

# Correction Action Plan

Version: Draft

**United States Coast Guard  
Lake Champlain Aids to Navigation Steel Lattice  
Tower Light House Point, Isle La Motte, Vermont  
VTDEC SMS ID: #2024-5457**

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## LIST OF ACRONYMS

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AMSL – above mean sea level  
ARA – Absolute Resources Associates  
bgs – below ground surface  
BMP – best management practice  
BUL – Button Underground Locating LLC  
CACCR – Corrective Action Construction Completion Report  
CAP – Corrective Action Plan  
CEU – Civil Engineering Unit  
COC – chain of custody  
COI – contaminant of interest  
COPC – contaminant of potential concern  
COR – contracting officer representative  
CQCM – Construction Quality Control Manager  
Credere – Credere Associates, LLC  
CSM – conceptual site model  
CV – coefficient of variation  
DI – deionized water  
DQCR – Daily Quality Control Report  
DQO – data quality objectives  
DU – decision unit  
DUA – data usability assessment  
EDD – electronic data deliverable  
EI – Engineer Intern  
EPA –Environmental Protection Agency, [United States]  
ESCP – Erosion and Sedimentation Control Plan  
GNSS – global navigation satellite system  
GPR – ground penetrating radar  
GPS – global positioning system  
iRULE – Vermont Department of Environmental Conservation (VTDEC) Environmental Protection Rules Chapter 35 – Investigation and Remediation of Contaminated Properties Rule  
ISM – incremental sampling methodology  
ITRC – Interstation Technology and Regulatory Council  
LCP – lead-containing paint  
LCS – laboratory control spike  
LCSD – laboratory control spike duplicate  
LG – Licensed Geologist  
LOD – limit of detection  
LOQ – limit of quantitation  
LSP – Licensed Site Professional  
MDL – method detection limit  
mg/kg – milligrams per kilogram  
 $\mu\text{g}/\text{m}^3$  – micrograms per cubic meter

MS/MSD – matrix spike/matrix spike duplicate  
NETL - Northeast Environmental Testing Laboratory, Inc.  
NOAA – National Oceanic & Atmospheric Administration  
NPS – National Park Service  
PD – percent difference  
PE – Professional Engineer  
PEL – permissible exposure limit  
PG – Professional Geologist  
PM10 – particulate matter smaller than 10 micrometers  
PPE – personal protective equipment  
QA – quality assurance  
QC – quality control  
QCM – Quality Control Manager  
RPD – relative percent difference  
SDG – sample delivery group  
SHM – Safety and Health Manager  
Site – Light House Point Property  
SIWP – Site Investigation Work Plan  
SOP – standard operating procedure  
SOW – Statement of Work  
SSHO – Site Safety and Health Officer  
TCLP – toxicity characteristic leaching procedure  
UCL – upper confidence limit  
USCG – United States Coast Guard  
USGS – United States Geological Survey  
UST – underground storage tank  
VGS – Vermont Geological Survey  
VTANR – Vermont Agency of Natural Resources  
VTDEC – Vermont Department of Environmental Conservation  
XRF – X-Ray Fluorescence [meter]  
%R – percent recovery  
° - degrees



## EXECUTIVE SUMMARY

Credere Associates, LLC (Credere) was retained by the United States Coast Guard (USCG) Civil Engineering Unit (CEU) Providence based in Warwick, Rhode Island, under contract 70Z0G123CABCD0007, to prepare and execute a Corrective Action Plan (CAP) at the USCG Lake Champlain Aids to Navigation Steel Lattice Tower, located on Light House Point in Isle La Motte, Vermont (Site). A Site Location Plan is provided as **Figure 1**, and a Detailed Site Plan including pertinent Site features is included as **Figure 2**. This CAP is completed in accordance with and as required by the *Statement of Work (SOW) for Environmental Site Investigation (ESI) Services, Site Remediation and Restoration Modification, PSN 6156736, Lake Champlain Aids to Navigation Steel Lattice Tower, Isle La Motte, VT (USCG, 2024)*.

This CAP is also being prepared in accordance with the Vermont Department of Environmental Conservation (VTDEC) Investigation and Remediation of Contaminated Properties Rule (IRule) §35-606 dated February 23, 2024, to address contamination at the Site identified in Credere's November 14, 2023, Site Investigation Report (SIR). An Evaluation of Corrective Action Alternatives (ECAA) was not prepared as the project is exempt under §35-604(b)(4) of the VTDEC IRule.

Previous investigation by Northeast Environmental Testing Laboratory, Inc. of Providence, Rhode Island identified lead-containing paint (LCP) on the tower base (0.229 percent [%]) and tower lattice (15.4 %). Lead in surface soil samples ranged from 920 milligrams per kilogram (mg/kg) to 2,334 mg/kg, each exceeding the VTDEC IRule Residential Soil Standard for lead of 400 mg/kg.

Credere's November 14, 2023, SIR delineated lead and mercury in soil exceeding the VTDEC Residential Soil Standard around the Site lattice tower. This delineation was based on the VTDEC Residential Soil Standards of 400 mg/kg for lead and 10.9 mg/kg for mercury under the VTDEC IRule, dated July 6, 2019, and totaled approximately 12 and 12.5 cubic yards, respectively. However, since the field work performed in October-November 2023, the VTDEC revised the IRule, dated February 23, 2024, which lowered the Residential Soil Standard for lead from 400 mg/kg to the state residential background concentration of 41 mg/kg. Based on this change, the extent of the excavation that exceeds the 41 mg/kg is likely beyond the current delineation and, in lieu of additional pre-delineation to this level, the soil concentrations at the excavation extent will be field screened in real time during excavation progress to determine the extent. A maximum of 110 cubic yards is estimated for possible removal within the total Site boundaries. The concrete footings for the former lattice tower will also be removed.

This CAP outlines the procedures and specifications for implementing this corrective action. The CAP also outlines the methodology for assessing the efficacy of the corrective action after implementation. Soil will be remediated to reduce lead and mercury concentrations to below the VTDEC IRule Residential Soil Standard, which will be demonstrated through soil screening using an x-ray fluorescence meter (XRF) and by collecting confirmatory laboratory soil samples. Ongoing operation and maintenance and institutional controls are not anticipated as part of the



corrective action as all contaminants of potential concern (COPC)/exposure pathways will have been removed from the Site.

## 1. INTRODUCTION

Credere Associates, LLC (Credere) was retained by the United States Coast Guard (USCG) Civil Engineering Unit (CEU) Providence based in Warwick, Rhode Island, under contract 70Z0G123CABCD0007, to prepare and execute a Corrective Action Plan (CAP) at the USCG Lake Champlain Aids to Navigation Steel Lattice Tower, located on Light House Point in Isle La Motte, Vermont (Site). A Site Location Plan is provided as **Figure 1**, and a Detailed Site Plan including pertinent Site features is included as **Figure 2**. This CAP is completed in accordance with and as required by the *Statement of Work (SOW) for Environmental Site Investigation (ESI) Services, Site Remediation and Restoration Modification, PSN 6156736, Lake Champlain Aids to Navigation Steel Lattice Tower, Isle La Motte, VT (USCG, 2024)*, which is included in **Appendix A**.

This CAP is also being prepared in accordance with the Vermont Department of Environmental Conservation (VTDEC) Investigation and Remediation of Contaminated Properties Rule (IRule) §35-606 dated February 23, 2024, to address contamination at the Site identified in Credere's January 17, 2024, Site Investigation Report (SIR). An Evaluation of Corrective Action Alternatives (ECAA) was not prepared as the project is exempt under §35-604(b)(4) of the VTDEC IRule.

### 1.1 PURPOSE AND SCOPE

Northeast Environmental Testing Laboratory, Inc. of Providence, Rhode Island, conducted an initial investigation at the Site in August 2010 (NETL, 2010). Paint chip samples identified lead-containing paint (LCP) on the tower base and tower lattice. Lead in surface soil samples ranged from 920 milligrams per kilogram (mg/kg) to 2,334 mg/kg, each exceeding the VTDEC iRULE Residential Soil Standard for lead of 400 mg/kg at the time.

