the development of the program.
>
> **Illicit Discharge Detection and Elimination**- Enforcement of ordinances that prohibits anything other than storm water, allowable non-storm water, and pollutants for which an NPDES permit issued from entering the City's storm sewer system.
>
> **Construction Site Storm Water Runoff Control**- Enforcement of construction site storm water runoff control program to reduce pollutants in any storm water runoff from construction activities.
>
> **Post Construction Storm Water Management**- Enforcement of post construction storm water management program to control and minimize increases in storm water runoff rates and volumes, soil erosion, stream channel erosion and nonpoint source pollution associated with storm water runoff of developing and developed lands within the City.
>
> **Pollution Prevention and Good Housekeeping**- Implement operation and maintenance programs that shall prevent or reduce pollutant runoff from municipal operations.

It shall be the long term goal of Clive Stormwater Manual to provide a centralized location to find background materials and references to the City of Clive's Stormwater Management Program.

This document is intended to be periodically updated to reflect changes in policy, programs and best management practices as determined by the City Council to be in the best interest of effectively managing storm water with the City of Clive.

POLICIES:

A Soil Management Plan (SMP) shall be a mandatory component of any required Post Construction Stormwater Management Plan (PCSWMP). At a minimum, the SMP will be developed to address both the development mass grading and individual lot construction processes. Specifically, the SMP will contain the following information:

- An analysis of the existing site soil characteristics. It is anticipated that 1 soil boring per acre (minimum of 2 soil borings on sites less than an acre) will be necessary to characterize the quantity and quality (organic matter content) of the soil profile.

- Identify critical areas (wetlands, forest, riparian, stream corridors, steep slopes, hydric soils) that will be preserved and protected.

- Quantify the amount of topsoil to be stockpiled and ensure adequate quantity is available for respread over the proposed final grade (minimum 8" generally and 12" within drainage ways).

- Identify areas where topsoil will be stripped and stockpiled.

- Select which method(s) of Soil Management and Soil Quality Restoration are to be used and identify where they will be employed.

All areas of a project site that have not been covered by impervious surfaces, incorporated into a stormwater management practice, or engineered as structural fill or slopes, shall, at project completion, use one or more of the practices identified in the Iowa Stormwater Management Manual (Chapter 2E-6 Soil Quality Management and Restoration) to achieve the required minimum depth of healthy soil underneath the prescribed vegetation.

The characteristics of a Healthy Soil shall be defined as the following:

Color- Darker, A-horizon with high organic matter content
Texture- Not sticky, lower clay content (less than 25%),
Structure/Consistency- Granular, loose, friable (bulk density less than 1.6 gm/cm^3)
Organic Matter- Organic matter content of at least 5.0 percent
pH- between 6 and 8

City inspectors shall verify that the SMP has been complied with during completion of each construction process. City inspectors will utilize a soil probe/shovel to verify depth, Dickey-john tester to verify soil compaction and ribbon test to verify clay content. A reading of less than 200 psi on the soil compaction tester will be required. Ribbon test results should be less than 2"

If the developer/homebuilder disputes the findings of the City inspector, the developer/homebuilder may have the site soils tested by a certified soil testing laboratory. One sample per acre (development phase) or two samples per lot (commercial building/homebuilding phase) will be deemed adequate to demonstrate compliance.

Methods (1 through 7) are outlined on pages 11-14

2E-6 Soil Quality Management and Restoration

BENEFITS Low = <30% Medium = 30-65% High = 65-100%			
Reduction of:	Low	Med	High
Suspended Solids	■	■	■
Nitrogen	■	■	
Phosphorous	■		
Metals	■	■	■
Bacteriological	■	■	■
Hydrocarbons	■	■	■

Description:
Soil quality management preserves and protects intact soil profiles. Soil quality restoration (SQR) reduces compaction, increases pore space, improves organic matter content, and re-establishes populations of soil dwelling organisms (microbes, worms, insects, etc.) on soils disturbed during construction.

Typical uses:
- Preservation of intact soil profiles
- Restoration of disturbed soils as part of final grading and stabilization of construction sites.
- Incorporation into lawn care management practices on established landscapes.

Advantages/benefits:
- Reduces stormwater runoff volume.
- Protects water quality by infiltrating and processing pollutants in stormwater runoff.
- Reduces the need for irrigation by increasing water holding capacity and water availability.
- May reduce the need for fertilizers and pesticides.

Disadvantages/limitations:
- Access to soil restoration services may be limited.
- Access to compost may be limited.
- May increase development costs.

Maintenance requirements:
- Annual applications of compost amendments is recommended (but not required).
- Lawn clippings should not be removed, as they decompose they add organic matter.
- Pesticide use should be minimized to maintain healthy populations of earthworms, soil dwelling insects, and soil microbes.
- Strategic use of native landscaping should be considered, as opposed to cool season grasses to maintain and enhance soil quality over time.

A. Description

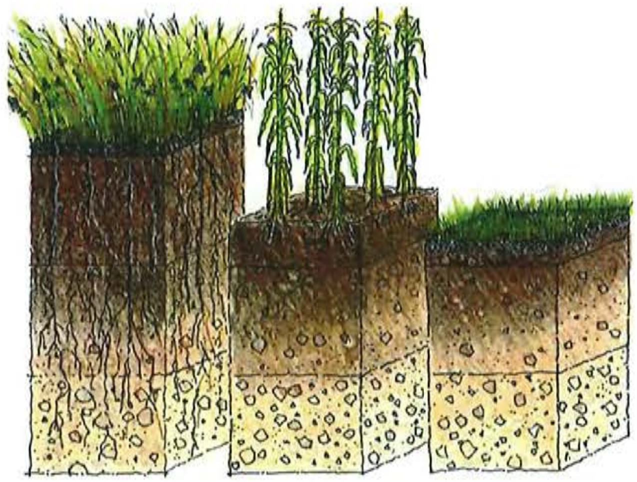
Chapter 2A-1 details how land disturbing activities generates additional surface runoff. Creation of impermeable surfaces (rooftops, pavements and other hardscapes) and compaction of soils through grading activities limit the ability of the landscape to infiltrate water during rainfall events. Grading and compaction of the landscape are the primary reasons land development activities increase the volume and rate of stormwater runoff. If soil compaction is a major component in the increase of runoff volume, then restoring soil to better allow rainfall to infiltrate and percolate through the soil profile is a key method to reduce runoff.

