Chapter 1 – Purpose and Function of the Guidelines

Introduction

The Connecticut Guidelines for Soil Erosion and Sediment Control (hereafter referred to as “the Guidelines”) are intended to provide information to government agencies and the public on soil erosion and sediment control. The Guidelines are a useful reference for projects that require erosion and sediment control planning, design, and implementation.

The Guidelines fulfill the requirements of Connecticut's Soil Erosion and Sediment Control Act (Public Act 83-388, codified in sections 22a-325 through 22a-329 of the Connecticut General Statutes) by providing guidance to municipal planning and zoning commissions. Contained within the Guidelines are methods and techniques for minimizing erosion and sedimentation based on the best currently available technology.

What’s New in this Chapter?

- Streamlined history of soil erosion and sediment control policy as well as the regulatory basis of the Guidelines
- Summary of major revisions to the Guidelines and where to find information on future updates
- Updated contact information for where recommendations for improving the Guidelines can be submitted.

As a useful reference, the Guidelines may be designated as a primary guiding document, or as the foundation and minimum requirements for development of best management practices for construction activities for several programs beyond the original intent of the legislation that required the creation of this document. Such programs include water planning; coastal resource management; tidal wetlands; structures / dredging / fill in tidal, coastal, and navigable waters; inland wetlands and watercourses; diversion of water; dam safety; solid waste management; and the stormwater general permit programs (See Regulatory-Permit Index, Appendix A).

While erosion can be caused by wind, ice, gravitational creep, and other geological processes, water accelerated erosion is unquestionably the most severe type of erosion in Connecticut. While the Guidelines make minor reference to controlling wind-generated erosion, the primary focus of the Guidelines is to prevent and control water-erosion and sedimentation.

Statement of the Problem

While all lands erode, not all land can be considered a source of sediment pollution. There has always been naturally occurring erosion. However, major problems can occur when human activity causes large amounts of sediment to enter our wetlands, watercourses and storm drain systems. The tendency of pollutants to adhere to the surface of, and move with, soil particles escalate the environmental damage.

Erosion on agricultural land occurs mainly as sheet and rill erosion over a period usually measurable in years. Conversely, on developing land, erosion is frequently in the form of gully erosion on land disturbed for a year or less. Both conditions result in lower quality of soil and water resources (see Chapter 2, Sediment Pollution and Damage)However, gully erosion, which is the result of concentrated flows of surface runoff, generates high sediment volumes requiring costly clean-up and the continual need for site stabilization during development. A construction site typically erodes at a rate of 50 tons/acre/year. This erosion rate is five times greater than cropland erosion and 250 times greater than woodland erosion. Each year more than one million acres of land in the United States are converted to urban use. These land use changes are the source of much of the sediment that pollutes our streams, rivers, lakes, ponds, and reservoirs.

The Guidelines are intended to assist landowners, developers, commission members, engineers, and architects to control sediment pollution caused by land disturbing activities.

History

Historical context for soil erosion and sediment control policy

In 1864, George Perkins Marsh published "Man and Nature on Physical Geography as modified by Human Action", which described the effects of deforestation and subsequent land management on erosion processes. George Perkins Marsh was far from the last to observe the impact on erosion processes. Yet, large areas of the United States were devastated by erosion caused by unfavorable climatic conditions coupled with abuse and mismanagement of the country's crop lands. It wasn't until these conditions cumulated and resulted in the devastating Dust Bowl of 1934, that the nation began enacting a soil erosion and sediment control policy. In 1935 Congress passed The Soil Conservation Act marking the first national recognition of the need for erosion and sediment control. The Act created the Soil Erosion Service, (also known as the Soil Conservation Service or SCS, now known as the Natural Resources Conservation Service or NRCS), an agency within the U.S. Department of Agriculture.[1]

Over the next 40 years, federal recognition would manifest into state soil conservation districts and eventually into local requirements by planning and zoning boards. By 1977 more than 70 Connecticut communities had adopted some form of erosion and sediment control requirements. However, only half of these were effective in solving erosion problems in developing areas. The Connecticut General Assembly responded to the limited effectiveness of local regulations, by enacting the Soil Erosion and Sediment Control Act, which is now sections 22a-325 through 22a-329 of the Connecticut General Statutes, in 1983.

The major goal of this policy was to create "a statewide coordinated erosion and sediment control program which shall reduce the danger from stormwater runoff, minimize non-point sediment pollution from land being developed and conserve and protect the land, water, air and other environmental resources of the state." In addition to increasing state oversight of municipal planning and zoning commissions, the Act required that guidelines be developed to outline methods and techniques for minimizing erosion and sedimentation based on the best currently available technology.

[1] https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_021255.pdf

Guidelines Established and Revised

The first guidelines were published in January of 1985 and were the result of a task force that included many state and federal agencies, private corporations, and individuals. They included excerpts from many sources but relied heavily on documents from the SCS in Storrs, Connecticut and the Virginia Soil Erosion and Sediment Control Handbook published in 1980. In 1988 the guidelines were republished with several corrections.

