5.2.1.2 Protect Erodible Soils on Steep Slopes

Description

The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) has identified a method of classifying “highly erodible soils.” In the Lower Tennessee Valley, new soils generated from the underlying parent material on undisturbed land replace about three tons of soil eroded per acre per year. Erosion rates lower than the rate of soil development are considered "tolerable." Erosion rates higher than the amount of soil formed yearly are considered either "potentially highly erodible" or “highly erodible.” A “highly erodible soil” can erode at eight times the “tolerable” erosion rate or more.

A number of factors determine susceptibility to sheet and rill erosion on slopes—in particular, rainfall, soil characteristics, depth to bedrock and bedrock composition, vegetative type, condition and extent of cover, and length and steepness of the slope. In combination with other factors, a long, steep slope increases the likelihood of soil erosion, particularly where the natural slope exceeds 15 percent. Even on shallower slopes of only 3 percent to 8 percent, many soils are susceptible to damage and removal by wind, water, animal, and manmade forces.

Protecting these fragile areas by ensuring minimal earth-moving and minimal removal of natural vegetative cover, especially on slopes greater than 15 percent, is essential. If disturbance is unavoidable, erosion control practices must be put in place prior to beginning the disturbance. It is critical to consider the effect of proposed grading on slope stability. Changes in grading above, below, and on steep slopes can trigger responses that range from minor soil failure such as eroded channels (accompanied by increased sedimentation of flow paths) to catastrophic failures, such as landslides, which can bury roads and buildings below.

BMP Functions Table

Deep, stable soils are an important and cost-effective BMP. Shallow soils on eroded slopes can no longer store and infiltrate stormwater. Eroding soils are often a source of sediments and pollutants that degrade water quality.

BMP	Applicability	Volume Reduction	Water Quality	Peak Rate Reduction	Recharge	Runoff Temperature Mitigation	Heat Island	Habitat Creation	Maintenance Burden	Cost
Protect Erodible Soils on Steep Slopes	U/S/R	H	M	H	H	M	M	H	L	L

KEY: U = Urban; S = Suburban; R = Rural; H = High; M = Medium; L = Low

Key Design Guidelines

- Distinguish erodible soils on the site (as identified by NRCS Land Capability Classification) http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.
- Make efforts to preserve the existing vegetative cover.
- Reduce the amount of proposed impervious cover.
- Minimize any earth-moving *(*see Section 5.2.1.1, Preserving Landforms, in this manual).

Advantages

- Stable soils minimize erosion and sedimentation, as well as minimize/prevent the risk of catastrophic slope collapse.
- Uneroded soils are often deep with a well-developed organic layer that supports nutrient recycling, water storage, and infiltration processes.

Disadvantages

- May require creative design to overcome perceived or actual restrictions on the amount of available developable land within an individual parcel.

Applications

- This BMP can be applied to any land development that has existing areas of erodible soil on steep slopes ranging from 15 percent and steeper.

Figure 5.2.1.2-1. Steep slope erosion management with established vegetation.

Applicable Protocols and Specifications

Protocol 4 Infiltration System Design and Construction Guidelines
Protocol 5 Planting Guidelines

Design Considerations

Site Analysis:

- Determine soil erodibility by checking NRCS soil maps. Use the NRCS web tool to map the development area and soil characteristics: http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.
  - Create an "Area of Interest" (AOI) using the Quick Navigation, Soil Survey Area tab on the left hand side of the screen. AOI can also be created by drawing a polygon around a particular area using the tools on the top left-hand side of the interactive map.
  - Click the Soil Data Explorer tab on the top of the map. A sub-section of tabs should appear below.
  - Click the Soil Reports tab to the far right within that sub-section. A list of soil reports will appear on the left hand side of the screen.
  - Chose Land Classification and then Land Capability Classification.
  - Click the View Soil Report. A report will be compiled at the bottom of the screen, below the soil map for the chosen AOI.
  - This will provide the applicant with a soil map of the proposed development site, a report that lists soil component symbol and name along with the land capability class and sub-class. Descriptions of the classes and sub-classes are provided below the spreadsheet data on screen.
  - Land capability classes are divided in eight categories and range from few limitation in their use to severe limitations. These are based off of ability for cultivation.
  - Land capability sub-classes are divided in 4 categories; e = erosion and runoff, w = excess water, s = root zone limitations, c = climatic limitations)
  - The land capability classes and sub-classes provide information about the degree of limitations for use, soil potentialities and management problems for broad programing and conservation planning. This level of information is suited for concept level investigation.
- Confirm this data with a visual site survey as part of the initial site analysis. Are there existing gullies onsite? Are these gullies old and stable or currently eroding?
- Determine slope steepness from topographic survey of the site.