Prior to settlement, Iowa soil within the native tallgrass prairie landscape had an 8-10% organic matter content. Rain infiltrating into the historic landscape moved slowly through the soil profile to emerge down-gradient as cool, clean groundwater discharge that fed and maintained stable, clean streams, rivers, wetlands and lakes. A healthy soil profile with 50% pore space should be able to infiltrate anywhere from 0.6 inches to 2 inches of water per hour into the soil profile. The water-holding capacity of most prairie soils should be around 0.2 inches of water per inch of soil profile. Therefore, a soil at field capacity with 50% pore space should be able to store a minimum of 2.4 inches of rainfall in the upper 12 inches of the soil profile.

Today, due to tillage-based agriculture and urban land development, many Iowa soils have only 4% soil organic matter (SOM) content or less. Most Iowa soils have about 2% SOM. Organic content can be even less where topsoil has been stripped and exported from development sites. Such soils have lost 60-80% or more of their ability to absorb, infiltrate, and store rainfall.

Undisturbed soils have layers or horizons that form over hundreds of years. Prairie soils have a surface O-horizon that is thin and contains a high concentration of SOM from decayed vegetation. The next layer, the A-horizon is what many refer to as topsoil. It is rich in SOM giving it a darker color and has less clay compared to subsurface horizons. The next is the B-horizon that has a higher clay content and lighter color than the A-horizon. The C-horizon or lowest horizon consists of the parent material in which the soil has been formed such as glacial till, or wind-blown deposits. Figure 1 shows the differences in soil profiles between prairie, corn and urban turf. The O-horizon that once appeared in the prairie soils has been either oxidized or eroded away due to modern agricultural practices as shown beneath the corn soil profile.

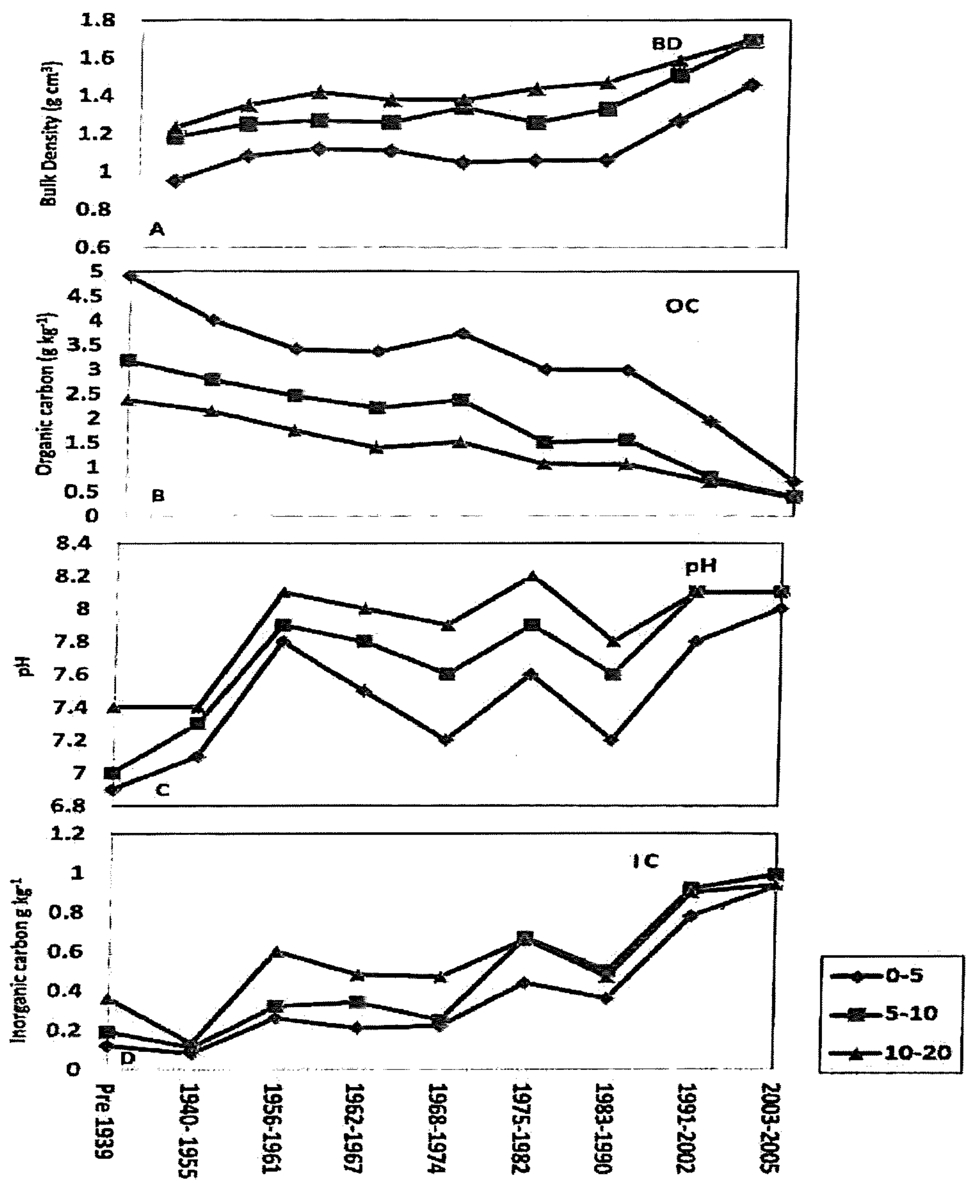
Figure 1. (L to R) Prairie soil profile, soils under modern agriculture and soils after urban development under turf grass.



Compaction of site soils through urban development have an NRCS curve number of nearly 90 (see open space, poor condition, soil group D; Table 2, Section 2C-5). Compare that with soils, with little to no compaction, where curve numbers of 40-60 may be expected (see open space good/fair condition, soil group A/B; same table). Consequently, heavily graded urban green space is typically "hydrologically dysfunctional," and the ability of these landscapes to absorb and infiltrate water is extremely limited.

Figure 2 provides results of research conducted in Ankeny, Iowa by Iowa State University that shows changes in soil quality indicators, bulk density and organic carbon, over time with changes in development practices. Bulk density, or the mass per given volume, is a measure of the compaction of soils. Organic carbon is related to organic matter content. Figure 1 shows bulk density has increased with time and organic carbon content has decreased with time. These marked changes began occurring in the 1980s onward when topsoil was being stripped and not replaced from sites and more mass grading and on-site vehicular traffic became common.