Guidelines Cited in General Permit for Construction Activities

In 1992 the Federal Environmental Protection Agency (EPA) mandated that states, like Connecticut, who had been given the authority to administer provisions of the Federal Water Pollution Control Act (33 U.S.C. Section 466 et seq.) and issue National Pollution Discharge Elimination System (NPDES) permits, make provisions for the regulation of discharges of stormwater and dewatering waste waters from construction activities. As a result, the Connecticut Department of Environmental Protection (now called the "Connecticut Department of Energy and Environmental Protection" or CT DEEP) issued the General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities (Construction General Permit) for these activities on sites whose construction activities resulted in the disturbance of 5 acres or more of land. Among other things, the Construction General Permit requires the development of stormwater pollution control plans that include provisions for erosion and sediment controls during construction. Those plans are required to ensure and demonstrate compliance with the guidelines.

Unlike the Soil Erosion and Sediment Control Act, the Construction General Permit also affects state agencies. Agencies like the Connecticut Department of Transportation have, over time, established independent specifications for erosion and sediment control measures, which need consolidation with the guidelines or modification to demonstrate the compliance required by the general permit.

The Construction General Permit has been reissued several times with and without modifications since it was first issued in 1992. Most recently, the Construction General Permit was reissued in 2020 with the following key provisions:

- Construction projects disturbing five acres or more that are required to receive municipal approval (Locally Approvable projects) must submit a registration to the CT DEEP and have a qualified professional prepare a Stormwater Pollution Control Plan (Plan).
- Construction projects disturbing more than one acre that are not reviewed and approved by a local land-use commission (Locally Exempt projects) must submit a registration to the CT DEEP along with a Plan prepared by a qualified professional for Department review.
- Provisions to follow the Connecticut Guidelines for Soil Erosion and Sediment Control.

- Conditions applicable solely to larger solar array projects including stormwater control measures for solar array projects.
- Updated design storm precipitation using NOAA Atlas 14, Volume 10, Version 2 rather than the older NWS Technical Paper #40.
- Post-construction stormwater management (retention and treatment) requirements consistent with the statewide and CTDOT MS4 General Permits.

Major Changes

The 2021 revisions to the Guidelines were made in conjunction with revisions to the Connecticut Stormwater Quality Manual. Given the limited funding available for revisions to both documents, updates to the Guidelines were focused on the Department's highest priorities, as determined by the CT DEEP project team and stakeholder workgroup that consisted of representatives of state agencies, municipalities, and other organizations with a role in stormwater management in Connecticut.

The primary objectives of the 2021 revisions to the Guidelines are to:

- Incorporate updated information, consistent with regional soil erosion and sediment control guidance, on the selection, design, construction, and performance of the soil erosion and sediment control Functional Groups and Measures.
- Resolve conflicts and improve consistency between the Guidelines and the Connecticut Stormwater Quality Manual for more effective integration of construction-phase and post-construction stormwater management.
- Update the Guidelines for consistency with the CT DEEP stormwater general permit programs, specifically the Construction Stormwater General Permit.
- Incorporate climate change and resilience considerations for soil erosion and sedimentation control.
- Enhance the usability of the Guidelines from the perspective of project designers and reviewers.

Format Changes

Appendices that provided miscellaneous reference materials, which can now be accessed online, have been removed or streamlined. Where necessary, figures and tables have been updated to reflect changes to the text or the current state of the practice.

Technical Changes

The 2021 version of the Guidelines incorporates revisions that include but are not limited to:

- Elements from the June 2011 Low Impact Development (LID) Appendix, where relevant.
- Information on soil erosion and sediment control for Solar Array Projects contained in the current Construction General Permit and applicable CT DEEP policy has been incorporated into the Guidelines, either directly or by reference.

Some new control measures were added, including:

- Fiber Rolls (Included in Check Dams and in Filter Socks)
- Filter Sock
- Vegetated Waterway
- Temporary Lined Channel
- Permanent Lined Waterway
- Temporary Stream Crossing
- Pumping Settling Basin

Several existing measures were updated, including:

- Stream Deflectors
- Soil Bioengineering for Stabilization
- Dust Control (Tackifiers, Soil Stabilizers and Polymer Flocculants)
- Level Spreader
- Outlet Protection
- Stone Check Dam
- Temporary Sediment Basin
- Stone Slope Protection

The section regarding Temporary Lined Chutes that are constructed of concrete or bituminous pavement were removed from this manual.

How to use the Guidelines?

The Guidelines are intended to serve as a technical guide for meeting the requirements of the Soil Erosion and Sediment Control Act and to assist in implementing the requirements of laws and statutes relating to construction-phase stormwater management and erosion and sedimentation control. The use of words such as "shall," "will," and "must" within design or implementation standards is meant to emphasize the direction which will ensure that the control measure or design procedure will serve its intended purpose.

The Guidelines provide technical details that are not site specific. Examples are provided which may not be applicable or sufficient to meet all engineering standards and building codes. Measures requiring an engineered design must be evaluated on a case-by-case basis by a professional engineer licensed to practice in Connecticut.

Innovative modifications to the control measures or design procedures contained in this guide are acceptable, and encouraged, especially if they improve upon sediment-loss mitigation. However, designers and plan reviewers must be sure that the modified procedure will be successful. Designers must present to plan reviewer's sufficient technical data that show the proposed modification is at least as effective as the guideline measure meant to be replaced.