Credere's November 14, 2023, SIR (Credere, 2023b) delineated lead and newly identified mercury in soil exceeding the VTDEC Residential Soil Standard around the Site lattice tower. This delineation was based on the VTDEC Residential Soil Standards of 400 mg/kg for lead and 10.9 mg/kg for mercury under the VTDEC IRule, dated July 6, 2019, and totaled 17.31 cubic yards of impacted soil. However, since the field work performed in October-November 2023, the VTDEC revised the IRule, dated February 23, 2024, which lowered the Residential Soil Standard for lead from 400 mg/kg to the state residential background concentration of 41 mg/kg. Based on this change, the extent of the excavation that exceeds the 41 mg/kg is likely beyond the current delineation and, in lieu of additional pre-delineation to this level, the excavation extent will be live screened during excavation to determine the extent. A maximum of 110 cubic yards is estimated for possible removal within the total Site boundaries. The concrete footings for the former lattice tower will also be removed.

Further details on the extent of contamination are provided in the conceptual site model (CSM) included in **Section 3**. These results were used to guide the remedial design and activities planned herein.



## 1.2 SITE DESCRIPTION AND HISTORY

Circa 1856, a stone pyramid with a lantern was erected and acted as the first beacon at the Site (D'Entremont, n.d.). In 1881, the existing Keeper's Quarters and 25-foot-tall conical cast iron lighthouse were built (NPS, 1994), followed by the addition of a brick oil house in 1906. In 1933, the beacon was shifted to an approximately 25-foot-tall steel skeleton tower (also referred to as a lattice tower) when the Site lighthouse ceased operations (NPS, 1994). In 1949, the Keeper's Quarters and the lighthouse were sold to the Clark family, who retain ownership (D'Entremont, n.d.) and the USCG retained ownership and easement to the lattice tower and surrounding 0.0293 acres. During at least a portion of the lattice tower operation, the beacon was battery powered. Batteries were reportedly disposed of on the tree line during historical operation of the lattice tower beacon. In 2002, the lighthouse returned to service as a result of historic restoration and the lattice tower was abandoned (D'Entremont, n.d.).

Grassy areas surround the tower, except for vegetation (cedar trees) to the south and southwest. Residential development in the area is sparse with the nearest residence more than 500 feet to the south and southeast of the Site. The adjoining Keeper's Quarters is currently vacant.

The Site's potable water is supplied by an off-Site well. Electricity is provided by Vermont Electric Coop via overhead lines. The off-site residence is heated with oil from an underground storage tank (UST) located southeast of the Site.

The Site is located at 44.906618° N Latitude, -73.343677° W Longitude.

## 1.3 PROPOSED REUSE

The Site is planned to be sold to the abutting land owner, who will presumably keep the land as open yard area.

## 1.4 OBJECTIVES

The objectives of the activities outlined in this CAP include the following:

- Remove the lattice tower from the tower base to a mutually agreed upon location as coordinated between the USCG and adjoining property owner.
- Remediate soil impacted by lead and mercury in excess of the VTDEC Residential Soil Standards to reduce risk of exposure to current or future occupants. The approach will incidentally address detections of hexavalent chromium that are believed to be false positives due to interference by the other Site COPC (i.e., mercury).
- Properly manage and dispose of soil as a non-hazardous waste at an appropriately licensed landfill (planned facility is Coventry Landfill in Newport, Vermont).
- Restore Site conditions in the remedial excavation area.



## 2. SUMMARY OF PREVIOUS INVESTIGATIONS

The following are summaries of prior environmental reports completed for the Site:

### **Paint and Soil Testing, Northeast Environmental Testing Laboratory, Inc., August 2010**

NETL of Providence, Rhode Island, conducted an initial prior investigation at the Site in August 2010 (NETL, 2010), which included two (2) paint chip samples (one from the steel tower lattice, and one from the steel tower base) and eight (8) surface soil samples. Paint chip sampling identified lead-containing paint (LCP) on the tower base (0.229 percent [%]) and from the tower lattice (15.4 %). Surface soil samples were collected from each of the four sides of the tower's approximately 10-foot by 10-foot base where the tower base contacts the ground surface. An additional four (4) surface soil samples were collected 12-inches out from the base, one on each side. Lead in surface soil samples ranged from 920 milligrams per kilogram (mg/kg) to 2,334 mg/kg, each exceeding the Vermont Department of Environmental Conservation (VTDEC) Environmental Protection Rules Chapter 35 – Investigation and Remediation of Contaminated Properties Rule (IRULE; VTDEC, 2019b) Residential Soil Standard for lead of 400 mg/kg at the time.

### **Site Investigation Report, Credere, November 14, 2023**

The primary purpose of the site investigation (SI) was to meet the scope outlined in the *SOW for ESI Services, PSN 6156736, Lake Champlain Aids to Navigation Steel Lattice Tower, Isle La Motte, VT (USCG, 2023a)* and the *Statement of Work for Environmental Site Investigation Services for Mercury Contamination Modification 1 (USCG, 2023b)*, and in accordance with the *Site Investigation Work Plan (Credere, 2023a)*. The following specific objectives were established for the scope of work:

- Delineate the horizontal and vertical extent of lead-impacted soil surrounding the Site skeleton tower that exceeds the VTDEC Residential Soil Standard for lead
- Establish the presence or absence of other unassessed constituents of interest (COIs), including other Resource Conservation and Recovery (RCRA) 8 metals (including speciation of hexavalent chromium from total chromium), volatile organic compounds (VOCs), total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), asbestos, and pesticides in soil surrounding the Site skeleton tower
- Assess if soil meets the definition of a hazardous waste for remedial planning purposes
- Identify utilities that may be affected by or hinder future remedial actions
- Identify and evaluate a local source of native backfill to replace soil remediated during future excavation activities and document backfill soil concentrations.

Based on identification of mercury as an additional COI that exceeded the VTDEC Residential Soil Standard during the lead delineation work in May 2023, the following additional objective was added to the scope of work:

- Delineate the horizontal and vertical extent of mercury-impacted soil surrounding the Site lattice tower that exceeds the VTDEC Residential Soil Standard

The following tasks were completed to address these objectives:

- A geophysical survey/utility clearance of investigation areas at the Site
- A lead in soil step-out assessment around the Site lattice tower, including sampling for additional metals (RCRA 8 metals with speciation of hexavalent chromium from total chromium)
- Incremental sampling methodology (ISM) sampling around the Site lattice tower to assess for additional COIs (TPH, PAHs, PCBs, asbestos, and pesticides) with discrete sampling for VOCs
- Supplemental mercury in soil step-out assessment where mercury was documented exceeding the VTDEC Residential Soil Standard during the May 2023 lead delineation work
- Collection of waste characterization samples from lead-impacted soil excavation areas
- Collection of soil sample from local source of backfill to document native concentrations that will be used to replace remediated soil during future excavation activities

Based on cumulative work conducted to date, Credere's conclusions regarding the previously established COIs and the investigation results, are presented below:

- The presence of lead and mercury in soil in excess of the VTDEC Residential Soil Standard was confirmed around the Site lattice tower. Delineated lead and mercury impacted soil totals approximately 12 and 12.5 cubic yards, respectively.
- VTDEC was notified of the concentrations of lead and mercury in soil via the Waste Management & Prevention Division on June 16, 2023, after receipt of the laboratory analytical results, data usability assessment, and tabulation. SMS ID 2024-5457 was assigned.
- No additional COIs were identified other than lead and mercury. Hexavalent chromium was also detected but is believed to be a false positive due to interference by the other Site COPC (i.e., mercury).
- Based on waste characterization results, any excavated soil will be acceptable for disposal at a licensed non-hazardous landfill after facility acceptance.
- Based on analytical results conducted as part of a previous nearby USCG project in Isle La Motte, the Williston Sand, LLC in Williston, Vermont, pit bank run soil is acceptable for use as backfill during future remedial excavation work.
- Based on results of the geophysical survey, there is one potential unidentified utility or obstruction extending from the northeast side of the lattice tower.

Based on the findings and conclusions of the SI and to bring the Site into compliance with applicable VTDEC guidelines, Credere made the following recommendations:

- Stabilize paint on the tower base and lattice prior to removal from the Site to limit the potential for additional LCP to be released to the ground during removal of the skeleton tower.
- Remediate soil impacted by lead and mercury in excess of the VTDEC Residential Soil Standards to reduce risk of exposure to current or future occupants. The approach will incidentally address detections of hexavalent chromium that is believed to be false positives due to interference by other Site COPC (i.e., mercury).
- VTDEC has been notified of the exceedances of the lead and mercury concentrations at the Site. Continue to apprise VTDEC of the progress of the project and provide a copy of this report for the VTDEC project repository.