Figure 2. Variation of (A) bulk density (BD), (B) organic carbon (OC), (C) pH, and (D) inorganic carbon (IC) values in soils by period of development of Ankeny, Iowa at depths of 0-5, 5-10, and 10-20 cm (A. Langner, Manu, A. and Nath D., SSSAJ, 2012)



The goal of soil quality management and restoration (and other infiltration-based stormwater management practices) is for urban landscapes to mimic the hydrologic functionality of the native pre-settlement landscapes, at least for the more commonly occurring small storm events. This is achieved through the protection or creation of soil profiles having at least 40% pore space, 2% (3-5% preferred) organic matter content, and a healthy population of soil microbes and other species of soil dwellers.

To reduce the effects of SOM loss and soil compaction, minimize mass grading activities. The first step in site design should be a review of site conditions prior to preparing a conceptual layout. Topography, existing soils, including soil depth and organic matter content, drainage paths, watershed boundaries, delineated wetlands and flood hazards should all be considered *before* site design begins. (Refer to Part F of this section for further details)

Soil quality is best maintained by minimizing the area impacted by construction. A designer should use the information gathered during the site review to determine ways to lay out the proposed development so the most permeable soils are preserved and the area disturbed or compacted by construction is reduced as much as possible. A "building envelope" should be delineated to confine grading activities, construction traffic, stockpiling of materials, and other construction activities within a defined area. An additional benefit to this step could be reduced grading and infrastructure development costs.

Where land disturbing activities are necessary, soil quality restoration (SQR) should be performed as part of final landscaping, prior to seeding or installation of sod. For single-family residential developments, this will generally be accomplished on a lot-by-lot basis after all construction activities are complete.

Foundation and basement excavation generates soil stockpiles, which along with other building activities can compact soils on a large portion of a typical residential lot. Soil conditions worsen when basement excavated subsurface soils are spread over the lot, prior to re-spreading topsoil.

When SQR techniques are used to counteract soil compaction, the soil profile under green space areas will be a water management and water storage resource. Locate pervious areas strategically so that stormwater runoff can be dispersed across it via sheet flow, where and when possible.

B. Stormwater management suitability

Where green space is limited, or transitioning runoff to sheet flow is not possible, another BMP will be necessary to manage stormwater runoff (ISWMM Part 2B).

The water quality volume may be managed on site with significant green space, when deep tillage practices are used. Runoff volume reductions for larger storms can be modeled through appropriate reductions in NRCS curve numbers by accounting for open spaces with higher quality soils and vegetation.

C. Pollutant removal capabilities

Good soil quality will generally provide for the capture of most of the major pollutants of concern, and would be comparable to bioretention for pollutant removal. Hydrocarbons, bacteria, sediment, metals, and other pollutants are generally captured in the top part of the profile when runoff is infiltrated. A healthy microbial population will degrade and utilize many of the pollutants as a food source. A pollutant, such as nitrogen moving in solution could move past the root zone of turf landscapes with high percolation rates. Incorporating strategic native landscaping along with soil quality restoration is recommended for increased evapotranspiration and more nutrient uptake.

D. Application and feasibility

Some component of SQR is applicable to almost all Iowa soils. Conditions such as hydric soils and surface ponding could render SQR not feasible. A hydric soil is permanently or seasonally saturated to cause anaerobic conditions in the upper part of the soil. Development on sites with hydric soils or surface ponding is discouraged as part of Low Impact Design due to the inability to infiltrate stormwater and generally because hydric soils are unsuitable for dwellings and other structures.

The potential infiltration and storage capacity of healthy soils makes an infiltration-based and groundwater driven hydrology feasible, which was the case back when the prairies and other native ecosystems were intact. If this type of a hydrology for 90% or more of rainfall events in Iowa can be replicated, then the potential for water quality enhancement and stabilization of stream flows seems quite feasible, as well.

E. Planning and design criteria

A soil management plan (SMP) should be created for each new development. It should be created and initiated before any site layouts or designs are prepared, and it should be modified as the design process continues. Soil management plans are needed to treat landscapes as mass grading is completed and infrastructure is installed. A SMP will be needed as well for individual lots.

Table 1: Process for developing Soil Management Plans (SMPs)
1. Investigate existing site soil conditions. 2. Identify areas where soils and vegetation will not be disturbed on a site map or scale drawing as part of Contract Documents or site Storm Water Pollution Prevention Plan (SWPPP). 3. Identify areas where topsoil will be stripped and stockpiled on a site map or scale drawing. 4. Select which method(s) of Soil Management and Soil Quality Restoration are to be used and identify where they will be employed. 5. If using tillage for Soil Quality Restoration (SQR) then determine the depth of tillage and provide recommendations for suitable moisture conditions. Tillage of wet soils can cause smearing. 6. Determine and quantify types and amounts of materials needed to complete SQR requirements. 7. Specify methods for establishing permanent vegetative cover (i.e. sodding, seeding rates). 8. Incorporate SMP into site specific SWPPP if one is required to be implemented from initial disturbance to final stabilization.

Step 1. Prior to site design, soils information from resources such as county soil maps, geotechnical reports or other available data should be reviewed. Identify areas expected to have higher quality soils with intact soil layers. If possible, determine the type, quality and organic content of topsoil available on site. County soil map information can be viewed through the USDA at the following link:

http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Step 2. First and foremost, areas having higher quality soils should be protected. By minimizing land-disturbing activities, soil profiles are left intact and compaction does not occur. Compaction, which increases bulk density and reduces pore space, is a primary culprit in the creation of hydrologically dysfunctional landscapes. During preliminary site design, orient improvements to minimize disturbance of higher quality soils. Plan grading activities to avoid compacting, filling or deep tilling under the drip line of any trees that are intended to be saved.

Step 3. Stripping and removing topsoil is another key aspect of post-construction soil quality problems. Topsoil contains organic matter that is the key to soils being able to absorb water. Soils with 2% or greater organic matter have the ability to absorb water like a sponge; lower than 2% and soils will absorb less rainfall, generating runoff quicker. Existing topsoil should be stripped, stockpiled and returned as part of final grading. Topsoil may need to be amended with compost to achieve the desired organic matter content of a minimum of 2%.

The SMP should identify where topsoil is to be removed, stockpiled and replaced. Stockpiles may need to be stabilized with temporary seed and mulch during construction and protected by perimeter sediment control measures (identified on the SWPPP and/or grading plan).

Step 4. Where land-disturbing activities cannot be avoided, SQR should be performed as part of final grading. Scarification and tillage should be done to a depth specified in the SMP.