While these Guidelines promote an integrated approach to construction-phase and post-construction stormwater management, the Guidelines are not intended to provide design guidance on post-construction stormwater management measures.

The reader should refer to the Connecticut Stormwater Quality Manual for guidance on post-construction stormwater management measures, including source controls and pollution prevention, non-structural LID site planning and design strategies, and structural stormwater Best Management Practices (BMPs). The stormwater management standards contained in the Connecticut Stormwater Quality Manual require the development and implementation of a soil erosion and sediment control plan in accordance with these Guidelines as part of an overall stormwater management plan for the site.

This document contains, to the extent possible, measures that will help prevent or correct sediment and erosion control problems when selected, designed, and maintained in accordance with the Guidelines and good engineering practice. However, the use of the Guidelines does not relieve the user of the responsibility of complying with laws and regulations that cite the Guidelines.

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Updates and Future Revisions

The Council on Soil and Water Conservation and CT DEEP may periodically update these Guidelines pending the availability of funding. Technical information regarding updates to the Guidelines will be available at:

https://portal.ct.gov/DEEP/Water/Soil-Erosion-and-Sediment-Control-Guidelines/Guidelines-for-Soil-Erosion-and-Sediment-Control

Future versions of the Guidelines will reflect the technical updates found on the website. Notices regarding future revisions of the Guidelines will also be posted at this website.

Chapter 2 – The Erosion and Sedimentation Process

Definition

Soil erosion and sedimentation is a three-stage process:

1) Detachment ➔ 2) Transport ➔ 3) Deposition

What's New in this Chapter?

- Minor updates to erosion and sedimentation process definitions
- Inclusion of consideration of climate change impacts on erosion and sedimentation.

Soil erosion involves the wearing away of the surface of the land by the action of wind, water, ice, and gravity. Once worn away, the detached soil particles are transported and ultimately deposited, resulting in sedimentation. Natural, or geologic erosion and sedimentation occur over long periods of geologic time resulting in the wearing a way of mountains and the building up of floodplains, coastal plains, deltas, etc., to create the topography we know today. Except for some cases of shoreline and stream channel erosion and sedimentation, natural erosion and sedimentation occur at a very slow rate.

Erosion and sedimentation become a problem when they are accelerated beyond natural rates. Accelerated erosion is primarily the result of the influence of human activities on the environment. Once exposed, unprotected soil is then subject to rapid erosion by the action of wind, water, ice, or gravity.

As stated in Chapter 1, erosion can be caused by water, wind, ice, and gravitational creep. The focus of these Guidelines is minimizing or preventing erosion caused by water.

Types of Erosion

Raindrop erosion or raindrop splash initiates the erosion process. Individual soil particles and small soil aggregates are detached and transported with splashing water droplets as the raindrop impacts the soil (see Figure 2-1). Although raindrop splash is incapable of moving sands or coarser materials very far, very fine particles can be suspended in water. They are then susceptible to and contribute to sheet erosion.

Figure 2- 1. Rain Drop Splash

Sheet erosion is the removal of a thin, uniform layer of soil from the land surface caused by shallow sheets of water running off the land. These very shallow moving sheets of water are seldom the detaching agents, but the flow transports soil particles which are detached by raindrop impact and splash. The shallow surface flow rarely moves as a uniform sheet for more than a few feet on land surfaces before concentrating in surface irregularities (see Figure 2-2).

Rill erosion develops as shallow surface flows begin to concentrate in the low spots and irregularities of the land surface. As the flow changes from the shallow sheets to deeper flows in these low areas, the velocity and turbulence increase. The energy of this concentrated flow can both detach and transport soil materials. This action begins creating tiny channels called rills (see Figure 2- 2). Rills are small but well-defined channels that are, at most, only a few inches (about 5 centimeters) deep.

Gully erosion occurs as the flows in rills come together to form larger channels (see Figure 2- 2 and Figure 2- 3). Size is the major difference between gully and rill erosion. Gullies are too large to be repaired with conventional tillage equipment and usually require heavy earthmoving equipment and special techniques