#### **VTDEC IRule Revision, February 23, 2024**

The SIR delineated the extent of lead and mercury to the direct contact soil standards of 400 mg/kg and 10.9 mg/kg at the time of the SI. However, on February 23, 2024, VTDEC revised the IRule and significantly lowered the lead standard to utilize the non-urban background concentration in Vermont of 41 mg/kg. The mercury standard was also lowered to 3.1 mg/kg. Based on these changes, the delineation in the SIR is no longer sufficient. Due to the unlikelihood of being able to delineate lead to 41 mg/kg using the previous SIR data, the proposed remedial action will use field screening to define the horizontal Site boundaries (if feasible) or remove the entirety of surface soil from the small USCG-owned property.



### 3. CONCEPTUAL SITE MODEL

A CSM was developed and will be updated in subsequent reports as new information becomes available or Site conditions change. This CSM includes a Site description, Site history, description of the physical setting of the Site, source areas and COPCs, nature and extent of contamination, exposure pathways, and potential human and environmental receptors.

#### 3.1 BACKGROUND

A Site background, including a description of the Site and Site history, is provided in **Section 1.1**.

#### 3.2 PHYSICAL SETTING

##### **Topography**

Based on Site observations and the United States Geological Survey (USGS) Topographic Map of the Rouses Point Quadrangle, New York-Vermont, the local area topography slopes to the west towards Lake Champlain, located immediately west of the Site; however, the Site around the lattice tower is generally flat. The Site is located at an elevation of approximately 112 feet above mean sea level (AMSL), with a latitude of 44.906497 degrees (°) North and longitude of 73.343444° West. An excerpt from the topographic map (USGS, 2019) has been included as **Figure 1**.

##### **Geology**

###### *Surficial Geology*

According to the Vermont Geological Survey (VGS) map, Surficial Geologic Map of Vermont (VGS, 1970), the Site is mapped as underlain by till. Till at the Site is described as till mantling the bedrock and reflecting the topography of the underlying bedrock surface, which is thicker in the valleys and thinner on the uplands. Marine/lacustrine sand may also be found at the Site, which would have been deposited during the presence of glacial and post-glacial lakes (or the Champlain Sea). Based on Site observations, surficial geology from 0 to 1-foot below ground surface (bgs) generally comprised a layer of sandy topsoil, which was underlain by increasingly finer soils (silt and clay) with depth with evidence of lacustrine inclusions (e.g., shells). During prior assessment, sampling was able to be conducted to approximately 2 feet bgs in most locations without encountering refusal.

###### *Bedrock Geology*

According to the USGS map, Bedrock Geologic Map of Vermont (Ratcliffe, 2011), the Site is underlain by the Stony Point Formation of the Trenton Group-Mohawkian Stage-Champlainian Series-Ordovician System, which typically consists of black, fissile, carbonaceous, calcareous shale. Bedrock outcrops may be present along the shoreline west of the Site. These potential outcrops could not be observed due to the lake water level at the time of the SI.

##### **Hydrology**

The Site is located within the surficial drainage basin of Lake Champlain, which is located approximately 50 feet west of the Site. Stormwater likely infiltrates the landscaped portions of the



Site or flows overland to Lake Champlain. Of note, a retaining/sea wall is present along the base of slope near the western Site boundary.

Based on mapped topography and the location of the nearest surface water body, groundwater at the Site is presumed to flow westward toward the nearby Lake Champlain.

### **Changing Climate Concerns**

Based on the National Oceanic and Atmospheric Administration (NOAA) interactive map of Sea Level Rise and Coastal Flooding Impacts (NOAA, 2023; <https://coast.noaa.gov/slr/#/layer/slr>), sea level rise of up to 6 feet and associated increased coastal flooding is not expected to impact the Site. The Site is not located within a flood zone according to Federal Emergency Management Association (FEMA) Flood Insurance Rate Map (FIRM) 5002240010B, effective April 15, 1980 (FEMA, 1980). Based on the base flood elevation of 102 feet AMSL and elevation of the Site ranging from 108-112 feet AMSL, the Site is not expected to flood.

Based on the nature of the proposed use of the Site and location of the Site outside of a flood zone, changing temperature, wildfires, changing dates of ground thaw/freezing, changing ecological zone, and saltwater intrusion are not likely to affect remediation at the Site. The adjacent lake may be impacted by more frequent and greater intensity storms; however, as the general contamination is located well above the lake elevation, these storms and any impacts to the lake are not likely to affect remediation at the Site.

### **3.3 SOURCE AREAS AND CURRENT CONTAMINANTS OF POTENTIAL CONCERN**

Based on the cumulative results of prior investigations, the current source areas and COPCs are listed below.

#### **Source Areas**

The following source areas were identified at the Site based on the known history, the SI, and previous environmental investigations for the Site:

- Site lattice tower
- Historical operations (batteries or light)

#### **COPC**

Based on previous environmental investigation at the Site, current COPCs that have been documented to exceed VTDEC standards at the Site include the following:

- Lead
- Mercury

Hexavalent chromium was detected above the VTDEC standards; however, is believed to false positives due to analytical interference from other Site contaminants (i.e., mercury) and since it



will be incidentally remediated with other Site COPCs, is not considered a formal COPC because there is no known source.

### 3.4 NATURE AND EXTENT

Based on cumulative results of current and previous environmental investigations at the Site, the nature and extent of COPCs and inferred nature and extent of COIs is summarized below:

#### **Lead in Soil**

As expected, lead concentrations were highest closer to the Site tower, and gradually decreased until meeting the former delineation criteria. Lead in soil impacts extended furthest in step out lines C, C/D, and D, located on the northeast, north, and northwest sides of the Site tower, respectively; however, based on the revised IRule soil standards, the extent is currently unknown. Final Site boundary XRF screening results were generally the VTDEC standard of 41 mg/kg near the surface (0-1 foot) and decreases to at or below the standard with depth.

Vertically in soil, lead concentrations were highest at the surface with diminishing concentrations with depth; a few areas nearer the Site tower had higher lead concentrations at deeper depths, but these instances were likely where soil from above had fallen into the screening hole as screening locations around these areas did not show similar lead concentrations at depth. Vertical screening and analytical results from the toxicity characteristic leaching procedure (TCLP) generally confirm lead is primarily bound within the paint and is not soluble under typical rainwater chemical conditions, and potential for vertical migration of lead through leaching and downward percolation of rainwater is considered limited.

Calculations of the volume of lead-impacted soil are presented on **Figure 3** along with color-coded depictions of the horizontal and vertical extents of lead in soil.

#### **Mercury in Soil**

Mercury in Site soils was not anticipated and the source at the Site is not readily apparent based on current Site conditions but is believed to be from the historical discarding of beacon batteries in the vicinity, or from a mercury containing light fixture during prior operations. Generally, mercury distribution trends radially southeast to northwest of the tower along the tree line and concentrations diminish with depth and distance from the Site tower. Mercury in soil impacts extended furthest in step out lines A and D, located on the southwest and northwest sides of the Site tower, respectively; however, the highest laboratory confirmed mercury in soil concentration was observed at the Site boundary in step-out location interval B-6 (0-0.5) on the southeast side of the Site tower at 27 mg/kg. Only step-out line D reached the 15-foot maximum screening distance from the Site tower established in the SIWP but the final two screening locations served as delineation with results below the mercury standard. The extent remains a data gap relative to the revised IRule standard but should be easily delineated in the field during remediation with a combination of XRF screening for lead, which appears more extensive in extent, and laboratory confirmatory samples.

Vertically in soil, mercury concentrations were highest at the surface with diminishing concentrations with depth; similar to lead, a few areas nearer the Site tower had higher mercury concentrations at deeper depths, but these instances were likely where soil from above had fallen into the screening hole as screening locations around these areas did not show similar mercury concentrations at depth. Vertical screening and TCLP analytical results generally confirm mercury is primarily bound to surface soil particles and is not soluble under typical rainwater chemical conditions, and leaching with vertical migration through downward percolation of rainwater is considered limited.

Calculations of the volume of mercury-impacted soil are presented on **Figure 4** along with color-coded depictions of the horizontal and vertical extents of mercury in soil.

Mercury has the potential to form vapors in elemental form (liquid droplets). As there are no buildings and considering the relatively low concentrations, vapor phase mercury is not anticipated at the Site.