Step 5. On sites where the majority of the landscape will be left as open space, deep tillage depths may be specified to address the water quality volume treatment requirements for adjacent open space. This is described in more detail later.

Step 6. Based on the selected method of SQR, the SMP needs to quantify the amount of materials (i.e. imported topsoil, compost, etc.) necessary to complete the work. Incorporate these quantities into the overall quantity estimate and/or bid documents for the project.

Step 7. Select the type of permanent stabilization to be provided for all disturbed areas (i.e. sodding, seeding, native turfgrass, lawn, etc.). The area where each measure is to be applied should be identified on at least one of the following: landscaping plan, seeding plan, or site schematic plan as part of the SWPPP; and quantified within the overall quantity estimate and/or bid documents for the project.

Note: Methods of SQR and vegetation establishment included within the SMP should be considered "non-structural practices" which are required to be identified within a SWPPP, when one is prepared. If a given project meets state or local thresholds that require a SWPPP to be prepared for a given site, the SMP needs to be made part of the SWPPP, either as an attachment or incorporated into the SWPPP.

Table 2: SQR design components, new construction	
Topsoil	Refer to SUDAS Section 2010 for definition of topsoil. Topsoil used for SQR should contain or be amended to contain a minimum of 2% organic matter content.
Tillage Depth	Compacted soil should be tilled to a specified depth based on the SQR method to be employed at a given site. Selecting the method of SQR depends on quality and availability of topsoil, subsoil properties and if WQv is intended to be managed for adjacent impervious areas. Use ripping tillage tools for deep tillage.
Soil Moisture Conditions	Do not remove or respread topsoil or perform tillage operations when soils are wet.
Compost Application	Apply compost as specified in soil management plan to achieve a minimum of 2% organic matter content. Apply compost before deep tillage to incorporate organic matter into the soil profile. Refer to later portions of this section for application rates.
Sand	Sand may be used to alter soil texture and increase infiltration/percolation rates.
Native Landscaping	Native landscaping with prairie or woodland grasses and forbs or native turf is encouraged, as they often have deeper, root systems that improve soil porosity and enhance runoff reduction by infiltration and transpiration.
Runoff from Adjacent Impervious Areas	Concentrated flows must be avoided. Disperse runoff from impervious areas across the SQR area in sheet flow, using a level spreader or other means to evenly distribute runoff across the treatment area.

Table 3: SQR design components, existing vegetation	
Aeration	Deep tine or deep plug aeration, do not perform aeration after a rain or on wet soils.
Compost Application	Apply a 1/2-3/4 inch layer of compost over aerated lawn.
NOTE: Direct stormwater runoff toward areas with restored soil quality. Disperse runoff as much as possible to discourage concentrated flow into one area and encourage sheet flow across the entire amended area.	

F. Design procedures

For all projects a SMP should be created. Refer to Part E and Table 1 of this chapter for guidance in developing the SMP. The SMP should detail one or more of the following methods for restoring soil quality and identify where these methods will be employed. The SMP should be included within the Storm Water Pollution Prevention Plan (SWPPP) for any site where one is required. (The SMP details methods to preserve or enhance soil health, which would be a non-structural stormwater management practice, required to be detailed within a SWPPP.)

For the purpose of this section, a healthy soil profile is defined as an A-horizon with a depth of at least 8 inches underlain by intact B- and C-horizons, meeting the following requirements:

i. Soil from an A-horizon with a clay content less than 25% meeting the definition of off-site topsoil as per SUDAS Section 2010-2.01-C.

ii. Soil does not have a bulk density that exceeds 80 lb/ft (1.3 gm/cm^{3}) (Michael J. Singer and Donald N. Munns. Soils and Introduction. 1987, Macmillan Publishing Company, New York) (Edward J. Plaster. Soil Science and Management. 2009, 5th Edition, Delmar, Clinton Park, New York)

iii. Soil is not hydric and has at least 2 feet of separation from normal high water table.

iv. A healthy soil profile could also have less than 8 inches of undisturbed topsoil with good structure and still meet the definition of a healthy soil profile if it has percolation rates of 1 inch/hour or more. It would need to meet the hydric guidance above.

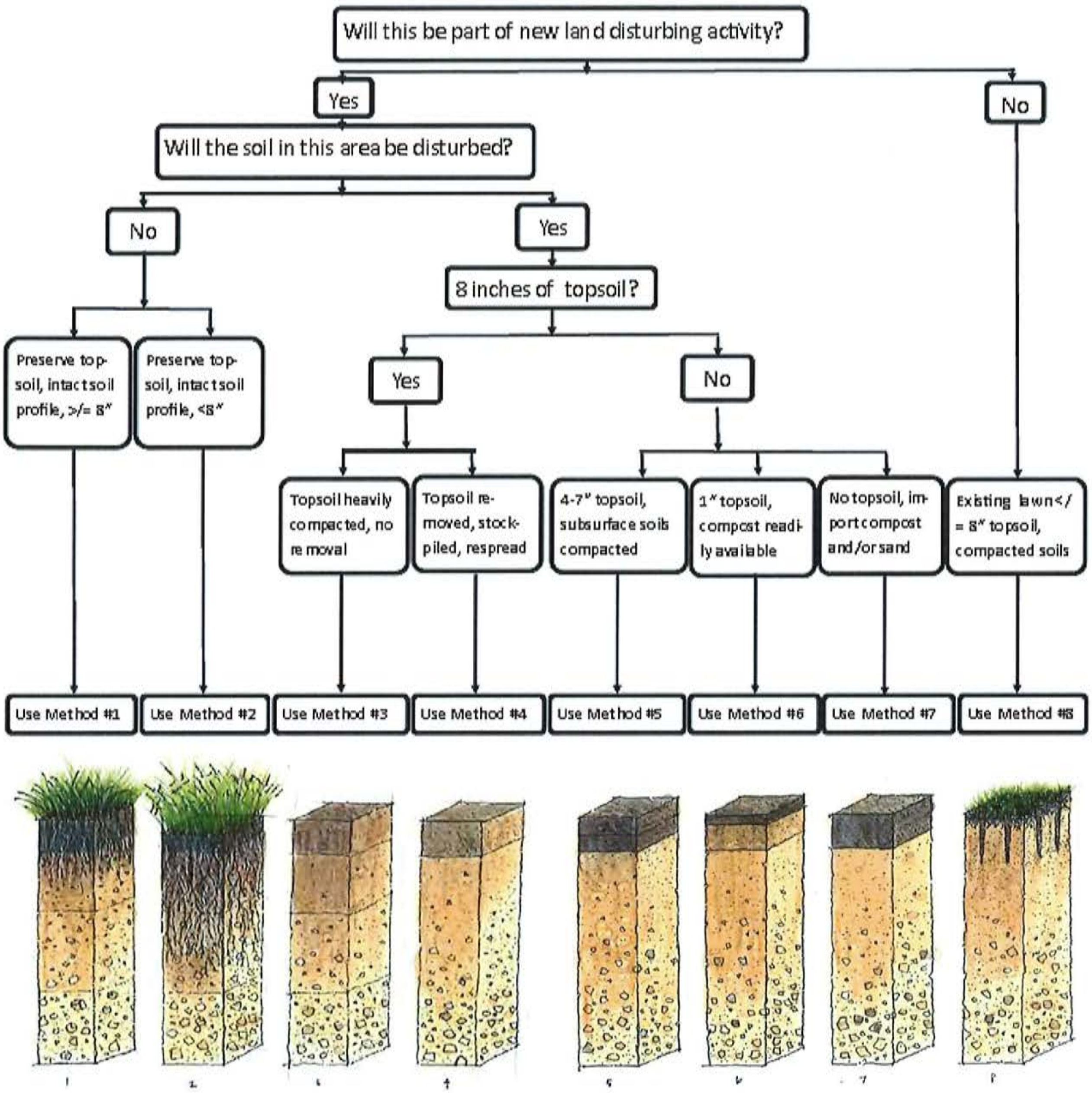
Prior to preparing a conceptual layout or site design, review sources of information to identify soil and determine existing soil conditions by reviewing county soil maps, geotechnical reports or field visits. Areas shown as Hydrologic Soil Groups “A” or “B” are best candidates for preservation (see Section 2C-5, page 4 for more information on soil groups).