Figure 2- 2. Gully Erosion and the Possible Progression

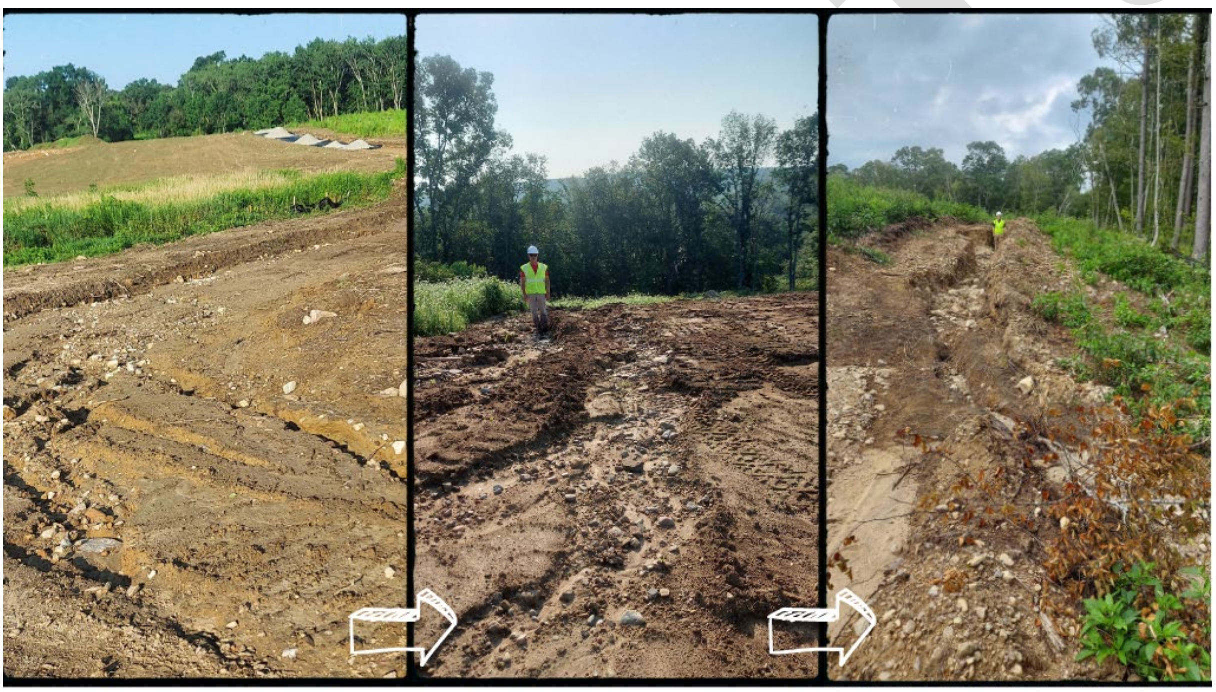
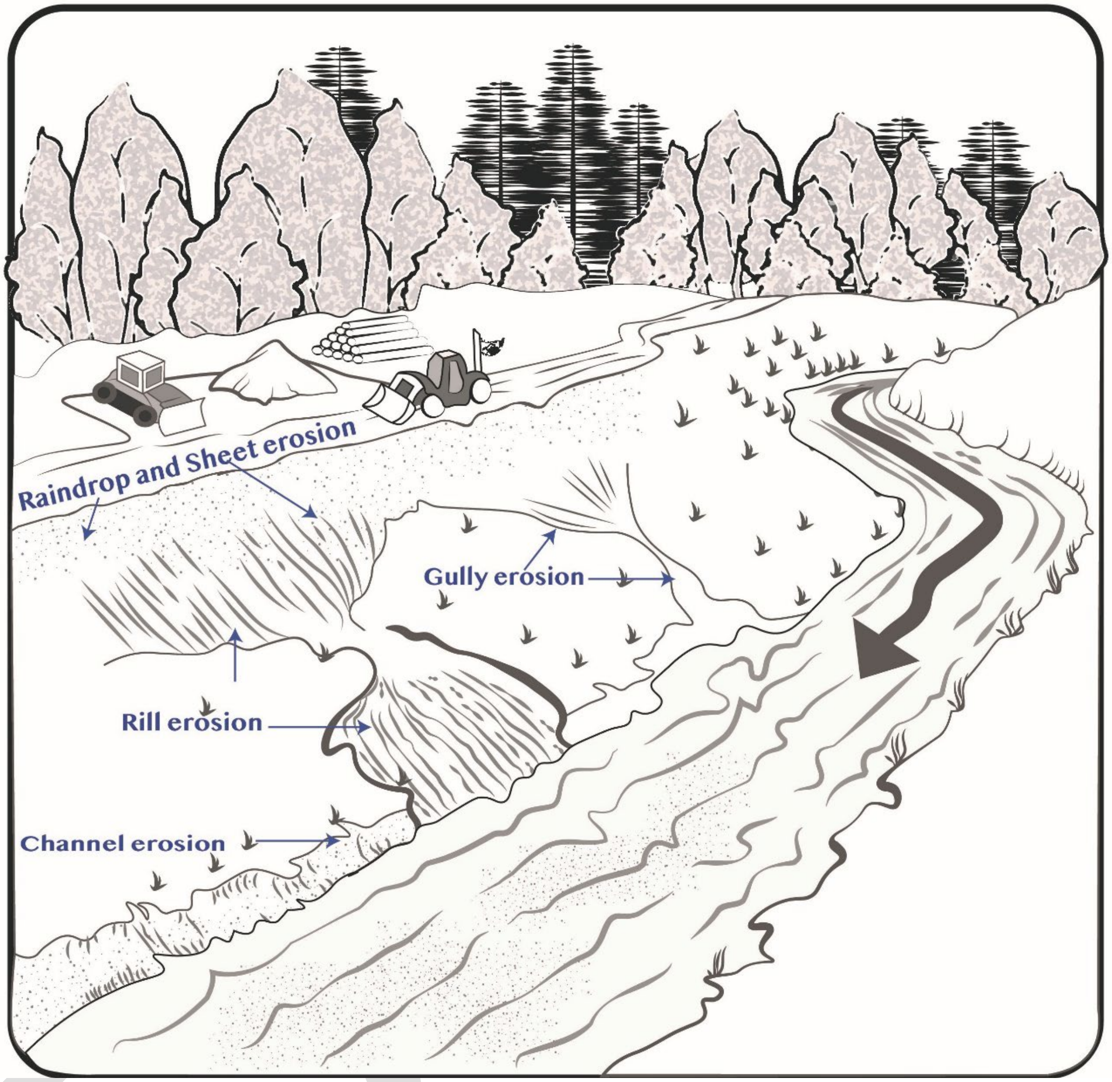


Image Source: Jean Pillo, CPESC, Eastern Connecticut Conservation District

for stabilization. Typically, they reach depths in excess of 1 foot but on rare occasions reach depths as much as 75 to 100 feet deep. Channel erosion occurs as the volume and velocity of runoff concentrate in drainage channels and cause movement of the stream bed and bank materials.