### 3.5 EXPOSURE PATHWAYS & POTENTIAL RECEPTORS

Exposure pathways describe how a human or environmental receptor come into contact with contaminants that may be present at the Site. Potential migration pathways through groundwater, standing water, air, soils, sediments, and biota were considered for lead and the source areas. A migration pathway is considered an exposure pathway if there is a mechanism of contaminant release from primary or secondary sources, a transport medium, and a point of potential contact with a receptor. Both current and potential future releases and migration pathways to receptors are considered. Exposure pathways presented in the CSM include the following:

Inhalation	This pathway is primarily associated with vapor-forming soil or groundwater contamination beneath or near an occupied structure or preferential pathway to an occupied structure. This pathway is applicable when receptors may inhale impacted media in the form of contaminated vapor. This pathway is also applicable when contaminated soil and/or groundwater are exposed via an excavation.
Dermal Absorption:	Exposure via dermal absorption occurs when receptors are exposed to chemical concentrations present in soil, groundwater, surface water, or hazardous building materials through direct contact with the skin.
Active Ingestion:	The active ingestion pathway represents exposure which may occur through the active ingestion of contaminant concentrations via a drinking water supply well or through direct consumption of soil (e.g., typically by children or improper hygiene/health and safety of soil workers).
Incidental Uptake:	This pathway is applicable when receptors may incidentally inhale or ingest impacted media in the form of contaminated dust or chips.



Potential Receptors are categorized by duration of exposure and intensity of use at the Site. Based on the current use and/or proposed redevelopment of the Site, the receptor categories described in the CSM include the following:

- |                      |  |
|----------------------|--|
| Resident:            | The residential receptor is defined by high durational exposure and high intensity usage which may occur through gardening, digging, and recreational sports. This group includes the occupants of a residential property or a residential neighborhood, or a daycare. |
| Construction Worker: | Excavation or construction workers are present at the Site for short durations though intensity of use is high, such as during non-routine activities including construction or utility work. Examples include utility and construction contractors and landscapers.   |

### 3.6 CSM SUMMARY

Site COPCs include lead and mercury. Current and future receptors at the Site include construction workers during remediation activities or future site work and residents/visitors of the house (the surrounding house property is periodically occupied by the Owners for landscape maintenance and lake access). No public access is currently permitted. Exposure pathways would include dermal absorption through direct contact with contaminated soil, incidental uptake of contaminated dust, or active ingestion of contaminated materials, or through inhalation by construction workers in excavations if mercury is in elemental form and at a sufficient concentration (not anticipated based on current understanding). All current exposure pathways are anticipated to be removed by the corrective action including backfilling of the excavation with at least 2 feet of clean fill.



#### 4. PUBLIC NOTICE

Upon a determination by VTDEC that the CAP meets all applicable requirements, the draft approved CAP will be provided to the Site owner, USCG, as well as adjoining properties for public comment. In addition, VTDEC will post the draft approved CAP online for additional public review and comment. Interested persons will have 30 days from the notice of available CAP to provide comments for consideration. The following table outlines the persons that will be provided a copy of the draft approved CAP for review during the 30-day comment period:

Name	Affiliation	Address	Contact Information
USCG Craig Edmunds	Site Owner	Site	(603) 436-4415 Craig.a.edmunds@uscg.mil
Robert Clark	Adjoining All Directions	Light House Point	Mailing address

A figure detailing the adjoining property is included as **Figure 2**. After the 30-day comment period, a response to comments and final CAP will be provided to interested persons.

## 5. PERFORMANCE STANDARDS

The goal relative to the identified COPCs is to eliminate the risks to human health and the environment through proper management, removal, and disposal of identified COPCs. To achieve this objective, the following cleanup goals or guidelines will be applicable to the cleanup:

### 5.1 ACHEIVMENT OF CORRECTIVE ACTION OBJECTIVE (§35-603)

Soil at the Site containing lead concentrations greater than the VTDEC residential soil standard of 41 mg/kg and mercury with concentrations greater than 3.1 mg/kg will be excavated up to the predefined extents and depths indicated on **Figure 3 and 4** (a maximum depth of 2 feet bgs or refusal). The proposed remedial action removes all soil previously delineated as well as additional soil field delineated in real-time during excavation work. The remedy replaces the contaminated soil with natively sourced clean fill that has been characterized to be below the VTDEC residential soil standards. This proposed action meets the objective listed in §35-603(a)(2). As no contaminated soil will remain within the USCG property, no engineered or institutional controls will be needed.

### 5.2 APPLICABLE ENVIRONMENTAL MEDIA STANDARDS

Soil sample analytical results have been, and future results of any samples collected during cleanup will be, compared to the VTDEC IRule Residential Soil Standards, adopted February 23, 2024.

### 5.3 EVALUATION OF PERFORMANCE

Real time excavation confirmatory soil screening will be completed in accordance with EPA Method 6200 Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment (EPA, 2007) to assess removal of lead-impacted soil to levels below the VTDEC residential soil standard of 41 mg/kg. XRF screening will occur throughout the final excavation on a 2-foot base grid and every 5 feet along the excavation sidewall/perimeter. Locations that exceed the 41 mg/kg screening criteria will be further excavated and re-screened until lead concentrations are below the screening criteria.

Following the removal of lead-impacted soil to the target threshold as measured by XRF or the maximum property boundary extent, confirmatory samples will be collected from remediated areas to confirm the remediation goal has been achieved.

ISM confirmatory samples will be used to calculate a 95% upper confidence limit (UCL) for the excavated areas across the Site for comparison to the VTDEC residential soil standard for lead and mercury. For each DU, data will be tabulated and a coefficient of variation (CV) of increments will be calculated. If replicate results have a CV of increments less than 1.5, results will be used to calculate a UCL using the Students-t method for determining variation. For replicate results with a CV of increments greater than 1.5, the Chebyshev method for determining variation will be used to calculate the UCL. The mean will be used when a CV of increments of 0 is obtained (i.e.,

when replicate results are equal). The mean or UCL will then be compared to the VTDEC Residential Soil Standards.

If the UCL exceeds the VTDEC Residential Soil Standard, Credere will notify the COR that additional excavation or institutional controls may be required. Excavation of additional soil volume beyond the contract volume of 130 cubic yards and outside the Site boundaries must be authorized by the COR.

## **6. LOCAL, STATE, AND FEDERAL PERMITS REQUIRED**

The only required permits for the project are associated with disposal facility approval, which will be obtained and approved by USCG prior to commencement of work at the Site.



## 7. REMEDIAL CONSTRUCTION PLAN

### 7.1 DIGSAFE AND PRIVATE GEOPHYSICAL UTILITY CLEARANCE

To mitigate the potential for damage to subsurface utilities during remedial activities, Credere subcontracted a geophysical utility locator to identify utilities located on the private property during the ESI (i.e., delineation) phase of the project.

On May 8, 2023, Credere subcontracted with Button Underground Locating LLC, of Jeffersonville, Vermont, (BUL) to identify and mark utilities on the Site. Credere instructed the locator to focus on the top 2 feet bgs as that was the maximum depth of assessment planned. BUL employed a Geophysical Survey Systems, Inc. (GSSI) SIR 400 ground penetrating radar (GPR) instrument with a Ridgid Sr24 receiver and ST-510 transmitter, and a Schonsted GA-72C magnetic locator.

The geophysical survey was conducted on the entirety of the Site and included tracing the telephone line offsite to the Keepers' Quarters. Observation of USCG boundary monuments and input from the Owner identified the real extent of the Site. The adjusted Site boundary was collected using a global positioning system (GPS) with sub-meter accuracy (see **Figure 2**). A small anomaly located with GPR was identified on the northeast side of the tower at a shallow depth; BUL provided no further indication of what the feature could be. No other utilities were identified within the Site boundary.

During survey of Site boundaries, an underground storage tank (UST) was identified southeast of the Site and its supply line was traced to the Keepers' Quarters. This UST is located offsite and was reportedly installed by the current owner. The approximate location for avoidance is shown on **Figure 2**.

A summary of the geophysical survey and a sketch prepared by BUL is included in **Appendix D**, and onsite/offsite utilities marked by BUL and recorded by GPS by Credere are depicted on **Figure 2**.

Utilities and any other underground anomalies identified during remediation will be located using a GPS unit and added to a Site plan to be included in the Corrective Action Construction Completion Report (CACCR).