- The stability of existing steep slopes (more than 15 percent) should be reviewed by a geotechnical engineer or qualified civil engineer in the preliminary phase of the design process to ensure that the design and drainage do not impact the stability of soils or geology. Determine if existing slopes need to be altered to accommodate proposed development. Where possible, revise design so that steep slopes are not impacted.
- Drainage – Using a site topographic survey, identify existing flow patterns within each sub-watershed (smaller drainage areas) within the site to identify how water presently drains off steep slopes. Document whether stormwater sheet flows over each slope and/or is concentrated in channels.
- The water system does not stop at the project site. Identify whether significant amounts of stormwater are entering the site from beyond the property boundaries. Locate main entry points for this stormwater and determine its volume and velocity for various storm events.
- Existing Vegetation – Document the vegetation presently found on steep slopes. Identify and show the cover type and/or landscape type on the preliminary site plan (lawn, ornamentals, meadow, old field, savannah, woodland, or forest). Also identify the condition (health) and density of the existing vegetation.
- Proposed Vegetation – Identify proposed cover type (landscape) on plan and design in concert with proposed soil stabilization measures. Ensure that the measures chosen support each other and are not in conflict.

Design Strategies:

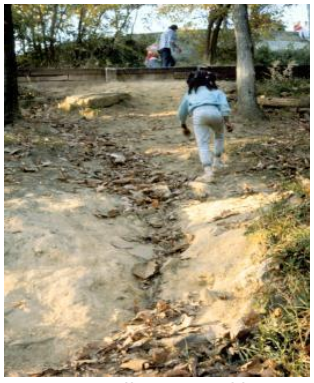
- Site Selection – The least expensive and easiest method to protect steep slopes with erodible soils is to avoid development on and around these slopes. This presents a challenge in Chattanooga. If possible, avoid development or regrading of areas immediately adjacent to the top and bottom of existing slopes and the slopes themselves. Do not direct concentrated flow onto these areas. Planning for this is done early in the design process. Strategies for fitting the owner/developer's program to site features apply here and are discussed in Section 5.2.1, Protect Undisturbed and Healthy Soils and Section 5.2.1.1, Preserving Landforms.
  Where possible, make every effort to avoid clearing and grubbing slopes greater than 15 percent.

5.2.1.2-2. Steep slope stone wall.

- Develop Proposed Protection/ Prevention and Repair Measures – For the concept plan, identify broad outlines of an approach and proposed measures to ensure slope stability and appropriate drainage. Provide design details and specifications in later phases. Strategies include:
  - Protection above and below slope
    - Protect bottom of slope from being undermined by reinforcing with large stones, built structures, and/or planted or bioengineered vegetative structures or vegetated buffers.
    - When developing on hilltops or terraces within a hillside, be aware of any new drainage directed toward the slope. Use piping or swales to collect and convey diverted stormwater around the slope to designed discharge points. Depending on the maximum design velocity and volume of the stormwater runoff, and if there is no chance that slope stability will be undermined, this water can be infiltrated into the slope using underground level spreaders placed along the top of the slope. This option promotes groundwater recharge and irrigates the vegetation on the slope.
    - Protect top of slope from excess soil being pushed over the existing slope edges unless properly placed in compacted layers. Leaving a vegetated buffer along the top of the slope is a good deterrent. *(*See Section 5.5.6, Vegetated Filter Strips, in this manual.)

5.2.1.2-3. Level spreader along contour of slope.

  - Repair measures
    - Repair existing gullies and drainage problems on the slope before proceeding with other construction.
    - Small checkdams can be used both to repair existing gullies and to prevent future gullying.
    - Regrading the slope to close the gully channels, and then stabilizing the slope, is an alternate solution. However, this solution will not prevent future runoff from recreating the same gullies. Drainage from above must be addressed first.
    - Consider bioengineering solutions to stabilize the slope if required. These include live staking, fascines, branch-packing, brushlayer in-fill, shrub mats, etc.