Figure 2- 3. Types of Erosion



Shoreline erosion occurs on tidal and inland waters as daily high tides, wave action, and storm surges erode coastal and estuarine shorelines. Existing shoreline structures can be heavily damaged by severe wave action, significant patterns of tidal exchange or flushing rates, freshwater input or existing basin characteristics and channel contours. Wave action caused by boat wakes can also cause shoreline erosion. Sediment displaced by land erosion can render shipping channels and harbors impassable and adversely impact coastal and estuarine habitats. Significant alteration of shoreline configurations, particularly within high velocity flood zones, can occur when the natural erosion patterns are altered. Tidal wetlands, intertidal flats, beaches and dunes, rocky shore fronts, bluffs and escarpments can be greatly affected through changes in their natural characteristics or functions.

Factors Influencing Erosion

The erosion potential of any area is determined by a combination of four principal factors: soil characteristics, vegetative cover, topography, and climate. Although each of the erosion factors is discussed separately here, they are interrelated in determining erosion potential and no one factor determines erosion potential alone.

Erosion potential during dewatering activities is a function of the turbidity of the water being pumped and the discharge velocities of the pump.

Table 2. 1 summarizes how erosion potential is influenced by these various factors. Understanding these four factors of soil erosion will aid the designer and planner in selecting the appropriate soil erosion control measure. Planning for soil conservation and water management requires knowledge of the relationship among these four factors that cause loss of soil and how these factors can be influenced to reduce such losses. In order to better understand the relationship of planned activities to soil erosion, a predictive soil erosion loss model, the Revised Universal Soil Loss Equation (RUSLE2), was developed. See Appendix B for a discussion of RUSLE.

Table 2. 1. Factors Influencing Erosion Potential

Factor	Erosion Potential	
	Lower	Higher
Soil Characteristics		
Soil Texture	Gravel and Coarse Sand	Fine Sand and Silt
Organic Content	Highly Organic	No Organic
Soil Structure	Blocky	Granular
Soil Permeability	Sand/Gravel	Silt/Clay
Vegetative Cover		
% Cover	100%	0%
Type of Cover	Trees with Mulch	No Cover
Topography		
Slope Length	Short	Long
Slope Gradient	Flat	Steep
Climate		
Rainfall Intensity	Low Intensity	High Intensity
Rainfall Frequency	Infrequent	Frequent
Rainfall Duration	Short Duration	Long Duration
Wind	Calm	Gusty
Temperature	Frozen	Thawed
Special Cases		
Dewatering Discharge Velocities	Low Velocity	High Velocity

Soil Characteristics

Soil characteristics that influence erosion by rainfall and runoff are those properties which affect the infiltration capacity of a soil and those which affect the soil's resistance to detachment and transport by falling or flowing water. The following four characteristics are important in determining soil erodibility:

- Texture (particle size and gradation)
- Organic matter content
- Structure
- Permeability

Soils containing high percentages of fine sands and silt are normally the most erodible. Terrace escarpment soils in the Connecticut River valley are examples of soils that contain higher percentages of fine sands and silts and are very prone to erosion when disturbed. As the clay and organic matter content of soil increases, the erodibility decreases. Clays act as a binder to soil particles, thus reducing erodibility. However, while clays tend to resist erosion, once eroded they are easily transported by water and the soil particles remain in suspension longer. In Connecticut, the existence of clay soils is very limited.

Gravelly soils are usually the least erodible. Soils high in organic matter have a more stable structure that improves their permeability. Such soils resist raindrop detachment and infiltrate more rainwater. Soils with high infiltration rates and permeabilities either prevent or delay and reduce the amount of runoff.

Vegetative Cover

Vegetative cover plays an important role in controlling erosion in the following ways:

- Protects the soil surface from the impact of falling rain
- Holds soil particles in place
- Enhances the soil's capacity to absorb water
- Slows the velocity of runoff
- Removes subsurface water between rain events through the process of evapotranspiration
- Improves infiltration rates

Soil erosion and sedimentation can be significantly reduced by limiting and/or staging the removal of existing vegetation and by decreasing the area and duration of exposure. Special consideration should be given to maintaining existing vegetative cover on areas of high erosion potential such as erodible soils, steep slopes, ditches, and the banks of streams.

Topography

Topography describes the configuration of the land surface. The size, shape, and slope characteristics of a watershed influence the amount and rate of runoff. As both slope length and gradient increase, the rate of runoff increases and the potential for erosion is magnified.