### 7.2 EROSION AND SEDIMENTATION CONTROL PLAN

This Erosion and Sedimentation Control Plan (ESCP) is intended to help ensure compliance with The Vermont Standards and Specifications for Erosion Prevention & Sediment Control (i.e., best management practices [BMPs]; VTDEC, 2019a). BMPs will be implemented to minimize the potential for erosion and prevent sediment from entering roadways, storm sewers, catch basins, wetlands, and/or surface water. BMPs were selected in accordance with The Vermont Standards and Specifications for Erosion Prevention & Sediment Control (VTDEC, 2019a) (included in **Appendix B**) and will be installed according to the design specifications and Vermont Erosion



Prevention and Sediment Control Field Guide (VTDEC, 2006). Controls will be installed prior to the commencement of construction activities, inspected daily, and maintained as necessary to ensure the integrity of the erosion and sedimentation controls.

### **Roadway Cleanliness**

Tracking soil onto roadways will be minimized by constructing temporary gravel roads for truck access to excavation areas. Tarps or polyethylene sheeting will be used to manage any soil that may fall next to trucks during loading. Additionally, construction vehicles will be decontaminated/cleaned to be free of bulk mud, soil, dust, or other residuals on vehicle wheels, fenders, and tailgates prior to leaving the Site and entering the public roadway to prevent tracking impacted materials.

### **Protection of Storm Drain Inlets**

No storm drains or other drainage structures are currently known to be present within the Site. However, upon mobilization, any storm drains present will be identified and marked. Identified stormwater inlets and/or catch basins that are operational during project work and have the potential to receive sediment-laden stormwater flow from the construction Site will be protected using storm drain inlet protection BMPs included in **Appendix B**.

Inlet protection will be cleaned or removed and replaced as sediment accumulates, the filter becomes clogged, and/or as performance is compromised. Accumulated sediment adjacent to the inlet protection measures will be removed by the end of the same workday in which it is found or by the end of the following workday if removal by the same workday is not feasible.

### **Silt Fence**

Silt fence will be installed downgradient, primarily to the west of excavation work. Supplemental BMP details are included in **Appendix B**. The approximate extent of silt fencing required is shown on **Figure 2**.

### **Soil Stabilization**

During excavation, stockpiling soil will be avoided. However, if necessary, stockpiled soil will remain within the excavation extent. At the close of workdays, stockpiles will be covered with polyethylene sheeting to prevent wind erosion, dust migration, and runoff in the event of precipitation.

At the conclusion of work activities, areas with disturbed soil will be restored according to **Section 7.8**. Supplemental vegetation BMP details are provided in **Appendix B**.

### **Inspection and Maintenance**

The erosion and sediment control measures and other protective measures will be inspected daily, and damaged components will be repaired or replaced immediately to ensure good and effective operating condition. Credere will conduct daily inspections of erosion and sediment control measures, particularly after significant rainfall or flooding events, and multiple times daily during

prolonged rain events. Inadequacies will be corrected prior to work commencing in or around the impacted area. The routine inspections will determine the condition and effectiveness of the protective measures.

Any sediment that accumulates will be placed in designated spoil areas, and sediment will not be allowed to migrate offsite. Sediment that has been in contact with contaminated materials will be incorporated into the contaminated materials and disposed of accordingly.

### **Inspection Reports**

Inspections will be documented as a part of the Daily Quality Control Report (DQCR; see **Section 9.4.1**) and will be furnished to the USCG Project Manager the following business day by e-mail. A copy of the inspection report will be maintained on the job site.

## **7.3 DUST CONTROL AND MONITORING PLAN**

This dust monitoring plan is intended to control the generation of fugitive dust and prevent the transport of impacted materials. Monitoring for airborne dust will be visual and measured using real time dust monitors.

### **Dust Control**

Fugitive dust will be controlled using wet suppression to prevent lead-impacted soil from becoming airborne. Several applications per day to roadways and work areas, especially to the excavation area and soil stockpile areas, may be utilized to control dust depending upon weather conditions and work activity. Over-spraying will be avoided as well as the discharge of water outside the work area. Continuous application will be required during active excavation, stockpiling, and/or loading to control the migration of fugitive dust unless freezing conditions inhibit the use of water in the work zone. As a general rule of thumb, no visible dust will be allowed. A mobile dust control unit will be used to supply and spray water, using an off-Site source of water. The source of water will be from a public distribution source.

Excavated soil will typically be loaded directly into trucks or stored in steel containers and covered. Containers and soil stockpiles may also be temporarily placed on and covered with tear resistant, fiber reinforced liner. Vehicles leaving the Site will be inspected and will have no visible mud or dirt on the vehicle body or wheels. Any foreign matter on the vehicle body or wheels shall be physically removed onsite prior to vehicles entering a public roadway. Haul truck cargo areas will be securely and completely covered during material transport on public roadways.

### **Perimeter Air Monitoring**

Perimeter air monitoring for airborne dust will be conducted during potentially dust generating work activities, including excavation and loading/stockpiling of soil. Air monitoring will cease once native soil in the excavation has been covered with clean backfill. Airborne dust will be visually monitored at all times to track the effectiveness of onsite dust suppression measures.



Perimeter dust monitoring will be conducted using Dust Traks capable of providing real time readings in the up-wind and down-wind locations from the work zone, as well as within the work zone, for a total of three (3) dust monitoring locations. The wind direction and speed will be obtained from the NOAA website for Alburg, Vermont, in the morning and mid-day daily to position the dust monitors. The position of the monitors will be recorded in the DQCR with the respective wind direction. Dust Traks will be set to record real time data of the maximum concentration per minute throughout the work period. Manual recording will be conducted approximately every hour to ensure the Dust Traks are continually operating, have not become clogged with dust, and that no action for further dust suppression is required.

Total respirable particulate matter smaller than 10 micrometers (PM10) shall not exceed 150 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ) for a 15-minute period or a permissible exposure limit (PEL) of 5  $\mu\text{g}/\text{m}^3$  for an 8-hour exposure.

Dust Trak data will be downloaded daily and compiled for inclusion in the DQCR and the PRCR (see **Section 9**).

### **Corrective Action**

If visible levels of airborne dust are observed or if the dust action levels are exceeded, the flow rate of water sprayers or added sprayers will be increased to prevent the generation of airborne dust. If this results in the generation of runoff, runoff water will be collected, containerized, and disposed of appropriately with other liquid investigation derived waste. If high winds are contributing to the generation of dust, work may be ceased for the day until wind speeds decrease.

## **7.4 DECONTAMINATION**

Decontamination of field equipment will be completed according to Credere standard operating procedure (SOP) CA-2 (included in **Appendix C**). Miscellaneous tools and equipment used for environmental sampling will be cleaned of bulk material, rinsed, washed with a detergent solution, rinsed with deionized (DI) water, rinsed with nitric acid and finally rinsed with DI water. Decontamination will be performed in contaminated areas or over a containment (bucket or bin) to prevent contamination of clean soil. Clean tools will be placed in a clean container or covered with aluminum foil to prevent cross contamination.

Heavy equipment will be cleaned of bulk material prior to leaving the excavation and again before leaving the Site. Every effort will be made to minimize tracking of contaminated soil from within the excavation to uncontaminated surface soil surrounding the excavation.

## **7.5 WASTE CHARACTERIZATION**

Waste characterization sampling was conducted to develop a waste profile and facilitate offsite disposal of lead impacted soil during the SI on May 11, 2023. Total lead concentrations throughout the delineated excavation area were known to exceed the TCLP 20-times dilution rule or 100 mg/kg (20 X the 5 mg/kg standard); therefore, TCLP analyses were required. Based on the contract volume of 130 cubic yard soil removal volume, approximately 190 tons are estimated. Therefore,

the nearest landfill in Coventry, Vermont, requires one (1) sample per 300 tons for the waste profile. Two (2) composite samples for a full suite of waste characterization analyses were collected from the Site during the SI, which are sufficient for the anticipated contract volume and a minor degree of overage. Based on the max excavation volume of approximately 110 cubic yards/164 tons, these samples should be sufficient for the maximum extent of the excavation area.

Waste characterization samples comprised at least ten (10) aliquots distributed evenly to represent the original soil delineation of the highest concentrations surrounding the tower. Aliquot sample collection was biased to the area delineated in the field that contained lead over the VTDEC lead standard of 41 mg/kg.