5.2.1.2-4. Gulley created by pedestrian cut-through.

- The USDA *Engineering Field Handbook*, Chapter 18, Soil Bioengineering for Upland Slope Protection and Erosion Reduction, illustrates these techniques: http://directives.sc.egov.usda.gov/viewerFS.aspx?hid=21429.

5.2.1.2-5. Eroded clearing and gulley on steep slope.

- Manage erosion – If disturbed or regraded, cover bare soil on slope with erosion management blankets and/or establish dense, deep-rooted vegetative cover as soon as possible.
  - In the event that steep slopes are modified or created, barren, steep slope areas should be stabilized as soon as possible.
  - See Protocol 5, Planting Guidelines, for species and recommended planting methods including meadow and woodland cover types.
    - Seeding on steep slopes: Most lawn grasses and ornamental ground covers are **not** suitable for this purpose. Do not use lawn grasses to stabilize steep slopes. Use deep-rooted meadow grasses and wildflowers for a quick cover. Ultimately, woody vegetation provides the best protection for steep slopes.

5.2.1.2-6. Live staking on steep slope.

Steep slopes require higher seeding rates, including cover crop rates, than typical seed mixes. To avoid disturbance, a two-part seeding process can be minimally invasive and economical. This system includes hydroseeding the slope with seed, starter fertilizer, tackifier, and fiber mulch on the bare soil of the slope, and then following with a fine and light layer of organic mulch applied hydraulically. Check with the

seeding supplier to verify that the seed being purchased is suitable for hydroseeding. Some native species cannot be hydroseeded.

If the timing of seeding is outside the window of the preferred seeding season, consider using a cover crop such as grain oats to stabilize the slope until the proper seeding time. Do not use cover crops that are invasive. Typical cover crops are annuals and should be eliminated at least two weeks before planting. Cover crops should be killed before they go to seed. Mechanical removal, such as mowing or rolling, can be utilized. Use chemical methods sparingly and cautiously, especially around water bodies.

5.2.1.2-7. Steep slope erosion management installation.

- Temporary erosion control blankets can successfully limit soil erosion and help to establish vegetation on steep slopes. Blankets provide immediate erosion protection from precipitation impact, sheet flows, and moderate shear concentrated flows.
  - Use only temporary blankets made from biodegradable, organic materials. These mats are degradable and are typically made of a variety of organic matrixes including straw, coir fiber, and a blend of both.

5.2.1.2-8. Jute fabric over straw.

- Blankets have many benefits. Blankets will:

  Reduce daily temperature swings

  Moderate seasonal soil temperatures – cooler in hot weather and warmer in spring/fall

  Reduce moisture loss from evaporation or wind dessication

  Reduce water velocity and protect bare slopes from erosion

- Properly Size Stormwater Management BMPs – Stormwater moving in large concentrations or at high velocities can erode the inflow and storage areas of BMPs placed on, or at the bottom of, a steep slope.
  - BMPs should be designed to prevent erosion by considering entrance velocities and sediment settling capabilities as well as the potential for accumulated sediment from contributing land uses.
  - Drainage conditions should be evaluated and velocities of stormwater calculated on a case-by-case basis.
  - All BMPs must be designed to hold up under maximum design stormwater velocities. On steep slopes, it may be necessary to limit the amount of flow that can enter a specific BMP in order to prevent erosion.
  - Infiltration BMPs should be designed and constructed with level bottoms (not sloped). Creating level bottoms for BMPs on steep hillsides may require an increased BMP area since the effective depth of water is not uniform and will decrease as a function of slope.
  - High runoff velocities may require terracing the hillside and/or constructing small "check dams" (with weirs). The location and spacing of check dams and weirs are a function of the slope and the desired maximum ponding depth (steeper slopes require more frequently spaced structures). Check dams and weirs may be constructed from a variety of materials including stone, metal, wood, concrete, or unexcavated subsoil.

5.2.1.2-9. Check dams below outlet on steep slopes.