Additional studies or testing is required to verify the presence of healthy soils. Geotechnical studies, coring or soil pits and percolation tests can be used to evaluate these properties. Soils determined to meet the definition of “healthy” as stated above should not require amending. Verify that at least the upper 8 inches of the soil horizon meets the definition of healthy soil.

Consider location of identified healthy soils in initial site design. Design should layout proposed improvements to avoid disturbing or compacting healthy soils as much as possible. Final design plans and the site SMP should identify which areas are to be preserved using this method. Both the design plans and SMP should note the method of protecting these areas (i.e. construction fence, etc.) to prevent them from being disturbed or compacted by tracking or storage of materials.

The following decision chart can be used to determine the appropriate methods to use for site conditions.

Figure 3: Decision guide for selecting soil management and soil quality restoration methods.



Soil Management on Undisturbed Sites

The goal of all methods is to maintain or create 8 inches of healthy soil profile. When tillage is performed, do not till wet soils (If ruts from equipment traffic form then the soils are too wet).

Method 1. Preserve existing healthy soil profile: Identify areas where healthy soils will not be disturbed and protect them from compaction.

Purpose: This method is intended to preserve areas determined to have a healthy A-horizon to a depth of at least 8 inches with a B- and C-horizon that appear to be intact. Prior to any site design, available information shall be reviewed to determine existing soil conditions. Geotechnical studies, coring, soil pits or other soil tests shall be performed on-site as needed.

Method 2. Preserve undisturbed areas that have intact A-, B- and C-horizons where the topsoil may never have developed to a depth of 8 inches but due to good soil structure and adequate porosity have a Hydrologic Soil Group of A or B and have percolation rates of 1 inch per hour. (Sandy soils or timber soils may never have developed an eight inch deep A-horizon but may have adequate infiltration and percolation rates to manage the WQv).

Purpose: This method is used where intact native soils have the ability to infiltrate and percolate the water quality volume even though the A-horizon may not be 8 inches.

Soil Quality Restoration on Disturbed Sites

Method 3. Eight inches or more of topsoil is present but compacted by land disturbing activities.

Purpose: This method is intended to restore at least 8 inches of compacted A-horizon soils to its previous, uncompacted, functioning state.

Procedure:

i. Topsoil used for SQR must meet the definition of a healthy soil and have an organic matter content of 2% or greater.
ii. Till disturbed, compacted area to a depth of at least 8 inches to achieve a bulk density that does not exceed 80 lb/ft^3 (1.3 gm/cm^3)

Method 4. Stockpile topsoil, respread 8 inches of topsoil.

Purpose: This method is applied where healthy topsoil is present at a site prior to construction, but is stripped, stockpiled and respread following construction.

Procedure:

i. Topsoil used for SQR must meet the definition of a healthy soil or be amended to have an organic matter content of 2% or greater.
ii. Site soils should be stripped and stockpiled in an approved location identified in the SMP. The SMP should identify the depth of the topsoil layer to be stripped and replaced. Stripping and stockpiling should occur before other site grading or construction activities are initiated to keep topsoil separate from lower horizon soils.

iii. Soil stockpiles should be protected by appropriate erosion and sediment control measures, identified within the SWPPP. Test stockpiled soils to determine if compost amendments will be required to achieve the desired organic matter content.

Method 5. Combination of 4-7 inches of topsoil and tillage to achieve an 8 inch soil profile depth.

Purpose: Use a combination of tillage and spread a minimum of 4 inches of topsoil or a blend of topsoil and compost to create an 8 inch soil layer.

Procedure:

i. Till or scarify the upper surface of the existing soil to a depth of 1-4 inches prior to placement of topsoil.
ii. Spread 4-7 inches of either a topsoil or topsoil /compost blend over the prepared area, as per SUDAS 2010, Part 3.02.C. Do not place wet topsoil.
iii. Perform tillage to a minimum depth of 4 inches to address compaction caused by topsoil placement.

Table 4: Recommended tillage, topsoil and compost depths for soil quality restoration to get 8 inches of healthy soil that includes 4 inches of topsoil.

Method	Tillage Depth (Inches)	Topsoil Depth (Inches)	Compost Depth (Inches)
5	1	7	0
5	2	6	0
5	3	5	0
5	4	4	0
6	6	1	1
7	8	0	2

Method 6. Compost amended and blended topsoil applied as surface blanket over tilled subsoil.

Purpose: Use when there is not enough topsoil onsite and/or compost readily available. Use 1 inch of compost in place of 3 inches of topsoil. The equivalent of four inches of topsoil can be achieved through a blend of 1 inch of topsoil and 1 inch of compost. This soil blend is spread as a surface blanket over 6 inches of tilled subsoil to result in an 8 inch healthy soil profile.