Waste characterization results were used to determine if soil could be disposed of as a special waste in a local licensed landfill or if the soil would be considered characteristic hazardous waste once excavated and require disposal at another appropriately licensed landfill (no hazardous waste landfills currently exist in the northeast). The only analytes detected in the waste characterization samples were metals. Total lead and mercury results were above the 20x rule and were also analyzed by TCLP. The lead and mercury TCLP results were below the limits for characterization of hazardous waste. Therefore, any excavated soil should be acceptable for disposal at licensed non-hazardous landfill after facility acceptance.

Site generated waste shall be managed in accordance with Vermont Solid Waste Management Rules (VTDEC, 2020).

## 7.6 CLEAN FILL CERTIFICATION

Backfill will be ‘Bank Run’ sand and loam sourced from Williston Sand, LLC of Williston, Vermont. One (1) sample was collected directly from the pit at Williston Sand, LLC in Williston, Vermont—the planned source of clean fill for backfilling the remedial excavation—as part of a previous local USCG project on May 8, 2023. This sample documented that native concentrations in the pit location do not further introduce contaminants to the Site and the source of backfill is acceptable for use as backfill during any future remedial action at the Site.

## 7.7 REMEDIAL ACTIONS

### *7.7.1 Dismantle And Remove Tower From Site*

The goal of dismantling and removing the tower from the Site is to eliminate the source of lead to soil from the Site. The tower will be removed as the first step in the project so that any paint disturbed during removal will be subsequently removed as part of the soil excavation. The following materials and/or methods are anticipated to be used by subcontractor:

- If feasible, the tower will be unbolted from the concrete footings rather than cut. Given the age of the tower, this is not considered likely and a powered saw will be used to cut the base of the tower as close to the concrete footings as possible.
- Using a telehandler, the tower will then be moved whole to a pre-determined staging area. The staging area will be setup with polysheeting sufficient to wrap the tower securely. The



tower will be laid down on the staged sheeting and wrapped in polyethylene sheeting. Sheeting will be secured with duct tape to prevent rainwater entry.

### ***7.7.2 Removal of Lead and Mercury Impacted Soil by Excavation***

Soil at the Site containing lead concentrations greater than the VTDEC residential soil standard of 41 mg/kg will be excavated to the predefined extents and depths indicated on **Figures 3 through 5** (a maximum depth of 2 feet bgs) plus a buffer of 6 feet to start (developed based on delineation at previous 400 mg/kg lead standard). Soil will be removed beginning at the eastern side of the former lattice tower and moving generally west and northwest. Excavated soil will be staged at the southern corner of the excavation area to minimize traffic for the loader within the excavation and prevent spreading lead-impacted soil over a greater area. Excavation includes work in close proximity to underground obstructions related to Site utilities and one other that is unknown (on northwest side of tower). These areas will be approached with caution and hand tools as needed to safely identify the geophysical anomalies. Groundwater and/or bedrock are not anticipated to be encountered at the proposed excavation depths, based on findings in prior reports.

The cedar trees within the excavation area will be protected as well as possible and excavation will minimize impacts to the roots in this area. Further, the wooden fence at the Site will be dismantled to allow for excavator and vehicle access, then reconstructed post-remediation.

After reaching the initial excavation extent, the perimeter will be screened with the XRF according to **Section 5.3**. If based on confirmatory soil XRF screening, the lead-impacted soil area is determined to be larger than current data indicates, the horizontal extents of the excavation will be increased at 3-foot step-outs to reduce lead to below the XRF field screening target threshold of 41 mg/kg. Step-outs will not exceed the property boundaries shown on **Figure 2**, nor will they extend beyond the contracted 130 cubic yards without USCG approval.

XRF screening will be conducted throughout the excavation bottom (likely at max depth of 2 feet bgs) to document that the excavation vertical extents have removed lead and mercury to below the action levels. If based on confirmatory soil XRF screening, lead impacted soil above the screening target is identified, additional vertical excavation will commence in 6-inch lifts until concentrations are below the screening threshold. Additional vertical excavation will stop at refusal and will not proceed beyond the contracted 130 cubic yards without USCG approval.

### ***7.7.3 Confirmatory ISM Sampling***

At the completion of the excavation, two DUs will be photo documented and confirmatory ISM samples will be collected: one from the final excavation base, and one from the perimeter sidewall of the final excavation. Each DU will be sampled with three replicates.

Each replicate will consist of 30 increments in a simple random pattern throughout the excavation bottom and sidewalls. Increments will be unbiased and represent the entire area of the DU.

Increments will be collected using a flat bottom scoop and extruded into a 1-gallon resealable bag. Samples will be submitted to Eurofins Portsmouth (formerly Absolute Resource Associates

[ARA]) of Portsmouth, New Hampshire, for ISM processing to include air drying and Japanese slabcake segmenting. Samples will then be analyzed for lead and mercury by EPA method 6020B and 7471B.

#### ***7.7.4 Soil Management, Transportation, and Disposal***

##### **Onsite Soil Handling**

###### ***Impacted Soil***

Excavated soil will be live-loaded into 15-yard roll off containers staged at the edge of the excavation. The roll off truck will enter the Site using Light House Point Road and will remain on the driveway unless moving containers. Containers will be covered with tarps or a manufactured cover system when not in use and/or while being transported.

###### ***Clean Backfill***

Clean soil will be placed directly into the completed excavation. Backfill will be placed and bucket-compacted in 12-inch lifts. If needed, clean soil transported onsite will alternatively be placed in a designated clean stockpile area to avoid mixing contaminated and clean soil. Equipment will be decontaminated prior to handling clean soil if it has been previously in contact with contaminated soil.

##### **Soil Transport and Disposal**

Trucks will transport impacted soil directly to the landfill with a non-hazardous waste manifest provided to each truck and signed by the waste generator (USCG) or Credere as authorized agent. Soil disposal at the Casella landfill in Coventry, Vermont, is anticipated, but is pending approval.

## **7.8 SITE RESTORATION**

##### **Restoration and Seeding**

Excavation areas and other grassy areas disturbed by heavy equipment will be restored to a grass surface. Excavation areas will be restored by backfilling with bank run sand and a minimum of 6 inches of loam at the surface. Areas impacted by heavy equipment will be graded to eliminate ruts, and loam will be spread at the surface. All impacted areas will be hydroseeded. Seed shall be selected based on the Site locality. Subsequent watering will be the responsibility of USCG.

##### **Additional Site Features**

Additional Site features, such as fence posts and minor landscape features, will be restored to original conditions if impacted by remedial activities. Existing materials will be reused.

## **7.9 BEST MANAGEMENT PRACTICES FOR GREEN AND SUSTAINABLE REMEDIATION**

In accordance with ASTM E2893-13, Standard Guide for Greener Cleanups, the proposed best management practices for remedial activities have been selected to address the core elements of

energy consumption, air quality, water quality, materials and waste, and land and ecosystems. The proposed best management practices specific to Site remedial actions include:

- Implementation of an idling management plan for trucks and excavators
- Use of local staff (including subcontractors) when possible to minimize resource consumption
- Establishment of green requirements as evaluation criteria in the selection of contractors and include language in requests for proposals, requests for quotations, subcontracts, contracts, etc.
- Use of phosphate free detergents or biodegradable cleaning products instead of organic solvents or acids to decontaminate sampling equipment.

## 7.10 SCHEDULE

The following schedule is proposed, pending approval of this CAP:

Task/Milestone	Date of Delivery
Draft Corrective Action Plan	August 16, 2024
Receipt of USCG/VTDEC comment on Corrective Action Plan	September 13, 2024
Draft Public Notice to Abutters	August 31, 2024
VTDEC Submission of Public Notice	August 31, 2024
Submittal of Final Corrective Action Plan	September 20, 2024
Site Mobilization, Remediation, and Restoration	September 23, 2024
Draft CACCR/Risk Assessment Report	November 1, 2024
Receipt of USCG/VTDEC comment on CACCR/Risk Assess.	November 15, 2024
Final CACCR/Risk Assessment Report/Certification Letter	November 22, 2024
Contract Completion/Closeout	December 23, 2024
Mailing of Final Report Hard Copies	December 23, 2024

All remedial work will be conducted between the hours of 0700 and 1800, unless otherwise approved by the USCG



## **8. OPERATIONS AND MAINTENANCE PLAN**

An operations and maintenance plan is not required for the project, as all COPCs and exposure pathways at the Site will have been removed at completion of the correction action.