Construction Sequencing

Before construction can begin, the site must be properly prepared and protected. After construction is complete, new interventions must be stabilized and monitored. Basic protocols can be implemented that, if followed, will greatly reduce the risk of future complications:

- Soon before actual construction
  - Mark limits of soil disturbance on the ground.
  - Put protection measures in place – slope stability, erosion and sediment controls, site protection fencing, tree protection fencing, etc. will help ensure the protection of existing site resources.
- During construction
  - Ensure that fencing remains standing and without holes.
  - Ensure that erosion control strategies are in place and functional.
- After construction
  - Stabilize all disturbed slopes greater than 5 percent as soon as the work is finished. Stabilize all existing or newly installed swales and/or channels, especially on steep slopes with highly erodible soils.
  - Remove protective fencing unless requested otherwise by owner.
  - Repair any accidental damage to protected areas.

Operations and Maintenance

Steep terrain requires monitoring to ensure that slope integrity is maintained after adjacent lands have been modified. Locations where new grades meet steep slopes also require monitoring to ensure that the transition remains seamless.

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5.2.1.2 Protect Highly Erodible Soils on Steep Slopes Criteria Checklist

ITEM DESCRIPTION	YES	N/A
The following checklist provides a summary of design guidance by the owner/applicant for successful implementation.		
• Determine soil erodibility by checking NRCS soil maps. Use the NRCS web tool to map the development area and soil characteristics: http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx. Confirm this data with a visual site survey as part of the initial site analysis.	☐	☐
• Determine slope steepness from topography survey of the site.	☐	☐
• Review stability of **existing** steep slopes (more than 15 percent) in the preliminary phase of the design process to ensure that the design does not impact the stability of soils or geology. Design so that steep slopes are not impacted.	☐	☐
• Identify existing flow patterns within the site to identify how water presently drains off steep slopes. Document whether stormwater sheet flows over each slope and/or is concentrated in channels.	☐	☐
• Identify stormwater entering the site from beyond the property boundaries. Locate main entry points for this stormwater and determine its volume and velocity.	☐	☐
• Stability of any **proposed** steep slope (more than 15 percent) should be reviewed to determine the potential impacts of proposed changes to existing site drainage that could undermine slope stability.	☐	☐
• Document the vegetation presently found on the steep slopes. Identify and show on the preliminary site plan, the cover type/or landscape type (lawn, ornamentals, meadow, old field, savannah, woodland or forest). Also identify the condition (health) and density of the existing vegetation. Provide photo documentation.	☐	☐
• Identify proposed cover type (landscape) on plan and design in concert with proposed soil stabilization measures. Ensure the measures chosen support each other and are not in conflict.	☐	☐
• Avoid development or regrading of areas immediately adjacent to the top and bottom of existing slopes and the slopes themselves. Do not direct concentrated flow to these areas.	☐	☐
• No clearing and grubbing will occur on slopes greater than 15 percent.	☐	☐
• Develop Proposed Protection/Prevention and Repair Measures – For the preliminary plan submission, identify broad outlines of your approach and proposed measures to ensure slope stability and appropriate drainage.	☐	☐
• If necessary, protect bottom of slope from being undermined by reinforcing with large stones, built structures, and/or planted or bioengineered vegetative structures or vegetated buffers.	☐	☐
• When developing on hilltops, or terraces within a hillside, be aware of any new drainage directed toward the slope. Convey any diverted stormwater around the slope to designed discharge points with appropriate erosion control and energy dissipation.	☐	☐

• Protect top of slope with a 10-foot minimum vegetated buffer.	☐	☐
• Repair existing gullies and drainage problems on the slope before proceeding with other construction. • Consider bioengineering solutions to stabilize the slope if required. These include live staking, fascines, branch-packing, brush layer in-fill, shrub mats, etc.	☐ ☐	☐ ☐
• Cover bare soil on slope with erosion management blankets and/or establish dense, deep-rooted vegetative cover as soon as possible.	☐	☐
• Seeding on steep slopes uses deep-rooted meadow grasses and wildflowers for a quick cover and is ultimately wooded.	☐	☐
• Use temporary erosion control blankets made from biodegradable, organic materials to limit soil erosion and help to establish vegetation on steep slopes.	☐	☐