Climate

Climate is the long-term average of atmospheric influences, principally moisture (including rainfall), temperature, wind, pressure, and evaporation. Understanding climate's impacts on frequency, intensity, and duration of rainfall can bring context to the amounts of runoff produced in each area. As both the volume and velocity of runoff increase, the capacity of runoff to detach and transport soil particles also increases. Where storms are frequent, intense, or of long duration, erosion risks are high. Seasonal and regional changes in temperature, as well as variations in rainfall, help to define the high erosion risk period of the year.

Additionally, wind can potentially remove more sediment than rainfall. Its impact on the land is generally limited to large areas that are unprotected for long periods of time. However, there are areas of special concern. This is particularly true of the sandy soils found in the Connecticut River Valley, which can be very susceptible to wind erosion if left unprotected during hot, dry weather. Wind can also agitate water bodies sufficiently to induce erosive wave action and/or cause the resuspension of deposited sediments.

Springtime is a period of higher erosion potential as the coastal storm track increases rainfall potential. Additionally, because the ground is still partially frozen, the absorptive capacity of the soil is reduced. While frozen soils are relatively erosion resistant, they melt from the top down, creating a soft erodible surface over a hard impervious sub-surface. In Connecticut, thawing of the soils often occurs in conjunction with the early spring rains combined with snow melt. Additionally, soils with high moisture content are subject to frost heaving and can be very easily eroded upon thawing.

Types of Sediment and Sedimentation

From the time the soil particle is detached (either by rain drop splash or moving water), the velocity, turbulence, and the size and types of material available are the primary factors determining the nature of the sediment load. The sediment is being transported as suspended load, bed load, or both.

Suspended load is generally comprised of very fine material (clays and silts) and stays in suspension for long periods of time resulting in a condition called turbidity. The amount of these materials in suspension is dependent on the type of soil and the resistance to detachment by the erosive agent. Turbidity is measured with a nephelometer and recorded as nephelometric turbidity units (NPU). In Connecticut, any increase in turbidity from the norm is considered pollution.

Bed load is the sediment that moves on or near the stream bed. Typically, this material moves at velocities less than the surrounding flow and can be measured in tons per unit of time. Bed loads are normally comprised of sands, pebbles, and cobbles.

The amount of the total sediment load being carried as suspended load and/or bed load is related directly to the flow and volume of the water. The movement of the sediment load tends to be in balance with flow conditions. This has an important bearing on channel stability. If the flow becomes loaded beyond its transporting capacity, deposition will occur. However, if the load is less than the transporting capacity, the flowing water attacks the channel to achieve a balance between load and capacity. Any change in sediment load or flow characteristics will influence channel stability and formation.

Deposition is the inverse of detachment. It occurs when the carrying capacity of the flow is reduced to a point below that needed to carry the sediment load. Deposition is a selective process. As flows slow down, the coarser fragments fall out of the water column first, followed by finer and finer particles, resulting in a noticeable gradation of particle sizes in the sediments.

Sediment deposits may occur in water bodies or on land. Deposits occur in water as a faster flowing stream flows into a slower one or into an area of slack water such as a pond or lake or ocean. A stream flowing from a steeper gradient to a lesser one will also lose velocity and carrying capacity and will form deposits. Additionally, deposition can take place on the inside bends of rivers and stream where flow velocities tend to be slower than on the outside of the bends. Deposits can also occur on land when the runoff loses velocity and hence the capacity to carry the same sediment load.

Sediment Pollution and Damage

Sediment pollution is soil out of place. It is the direct and indirect result of human activities that lead to severe soil loss. From the more than four billion tons of sediment delivered to our nation’s water bodies, about one billion tons reach the ocean. Although about 10% of the sediment is estimated to be generated by highway construction and land development, these activities could represent over 50% of the sediment load carried by many streams draining small sub-watersheds that are undergoing development.

Sediment pollution causes physical, chemical, and biological damage. The type of damage is related to the size of the sediment particle. Table 2. 2 shows the relationship of particle size and character to damage or impact.

Table 2. 2. Particle Size vs Damage Impact

Damage Impact with Change in Particle Size	Boulders, Cobbles, Gravel / Very Coarse to Medium Sand	Fine Sands, Silts, and Clays
Biological	▪ Burying of benthic (aka bottom living) organisms ▪ Habitat degradation by damaging rooted plants and possibly changing the substrate (e.g., cobble to sand ▪ Decrease in biological diversity ▪ Increase in embeddedness and loss of interstitial spaces in gravel	▪ Loss of aquatic eggs, larva, and fry ▪ Clogging of fish gills increasing disease and susceptibility ▪ Damage to food chain ▪ Decrease in biological diversity ▪ Increase in algal blooms downstream impoundments ▪ Reduced ability to grow plants on eroded land
Chemical	▪ Water temperature increases from increase sunlight absorption caused by shallowing of water body	▪ Nutrient transport (causing increased eutrophication of downstream waterbodies and lost fertility from eroded lands) ▪ Water temperatures increase from sunlight absorption caused by water opacity (aka cloudiness or turbidity) ▪ Can result in lower dissolved oxygen levels
Physical	▪ Reduced channel capacity, navigation obstruction requiring dredging, reduced flood storage capacity, increasing future flood damage from floods and increasing frequency of floods, increasing maintenance on culverts and storm drains, loss of reservoir storage capacity for drinking and industrial water supply ▪ Loss of land	▪ Turbidity adversely affecting use for surface water drinking supply and manufacturing, increasing filtration costs ▪ Poor aesthetics ▪ Widening of channel ▪ Loss of deeper pools and refuge habitat ▪ Loss of cut-bank habitat