### **8.1 INSTITUTIONAL CONTROL PLAN**

As no contaminants above the VTDEC residential soil standards are anticipated to remain, no institutional controls are needed. However, institutional controls may need to be evaluated if the vertical extent of contamination cannot be reduced to below the residential soil standard due to refusal.

### **8.2 LONG TERM MONITORING PLAN**

No long-term monitoring will be required.



## 9. QUALITY ASSURANCE & QUALITY CONTROL PLAN

### 9.1 DATA QUALITY OBJECTIVES (DQO)

The primary DQO is to ensure a) measurements are representative of actual Site conditions and data resulting from field, sampling, and analytical activities be comparable, reproducible, and generated in a scientifically valid and legally defensible manner; and b) judgments can be made against the applicable comparison criteria with minimized uncertainty for making project decisions.

The primary analytical DQO will be for the LOQ to be sufficiently lower than the associated VTDEC Residential Soil Standard. VTDEC Residential Soil Standards and laboratory analytical sensitivities are presented in the following table for comparison to identify compounds that can be adequately assessed using standard Environmental Protection Agency (EPA) methods. Methods are sufficiently low to assess concentration in a residential setting. Laboratories will follow standard analytical methods to ensure their quality assurance.

Analyte	VTDEC Residential Soil Standard (mg/kg)	Limit of Quantification (LOQ) (mg/kg)	Limit of Detection (LOD) (mg/kg)	Method Detection Limit (MDL) (mg/kg)
<b>Metals by EPA Method 6020B</b>				
Lead	41	2.5	1.2	0.92
<b>Mercury by EPA Method 7471B</b>				
Mercury	3.1	0.144	0.08	0.03

Note: LOQ, LOD, and MDL values provided by ARA

The accuracy range for lead with the Innov X XRF is  $\pm 8$  mg/kg. Given the field screening target threshold of 41 mg/kg, and the narrow accuracy range, the XRF is performing adequately for lead assessment purposes.

Laboratories will follow standard analytical methods to ensure their quality assurance.

### 9.2 STANDARD OPERATING PROCEDURES

The following Credere standard operating procedures (SOPs) will be followed and are included in **Appendix C**.

SOP No.	SOP Title
CA-1	Field Activity Documentation
CA-2	Equipment Decontamination Procedures
CA-5	Environmental Soil Sampling
CA-16	Chain of Custody
CA-18	Lead Paint Activities and XRF Safety
CA-20	Relative Elevation Survey & Trimble GNSS Basic Operation
CA-26	Incremental Sampling Methodology

GNSS – global navigation satellite system

XRF-X-ray fluorescence



ISM sampling will also be in accordance with the guidance of the ITRC ISM document (ITRC, 2020).

### 9.3 SAMPLE HANDLING

#### **Sample Identification**

Confirmatory ISM samples will be identified by indicating the DU the sample is associated with (i.e., ILMDU-BASE or ILMDU-SW), as shown on **Figure 2**. Replicate DU samples will be designated as follows: ILMDU-BASE-1, ILMDU-BASE-2, and ILMDU-BASE-3.

#### **Sample Labeling**

Each sample container will be affixed with a self-sticking, waterproof, adhesive label. Each label shall be completed with a pen of indelible ink or a permanent marker and contain the following information:

- Client Name: Credere Associates, LLC
- Site Name: USCG Isle La Motte Steel Lattice Tower
- Site Location: Isle La Motte, Vermont
- Client Sample ID: ILMDU1-1, for example
- Date Collected: (month/day/year)
- Sample Time: given in 24-hour format (for example: 1400)
- Initials of Collector: Credere field sampler
- Analytical method/analysis requested

#### **Sample Chain of Custody**

Credere will follow procedures outlined in Credere SOP CA-16. ARA will provide Credere with approved chain of custody (COC) forms to be completed by field personnel, which are designed to ensure each sample is accounted for at all times. A chain of custody form must be completed by the appropriate sampling and laboratory personnel for each sample.

The objective of the sample custody identification and control system will be to assure the following:

- Samples scheduled for collection are uniquely identified.
- The correct samples are analyzed and are traceable to their records.
- Samples are protected from loss, damage, or tampering.
- Alteration of samples (e.g., filtration, preservation) is documented.
- A forensic record of sample integrity is established.



The COC form includes the following:

- Sample number and sample bottle identification number, where applicable
- Names of the sampler(s) and the person shipping the samples
- Purchase order number and/or project number
- Name, telephone number, and fax number or email address of the contact person from Credere
- Project name (including specific portion of the Site if a large project)
- Signature of the sampler
- Date and time that the samples were collected
- Names of those responsible for receiving the samples and the date and time received at the laboratory
- Matrix of the sample
- The number of containers for each sample
- Analysis, container type, and preservative information
- Required deliverable (i.e., Electronic Data Deliverable [EDD])

Corrections to a chain of custody will be made by putting a line through the incorrect entry and initialing and dating it. The chain of custody record will accompany the samples to the laboratory and a carbon copy of the chain of custody will be retained by the sampler. The chain of custody forms will be supplied by the laboratories with the data package and will be included with the laboratory analytical reports.

Sample delivery groups (SDGs) will be limited to 20 samples per COC and will generally include a Credere designated matrix spike/matrix spike duplicate (MS/MSD) where feasible.

### **Sample Handling**

Samples will be stored onsite in coolers packed with ice until they are sent to the laboratory for analysis. ISM samples will be double bagged to prevent leakage into the bags. Ice will be added to the cooler, and the chain of custody form will be placed in the cooler in a waterproof bag. Samples will be placed in the coolers directly after sampling to prevent overexposure to sunlight and to keep them cool for preservation.

Field personnel will be responsible for the security of the samples before they are shipped/transferred to the laboratory. Coolers and samples will be stored in a secure or monitored area onsite until they are shipped/transported to the laboratory. During times of excessive heat or prolonged holding of samples, the field personnel are responsible to maintain the ice preservation and avoid the submersion of sample containers in water and obscuring the sample labels.

Sample coolers will be sealed with a custody seal and duct/packing tape, if using a courier service, and then transported to the laboratory for analysis.

## 9.4 REPORTING

### 9.4.1 Field Documentation

Field documentation will be completed according to Credere SOP CA-1.

#### **Field Logbook**

Field activities will have a dedicated field logbook, which will be reviewed for accuracy and completeness in accordance with Credere's SOP CA-1 by the Project Manager and scanned into the electronic project file with an appropriate file designation that includes the field activity and date at a minimum.

The daily entry will begin at the top of a new page and be printed legibly. Entries will be recorded using a 24-hour time clock and entered in the order that they occur. A new entry for each day will begin with the following:

- Date and project at the top of the page
- First and last name of Credere employee followed by initials and time of arrival onsite
- Full names and initials of additional team members and the time of their arrival onsite
- Scope of work for the day
- Weather (e.g., temperature, precipitation, wind directions) and tides
- Subcontractors and duties (e.g., driller, make and model of drilling equipment, foreman)
- Documentation of a safety acknowledgement or toolbox meeting

If field activities extend beyond one (1) page, each successive page shall have the date, project and initial of person doing logbook entries written at the top. If the logbook changes hands during a daily entry, the initial writer shall sign after their last entry and the full name and initials of the new writer shall be entered consecutively.

The final page of a daily entry shall have open lines marked diagonally with a strike and shall be signed and dated.

The following is a partial list of information typically recorded during field tasks:

- Level of personal protective equipment (PPE)
- Changes to PPE level
- Changes in personnel
- Sampling equipment serial numbers
- Equipment calibration details



- Decontamination procedures
- Field screening results
- Observations
- Unusual circumstances
- Problems encountered
- Deviations from the work plan
- Problem resolutions
- Safety issues/accidents/near misses/discussions with contractors
- Safety resolutions
- Name and time onsite/offsite of anyone who enters the Site
- Correspondence with project managers
- Sample IDs
- Sample depths
- Method of collection
- Sample times
- Sample analysis requested
- Sample preservation
- Sample volume collected
- QC samples
- Sample duplicate locations
- Site sketch
- Changes in weather

### **Daily Reporting**

A DQCR will be completed each day that work is conducted onsite by the onsite CQCM and will be submitted to USCG electronically the following business day.