Procedure:

i. Till or scarify the upper surface of the existing soil to a depth of 6 inches prior to placement of topsoil and compost blend. Do not till wet soils.
ii. Spread 2 inch soil blend as a blanket over the tilled subsurface soils. Do not place wet topsoil and compost blend.
iii. Minimize recompaction when spreading the compost/topsoil blanket.

Method 7. Create an engineered healthy soil onsite where topsoil is absent by importing compost and/or sand.

Purpose: Use when healthy topsoil is absent at a site prior to construction, or topsoil is exported because space is not available to stockpile stripped topsoil.

Procedure:

i. Upon completion of site grading and construction activities, the area where soil is to be amended should be inspected. The surface should be free of any debris and stones larger than 1 inch in diameter (1/2 inch if permanent vegetation is to be turf grass). Remove smaller rocks or gravel if they densely cover the surface in a given area.

ii. Spread 2 inches of compost prior to tillage.

iii. Sand may be added to change the texture of topsoil to increase infiltration and percolation rates. Refer to Section 2E-1, Part E for additional information. If sand is to be added, spread a minimum of 1 inch or calculate the depth of sand by volume required to change the soil texture class to at least that of a loam or sandy loam soil (Section 2E-1, Table 1 and Figure 4). Sand should be added in a uniform layer before tillage. Refer to Table 5 on recommended additions based on soil texture. It is recommended to test site soils to determine actual sand application rates, which should be less than those listed in the table below. Alternatively, sand and compost can be mixed elsewhere prior to spread and then spread and tilled.

iv. Incorporate the compost and/or compost and sand blend through tillage to a minimum depth of 8 inches. Upon completion, remove any clods, lumps, roots, litter or other undesirable material, or any stones larger than 1 inch in diameter (1/2 inch if the permanent vegetation is to be turfgrass).

v. Alternatively, sand and compost can be mixed elsewhere then spread and tilled in.

Table 5: Estimates of Sand Amendment Rates Required to Change Texture Class

Soil Texture Class	Silt* %	Sand* %	Clay* %	Amendment Rate (CY sand / CY original material)
Sandy Loam	30	50	20	None
Loam	50	23	27	None
Silt Loam	68	5	27	0.35 / 1.00
Sandy Clay Loam	19	44	37	0.80 / 1.00
Clay loam	40	19	41	0.50 / 1.00
Silty clay loam	54	5	41	0.50 / 1.00
Sandy clay	5	39	56	1.75 / 1.00
Silty clay	40	5	55	1.75 / 1.00
Clay	5	5	90	3.50 / 1.00

** Based on ISWMM Section 2E-1, Figure 4 using percentage values for a given soil requiring the greatest amount of sand amendments to make soil act as a sandy loam or loam textural class Hydrologic Soil Group "B".*

Method 8. Enhance Soils under Existing Vegetation. Use aeration and compost applications to make existing soils and vegetation able to absorb the WQv.

Purpose: Use to improve soil quality to support existing vegetation and reduce runoff from open space areas. This method will provide for the capacity for the landscape to absorb the WQv, but is not intended to address WQv requirements for adjacent hard surface areas.

Procedure:

i. Mow existing vegetation to a height of approximately 2 inches.
ii. Aerate to a depth of 4 inches (6 to 8 inches preferred).
iii. Apply ½ – ¾ inch compost blanket over the mowed area.
iv. Apply seed as specified or incorporate seed into the compost blanket if using a pneumatic blower.
v. Water twice daily (morning and evening) until vegetation is established.

G. Water Quality Volume Management Guidelines

The recommended approach to determining the available soil water storage is based on research conducted by Hudson (1994) that provides data on the relationship between available soil water and percent organic matter in soil. Data collected in this research included soils information on samples collected from Iowa. Hudson's research shows that the higher the organic matter content, the greater the available storage capacity of the soil. Essentially, soils with higher organic content have greater ability to swell like a sponge, retaining more water within their pore spaces. Data from the Hudson study can be used to determine the available water storage characteristics for soils which have been preserved or where SQR techniques have been applied. This can be used to determine the depth of soil with a given organic matter content needed to manage the WQv.

If the organic matter content of a soil is known, Table 6 can be used to determine the available water storage for every inch of depth for the restored or preserved soil profile. From that, it projects the available storage within soil profiles of 4, 6 and 8 inches. This table is based on the Hudson research, which included soils with a a silt loam texture and a bulk density of 1.25 gm/cm^3 (78.0 lb/ft^3).

Table 6: Amount of available water storage in healthy soil profiles based on percent organic matter content. Data is based on research conducted by Hudson (1994).
Assumes bulk density of 1.25 gm/cm^3 and silt loam texture.
Available Water Content (AWC = Field Capacity – Permanent Wilting Point);
AWC = Theta * 100; Theta = Volumetric Water Content

%SOM by weight	Bulk Density (gm/cm3)	Available Water Storage (in/in soil)	Available Water Storage (in/4 in soil)	Available Water Storage (in/6 in soil)	Available Water Storage (in/ 8 in soil)
1	1.25	0.13	0.52	0.77	1.03
2	1.25	0.17	0.66	1.00	1.33
3	1.25	0.20	0.81	1.22	1.62
4	1.25	0.24	0.96	1.44	1.92
5	1.25	0.28	1.11	1.66	2.22
6	1.25	0.31	1.26	1.88	2.51
7	1.25	0.35	1.40	2.11	2.81
8	1.25	0.39	1.55	2.33	3.10

There are a few things to keep in mind while using Table 6:

1. To properly use this table, you will need to know the organic matter content for a given soil. Since evaluation and design will be occurring before construction the content for the future restored soils will usually be unknown. An assumed value will need to be used that is supported by actual soil data collected from the site. This value will need to be verified by post-construction testing. Care should be taken in making this assumption, as if testing shows that the assumed value has not been achieved, additional SQR measures will be needed to meet the selected value, or other BMPs will be needed downstream to address the volume of runoff not addressed by this practice.

2. The column in orange can be used to calculate the available water storage for a soil of any depth, by selecting the value for a given organic matter content (%SOM) and multiplying it by the depth of the soil profile in inches.

3. Remember that the first 1.25 inches of water storage are needed to address the volume of rainfall that falls directly onto the preserved or restored area. When the available storage exceeds this value, there is surplus storage which can be used to manage the WQv requirements of adjacent areas, when their runoff is to be directed across the preserved or restored area. (Profiles with such conditions are highlighted in light blue in Table 6.) Refer to following pages for section titled "Guidance on Using Preserved or Restored Areas to Manage WQv for Adjacent Areas".