Land Use Changes and Development Impacts on Erosion and Sedimentation

Land use changes and land development activities affect the natural or geologic erosion process by:

- Removing the existing protective vegetative cover.
- Prolonging the exposure of unprotected disturbed areas.
- Exposing underlying soil or geologic formations less pervious and/or more erodible than original soil surface.
- Compacting soils with heavy equipment and increasing impervious surfaces, thereby reducing rainfall absorption and increasing runoff.
- Modifying drainage areas.
- Altering the topography in a manner that results in shortened times of concentration of surface runoff (e.g., altering steepness, distance and surface roughness, and installation of "improved" storm drainage facilities).
- Altering the groundwater regime (e.g., placing a detention basin at the top of a slope).

Reshaping of land during construction or development alters the soil cover and the soil in many ways, often detrimentally affecting on-site drainage and stormwater runoff patterns. Many people may be adversely affected regardless of the size of the area being developed. Erosion and sediment from these areas often cause considerable economic damage to individuals and to society in general. Sediment deposition in waterways and reservoirs creates or aggravates flooding and surface water pollution problems. The result is damage to public and private property. Additionally, erosion and sedimentation may have adverse impacts on recreation, natural resources, and wildlife due to the alteration and/or loss of aquatic habitat.

It is because of these adverse effects that steps must be taken to control the erosion and sedimentation that is associated with land use changes and development.

Climate Change Impacts

As noted above, water resources in Connecticut are affected by climate conditions. Much of the climatic conditions can be mitigated with thoughtful planning. However, when those climate conditions begin to change, this creates additional stressors in water resources and erosion control infrastructure when it is also not considered in the planning and design. These additional stressors can include increasing temperatures, changing precipitation patterns, extreme events (storms, floods, and drought), and rising sea levels. These changing conditions have implications for construction-phase and post-construction stormwater management.

Ongoing and future climate change will continue to increase the potential for erosion and sedimentation. The observed and predicted future changes to Connecticut's climate) directly influence the climate factors that affect erosion potential, including rainfall intensity, rainfall frequency, rainfall duration, wind, and temperature. Table 2. 3 demonstrates that the observed conditions, where we have reliable long-term measures, have already seen significant changes and will likely be even more so in the near future. As such evaluating climate impacts on with a static value is detrimental for current and future planning and designs. Therefore, in general it is suggested that planners and designers take careful consideration of current and projected climate values when considering site options.

- More intense downpours have greater erosion potential as a result of increased energy associated with rainfall directly onto exposed soils and increased runoff generation potential.
- More frequent high-intensity rainfall events and longer-duration storms also increase erosion potential. Projected increases in the number of days of precipitation over 1 inch, as well as the total amount of precipitation falling in the heaviest 1% of rainfall events are important factors in determining erosion potential and sedimentation.
- An increase in the occurrence of extreme storms also increases the potential for wind-induced erosion.
- Warmer temperatures contribute to a reduction in the duration of frozen ground conditions and an earlier spring thaw. Coupled with an increase in high-intensity precipitation, warming temperatures can result in increased erosion risk in the early spring.
- Increased sediment and associated pollutant loads, combined with warmer air and water temperatures, will increase the potential for harmful algal blooms,

Summary of Climate Change Impacts in Connecticut

- By 2050, average temperatures are expected to increase about 5°F, with increases thereafter dependent on emissions choices now.
- Average precipitation is expected to increase about 8% (4 inches/year).
- Indices of hot weather, summer drought, and extreme precipitation are expected to increase.
- Sea level is expected to rise by up to 20 inches by 2050 and to continue increasing after that.
- Small changes in mean sea level have a big impact on the frequency of flooding.
- Areas that experience flooding every few years now should expect flooding multiple times a year by 2050.

Source: Connecticut Institute for Resilience & Climate Adaptation (CIRCA) Fact Sheets

Temperature and Precipitation

Sea Level Rise

loss of high-quality headwater streams and cold-water habitat, further degradation of impaired waters, and negative impacts on recreational use of waters.

- Sea level rise and increased frequency and intensity of coastal storms has implications for erosion and sedimentation along the Connecticut coast and tidally-influenced areas. Continued rising sea levels and more frequent and intense coastal storms will result in greater potential for coastal erosion and flooding.

These Guidelines incorporates climate change and resilience considerations for erosion and sedimentation control, including:

- Preserving pre-development site hydrology through the use of LID site planning and design strategies (Chapter 3) and erosion and sedimentation control measures (Chapters 4 and 5)
- Discussion of updated design storm precipitation for design of erosion and sedimentation controls and post-construction stormwater management measures (Chapter 5).

Table 2. 3. Observed, Projected and Potential Soil Erosion Impacts of Climate Change

	Climate Change Observations\Measurements	Future Climate Change Predictions	Potential Impact to Soil Erosion & Sediment Control
Temperature	Connecticut's observed annual and seasonal temperatures have observed upward trends since measurements began in 1895 and continue to do so. CIRCA reported that at the beginning of the 20th century Connecticut's annual average temperature was 47F, and in 2015 the average annual temperature was 50F. With more extreme warming trends occurring in the coldest days.	CIRCA reports a similar warming trend is expected to continue, with average temperature increasing by 5 degrees by 2050 and warming of the coldest days as much as 9.51 F.	Warmer temperatures contribute to a reduction in the duration of frozen ground conditions and an earlier spring thaw. Coupled with an increase in high-intensity precipitation, warming temperatures can result in increased erosion risk in the early spring.
Sea Level Rise	According to NOAA's National Water Level Observation Network, mean sea level at Bridgeport Connecticut has risen 3.8 mm/ year and 2.72 mm/year at New London buoy since 1964.	As demonstrated by the Connecticut Institute of Resilience and Climate Adaptation, fairly consistent model agreement predicts Connecticut's coastline will see approximately a 20" rise by 2050 compared to the National Tide Datum (1983-2001 data). Beyond 2050, models are directionally consistent but predictions to the magnitude are less certain. None the less	Sea level rise and increased frequency and intensity of coastal storms has implications for erosion and sedimentation along the Connecticut coast and tidally influenced areas. Continued rising sea levels and more frequent and intense coastal storms will result in greater potential for coastal erosion and flooding.

	Climate Change Observations\Measurements	Future Climate Change Predictions	Potential Impact to Soil Erosion & Sediment Control
		increases from 2050 levels are a consistent prediction. Therefore, at this time it is recommended that future planning consider 2050 scenarios and expect increasing sea level.	
Precipitation-Intensity	The heaviest rainfall events have significantly increased. As noted in CIRCA's 2019 CT-PSCAR, "the 4th National Climate Assessment noted the daily 20-year return level precipitation increased by 0.08-0.25 inches (depending on season) during 1948-2015, the 5-year maximum daily precipitation increased by 27% during 1901-2016, and the 99th percentile of daily precipitation increased 55% during 1958-2016. For frequency, the number of 2-day precipitation events exceeding 5-year recurrence interval increased by 74% during 1901-2016 and by 92% during 1958-2016."	These trends are expected to continue. As noted in CIRCA's CT-PSCAR, "[b]y the late century under RCP8.5, precipitation in the wettest day of the year would increase by 20-30%, and extreme events such as daily precipitation with a return period of 20 years in the present climate would occur 3-4 times as often in the Northeast compared to the late 20th century."[2]	More intense downpours have greater erosion potential as a result of increased energy associated with rainfall directly onto exposed soils and increased runoff generation potential More frequent high-intensity rainfall events and longer-duration storms also increase erosion potential. Projected increases in the number of days of precipitation over 1 inch, as well as the total amount of precipitation falling in the heaviest 1% of rainfall events are important factors in determining erosion potential and sedimentation. Increased rainfall will impact the existing infrastructure as

[2] Walsh, J., Wuebbles, D., Hayhoe, K., Kossin, J., Kunkel, K., Stephens, G., Thorne, P., Vose, R., Wehner, M., Willis, J., Anderson, D., Doney, S., Feely, R., Hennon, P., Kharin, V., Knutson, T., Landerer, F., Lenton,T., Kennedy, J., Somerville, R. (2014). Ch. 2: Our Changing Climate. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, T.C. Richmond, and G. W. Yohe (eds.), U.S. Global Change Research Program, Washington DC, pp. 19-67.

	Climate Change Observations\Measurements	Future Climate Change Predictions	Potential Impact to Soil Erosion & Sediment Control
Precipitation-Quantity	Annual and seasonal averages have also measure increases. As noted in 2019 CT-PSCAR, "Easterling et al. (2017) showed that annual precipitation during 1986-2015 increased by 5-15% over most of the Northeast relative to the 1901-1960 climatology, and the largest increase was found for the fall season (+15% over most of the region)."[3]	Again these trends are expected to continue, As noted in the 2019 CT-PSCAR, "[b]ased on output from CMIP5 models (RCP8.5), Walsh et al. (2014) and Easterling et al. (2017) found that by the end of the 21st century precipitation amount in the Northeast during winter and spring would increase significantly (by 10-30%) with a high degree of model consensus;"[2]	the capacity of many infiltration systems will be exceeded more frequently than the original design anticipated. Additionally, increased precipitation can wash away seeding.
Wind	Wind speed trends are less certain, however year to year analyses can be obtained from NOAA's National Center for Environmental Information	Similarly, predications for wind speed trends are less certain.	An increase in the occurrence of extreme storms also increases the potential for wind-induced erosion.

[3] Easterling, D.R., Kunkel, K.E., Arnold, J.R., Knutson, T., LeGrande, A.N., Leung, L.R., Vose, R.S., Waliser, D.E., Wehner, M.F. (2017). Precipitation change in the United States. In: Climate Science Special Report:Fourth National Climate Assessment, Volume I. Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.). U.S. Global Change Research Program, Washington DC, pp. 207-230.