   For example: An 8 inch soil profile known to have 6% OM has 2.51 inches of available storage. The first 1.25 inches of storage will absorb rainfall from the 1.25 inch WQv event. That means that 1.26 inches of storage remain available to absorb runoff to that soil profile from outside areas.

   Organic matter content at a given site may be unknown, or soils may either be compacted or lack adequate organic material to meet WQv requirements. In such a case, the following guidelines may be applied to use compost as a SQR technique to improve the water storage capacity of a soil profile.

Table 7: Water volume managed based on disturbed soils amended with compost. Assume a soil bulk density of 2 gm/cm^3 (120 lb/ft^3) for soil material (compacted subsoil or B-horizon).

Soil (in) /Compost (in)	Weight Soil (lb)	Weight Compost (lb)	Total Weight (lb)	% OM	Water Volume Managed (in)
7/1	70	3.7	73.7	1.5	1.2
6/2	60	7.4	67.4	3.2	1.7
5/3	50	11.1	61.1	5.5	2.4
4/4	40	14.8	54.8	8.1	3.2

Guidance on Using Preserved or Restored Areas to Manage WQv for Adjacent Areas:

As noted previously, when it can be verified that there is storage capacity in a given soil profile which exceeds the 1.25 inch WQv rainfall depth, there is an opportunity to manage runoff from adjacent areas. Flow from upstream areas could be directed to the preserved or SQR area, in a manner which would allow that runoff to infiltrate into the healthy soil profile. This allows these areas to act as stormwater Best Management Practices (BMPs) for managing the WQv requirements for such adjacent areas.

If this is the intent of a given design, the following requirements should be met:

1. Install and maintain appropriate site and perimeter controls to prevent sediment discharge from the adjacent construction areas to the BMP during construction.

2. After construction, provide for adequate separation between any impervious surfaces and the BMP area for a pretreatment buffer.

3. To act as a BMP for managing runoff from adjacent areas, runoff needs to be distributed evenly as sheet flow across the area to be counted as a BMP so it can infiltrate into the soil profile.

    i. For smaller applications (runoff from adjacent residential roofs, open spaces without SQR and small impervious areas) careful grading at the point of entry can be used to spread out flows.

    ii. For larger areas, it may be necessary to employ a level spreader or other structural method to convert concentrated flow to sheet flow or to prevent runoff from following a concentrated path of flow into the BMP.

    iii. The finished surface of the BMP area should be graded as such that flow to be treated will spread out across it. Flow should remain as sheet flow and not concentrate into low points or swales.

    iv. There can be larger areas preserved or where SQR is applied, but only those areas where sheet flow will pass over the finished surface should be counted as a BMP towards treating the WQv for adjacent areas.

4. To reduce flow velocity, minimize erosion and promote infiltration, the slope within the BMP area being counted toward WQv treatment should not exceed 6%.

5. The BMP area will need to be verified to have healthy topsoil to the desired depth and organic matter content needed to manage the WQv. Refer to Part I, "Construction Observation and Verification Requirements" within this Section.

If items 1-5 above are satisfied, the BMP area will be able to manage part or all of the WQv requirements for adjacent areas. The following table shows the relationship between the excess water storage volume in a soil profile to the size of an adjacent impervious surface which can be managed by the BMP in order to meet 100% of the WQv requirements for the adjacent impervious area. Keep in mind that open space areas without preserved healthy soils or where SQR techniques have not been applied to a depth of at least 4 inches should be treated as if they were 50% impervious (such areas will generate runoff during the WQv event which will need to be treated.

Table 8: Minimum BMP Area Ratios to Fully Manage WQv

Excess Water Storage Volume (inches)	**Multiply BMP Area by This Factor to Determine Maximum Impervious Area to be Treated**
0.50	0.42
1.00	0.84
1.25	1.05
1.50	1.26
2.00	1.68

Note the following when using Table 8:

1. Excess water storage is determined by finding the available water storage in a soil profile and subtracting 1.25 inches (the rainfall depth for the WQv event, which falls directly onto the BMP area).

2. Areas determined to have excess water storage volume, but that don't meet conditions 1-5 listed prior to Table 8, should not be included as part of the BMP area used to treat runoff from adjacent areas.

3. Upstream open spaces where healthy soils have not been verified and preserved or where SQR techniques have not been applied should be treated as 50% impervious area.

4. The relationship in Table 8 may be calculated for any value, by dividing the excess water storage volume by 1.1875 inches (runoff from a impervious surface generated by the 1.25 inch WQv event).

   For example: A soil profile for a 10,000 square foot SQR area has been found to have 1.40 inches of excess storage volume.

   = 1.40 inches / 1.1875 inches = 1.18

   The upstream impervious area to be treated by the BMP can be up to 1.18 times as large as the BMP area. 1.18 x 10,000 SF = 11,800 SF. Therefore, the SQR area in this example can manage the WQv for 11,800 SF of upstream impervious area.

Guidance on Partial Credit for Managing WQv with These Techniques:

In cases where a preserved or SQR area to be used as a water quality BMP does not have sufficient area to fully manage the WQv for the upstream impervious area, partial credit may be given. In such a case, other practices will need to be distributed elsewhere on site to fully meet the WQv requirements. This can be done by calculating the WQv stored by the BMP, and determining the remaining volume to be addressed by other practices.

For example: A soil profile for a 10,000 square foot SQR area has been found to have 0.50 inches of excess storage volume. It receives runoff from 8,000 square feet of impervious surfaces, 4,000 square feet of compacted open space and 5,000 square feet of verified healthy open spaces which have been preserved.

1. The effective impervious area within the watershed of the SQR will be:

   8,000 SF + (4,000 SF x 50%) + (5,000 SF x 0%) = 8,000 + 2,000 + 0 = 10,000 SF

2. Calculate the required WQv for the adjacent impervious area (refer to Section 2C-6):

   Rv = 0.05 + 0.009 (I) = 0.05 + 0.009 (100) = 0.95

   WQv = Rv x 1.25 inches = 1.1875 watershed inches

   = 1.1875 inches x 10,000 ft2 / 12 inches per foot = 990 ft3

3. Determine the available water storage within the SQR area to serve as the BMP:

   = 10,000 SF x 0.50 inches / 12 inches per foot = 417 ft3

4. Determine the difference between available storage and required volume:

   = 417 ft3 – 990 ft3 = - 573 ft3

Therefore, 573 cubic feet of treatment volume would need to be provided by another practice within the site, in order to meet the site's WQv requirements.

Should there be found to be excess storage available within a given BMP, that surplus should not be used to offset for other impervious surfaces whose runoff leaves the site without measures to address the WQv. Having surplus storage in one area, will not offset the effects of allowing runoff from other areas to leave the site without treatment.

H. Stormwater Modeling Guidelines

Providing healthy soils through preservation or SQR techniques should reduce the amount of runoff generated from that area for all storm events. Conversely, leaving soils in a compacted condition or with a lack of organic matter will likely increase runoff volumes. This section provides guidance on how to apply these principles in stormwater modeling.

Rainfall losses (the amount of rainfall not converted into runoff) can be estimated by the proper selection of curve numbers. These curve numbers (CNs) should be selected based on the Hydrologic Soil Group listed in the County soil survey for the given area, unless site tests indicate another soil group should be used. For open spaces they should also be selected based on the cover type and based on the criteria below:

No Preservation or SQR Technique Implemented	Use POOR condition
Healthy Soils Verified to Minimum 4" Depth	Use FAIR condition
Healthy Soils Verified to Minimum 8" Depth	Use GOOD condition

Refer to Section 2C-5 (NRCS TR-55 Methodology) to select the curve number that applies for the appropriate condition for the expected surface cover of a given area.

I. Construction Observation and Verification Requirements

Methods 1-2:

1. Prior to construction, complete testing methods to determine organic material content in areas proposed to be preserved. Verify that the areas to be preserved are protected by construction fences or other means deemed acceptable by the jurisdictional engineer.

2. Throughout construction, verify that no tracking, storage of materials or other disturbance is allowed within the protected area.

Methods 3-7:

1. Complete SWPPP management and inspections and install pollution prevention measures throughout construction (if required for a given site).

2. Compare site conditions with SMP.

3. When on-site topsoil is used, verify that the topsoil stockpile has been properly located and other site soils, debris, revetment stone or other materials are not being mixed with topsoil stockpile.

4. Verify surface, where SQR is to be completed, has been prepared and is free of debris, rocks larger than 1 inch in diameter (1/2 inch for turf grass areas) or other areas densely covered with smaller rocks and/or gravel.

5. Where topsoil is to be placed, observe site conditions, that the prepared surface is tilled to the required depth prior to topsoil placement and that it is not wet.

6. Refer also to other requirements of SUDAS Section 2010 related to the stripping, stockpiling and placement of topsoil. Verify that clods, lumps, roots, litter, other undesirable material, or stones larger than 1 inch (1/2 inch for turfgrass) have been removed prior to placement of any compost / sand or topsoil.

7. Observe that tillage is performed to the depth required. Do not allow wet soils to be tilled.

8. Use visual observation to determine topsoil is placed to the depth specified within the SMP.

9. Use visual observation and collect delivery tickets or tags to determine specified volume of compost is applied to the SQR area. Compare delivery tickets with the SMP to match delivery location, total quantity of material, product description and source of material. Any deviation from specified materials will require laboratory test results to verify that the delivered materials are equivalent to those specified.

10. Verify depth of amended soil and scarification by using a shovel to dig at least one test hole per acre (a minimum of one test hole on smaller sites). The test location should be randomly selected by the site observer. Test holes should extend at least 4 inches below the expected tillage depth and/or topsoil layer and be at least 1 square foot in area. The amended soils and/or topsoil layers should be easy to dig, driven solely by the weight of the observer. The soil should be darker than existing soil below. Particles of organic matter are likely to be visible. Soil that requires vigorous chipping with the shovel to penetrate properly does not meet the specification. Where topsoil has been placed, the next 2 inch depth of soil should be loose enough to penetrate with the shovel. The loosened depth may vary based on pattern of scarification, some sections of the 1 square foot hole should be loosened 2 inches below the topsoil layer. Collect samples from the test hole locations and have tests completed to determine that the organic material content assumed in design has been met or exceeded.

11. Use a rod penetrometer to confirm the soil is uncompacted to the desired tillage depth at a minimum of ten locations per acre (with a minimum of ten on sites less than one acre). Locate test spots by dividing the site (or each acre) in half lengthwise, then dividing each half into five nearly equal sections. Conduct the test near the middle of each section. The rod penetrometer should enter the soil through 2 inches below the amended soil depth and/or topsoil layer, driven solely by the weight of the observer. Irregular scarification or rocks in subsoils may require probing a few spots at each location.

12. Record the results of the shovel and penetrometer tests on a Field Verification Form to be included with Site Record Documents. If a given site does not fulfill the intent of the SMP, corrective action will need to be taken prior to site stabilization.

13. Perform seeding, sodding or other stabilization techniques as specified. Collect tickets or other information as needed to verify that the appropriate materials and application rates are being used.

Do not allow vehicular traffic, storage of materials or other disturbance within the SQR area during or after application of stabilization measures.

14. Continue SWPPP management and inspections and install pollution prevention measures until final stabilization. Should surface erosion occur, repair such areas with compost or appropriate topsoil-compost blends. Hand rake and reseed as necessary.

Method 8:

1. Verify that existing vegetation over the identified area for SQR is mowed to a height of 2 inches.

2. Observe the area has been aerated to a minimum depth of 4 inches.

3. Observe the area has been treated with a ½" to ¾" layer of compost.

4. Use visual observation and collect delivery tickets or tags to determine that the appropriate volume of compost is applied to the SQR area. Compare delivery tickets to match delivery location, total quantity of material, product description and source of material with SMP. Any deviation from specified materials will require laboratory test results to verify that the delivered materials are equivalent to those specified.

5. Perform seeding as specified.

6. Collect tickets or other information as needed to verify that the appropriate seed and application rates was used.

J. Maintenance Requirements

1. Monitor weekly and after rains of 0.5 inches until vegetation is well established.

2. Long-term maintenance involves maintaining organic matter content. Leave lawn clippings on the yard to decompose and recycle nutrients and organic matter. Annual applications of 1/2 to 3/4 inches of compost will help maintain or increase organic matter.

K. Reference Information

Soils for Salmon. http://www.soilsforsalmon.org/

SUDAS. http://www.soilsforsalmon.org/

*Hudson, Berman. 1994. Soil Organic Matter and Available Water Capacity. Journal of Soil and Water Conservation. 49(2), 189-194