The DQCR will include a summary of daily construction activities, as well as a summary of daily phases of work inspections, safety and health meetings, conferences, issues, incidents, near misses, daily monitoring results (Dust Trak data), any sampling results, and actions taken to address and resolve any encountered safety and health issues. The DQCR will include information describing the cause of delays, impacts, or changes to the work, if any, and will contain sufficient information as to describe why the work was affected.

#### ***9.4.2 Corrective Action Construction Completion Report***

Upon completion of field work, Credere will prepare a CACCR including a summary of information and results collected during prior investigations, a narrative of work performed, documentation of waste facility profiling and acceptance, documentation of clean fill certification, a presentation of laboratory analytical and field screening confirmatory results compared to VTDEC Residential Soil Standards, Site figures identifying sample locations, a Site photo log, and field work documentation including chains of custody, laboratory analytical reports, transportation and disposal records, DQCR, and quality assurance (QA)/QC documentation. The CACCR will also include any necessary recommendations.



## **Data Usability Assessment**

The CACCR will include a DUA. Laboratory data will be evaluated in accordance with the National Functional Guidelines. The data quality indicators are discussed below and include precision, bias, accuracy, representativeness, comparability, completeness, and sensitivity.

### *Precision*

Precision refers to the closeness of agreement between individual test results obtained under prescribed conditions. Both field and laboratory replicates are used to assess the total precision of data. Field precision is determined from field duplicate samples. For environmental samples laboratory precision is determined from lab duplicate samples (MS/MSD or laboratory duplicate samples). To establish the precision of a given analytical method without the effect of a matrix, a laboratory control sample is necessary. A laboratory control spike (LCS) /LCS duplicate (LCSD) is used for most analyses. Precision is measured by relative percent difference (RPD). The criteria for acceptable RPDs will be the laboratory established limits.

Precision is quantified through the use of the following mathematical formulae:

- For two (2) samples, RPD

$$RPD = [ | A - B | \div \frac{(A + B)}{2} ] \times 100$$

Where,

A and B are the concentrations (or percent recoveries) detected in the two (2) samples.

Coefficient of Variation is quantified through the use of the following mathematical formula:

- For three (3) samples, CV

$$CV = (SD/Mean) \times 100$$

Where,

SD is the standard deviation of the sample concentrations and

Mean is the mean of the sample concentrations

### *Bias*

Bias refers to the systematic or persistent distortion of a measurement process that causes errors in a single direction (above or below the true value or mean). Bias assessments are typically based upon the analysis of spiked reference materials or spiked samples (LCS, LCSD, MS, MSD and surrogate spikes). Bias values are expressed as percent recovery (%R). The % Bias = %R – 100. For this project, the bias is determined by the percent recovery lower and upper limits as defined by the laboratory for LCSs, MSs and surrogate spikes.



### *Accuracy*

Accuracy is the measure of the closeness of an observed value to the true value. It is assessed by the LCS, MS/MSD and surrogate spike recoveries.

Accuracy is quantified using the following equations:

- %R in authentic samples (e.g., matrix spikes)

$$\%R = [(C_s - C_u) \div S] \times 100$$

Where,

$C_s$  = concentration of spiked sample

$C_u$  = concentration in unspiked sample and

$S$  = expected concentration of spike in sample

- Percent Recovery based on known concentrations (e.g., surrogates)

$$\%R = (C_s \div C_c) \times 100$$

Where,

$C_c$  = certified or true concentration and

$C_s$  = concentration of sample

- Percent Difference (PD) based on known concentrations (e.g., certified reference material)

$$PD = (|C_c - C_s| \div C_c) \times 100$$

Where,

$C_c$  = certified or true concentration and

$C_s$  = concentration of sample

### *Representativeness*

Representativeness refers to the degree to which sample data accurately and precisely describe the characteristics of a population of samples, parameter variations at a sampling point, or environmental condition. Representativeness is a parameter that is concerned primarily with the proper design of the sampling program. Representativeness can be assessed by a review of the precision obtained from the field and laboratory duplicate samples.

### *Comparability*

Comparability is a qualitative objective of the data, expressing the confidence with which one (1) data set can be compared with another. Sample data should be comparable for similar samples and sample conditions. Comparability is achieved using standard techniques to collect representative samples, consistent application of analytical method protocols, and reporting analytical results with appropriate units.



### *Completeness*

Completeness is the percentage of measurements judged to be usable compared to the total number of measurements planned. The completeness goal for this project is 100% given the small number of samples included in meeting the DQOs.

### *Sensitivity*

Sensitivity is used to describe the method reporting limits to meet the project DQOs. The LOQ represents the value at which the laboratory has demonstrated the ability to reliably quantitate target analytes within a prescribed performance criterion for the method, and establishes the lowest concentration at which the data may be reported without qualification as an estimated value.



## 10. COST

The following is breakdown of anticipated cost for implementation of each component of the corrective action:

Finalizing CAP/Public Review	\$14,000
Consulting and Engineering/Project Management	\$15,000
Environmental Cleanup Oversight	\$101,000
Completion Reporting	\$6,500
10% Contingency	\$13,650
<b>Total</b>	<b>\$150,150</b>



## 11. PROJECT TEAM AND CONTACT INFORMATION

The following table summarizes project personnel and project stakeholders contact information for field reference.

Name	Role/Title	Organization	Contact Information
Craig Edmunds	Contracting Officer Representative (COR)	USCG	(603) 436-4415 Craig.a.edmunds@uscg.mil
Daniel Walker	Contracting Officer	USCG	(401) 736-1764 Daniel.b.walker@uscg.mil
Rip Patten, PE, LSP	Program Manager, Vice President, Engineer	Credere	(207) 730-1039 rpatten@credere.com
Theresa Patten, PE	Quality Control Manager (QCM), President, Engineer	Credere	(207) 730-1053 tpatten@credere.com
Allison Drouin, PG, LG	Project Manager, Alternate QCM, Geologist	Credere	(207) 749-1141 adrouin@credere.com
Nathaniel Weiss	Technical Lead, Construction QCM (CQCM)/Alternate Site Safety and Health Officer (SSHO), Engineer	Credere	(518) 570-1718 nweiss@credere.com
Connor Duffy, EI	CQCM/SSHO, Engineer	Credere	(610) 908-7218 cduffy@credere.com
Grant Kern, EI	Alternate CQCM/SSHO, Engineer	Credere	(207) 807-9991 gkern@credere.com
Sean Gannon, PG	Alternate CQCM/SSHO, Geologist	Credere	(860) 733-2510 sgannon@credere.com
Lauren Kaija, EI	Alternate CQCM/SSHO, Engineer	Credere	(802) 952-3669 dwalker@credere.com
Chris Beahm	Safety & Health Manager (SHM), Environmental Scientist	Credere	(207) 766-1473 cbeahm@credere.com
Stacy Towne	Alternate CQCM/SSHO, Field Technician	Credere	(207) 284-3056 stowne@credere.com
Scott Sampson	Landfill Sales and Marketing	Casella Waste Systems	(603) 235-3597 scott.sampson@casella.com
Aaron Dewees	Laboratory QC Officer, Chemist	Eurofins Portsmouth (formerly ARA)	(603) 436-2001 Aaron.dewees@et.eurofinsus.com

LG – Licensed Geologist  
EI – Engineer Intern

PE – Professional Engineer  
LSP – Licensed Site Professional

PG – Professional Geologist



## 12. REFERENCES

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## FIGURES



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DATE: 03/28/2023

CHECKED BY: ASD

PROJECT: 23001761



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## FIGURE 1 SITE LOCATION PLAN

LAKE CHAMPLAIN AIDS TO NAVIGATION  
STEEL LATTICE TOWER  
LIGHT HOUSE POINT, ISLE LA MOTTE, VT

1,000 0 2,000  
Feet

1 inch = 2,000 feet





Community

Economy

Environment

**Drawn by:** NWW  
**Checked by:** ASD

**Date:** 02/15/2024  
**Project:** 23001761

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BASEMAP SOURCE: GOOGLE EARTH

**FIGURE 2**  
**DETAILED SITE PLAN**

**LAKE CHAMPLAIN AIDS TO NAVIGATION**  
**STEEL LATTICE TOWER**  
**LIGHT HOUSE POINT, ISLE LA MOTTE, VT**

SITE BOUNDARY	UNDERGROUND STORAGE TANK	WOOD FENCE
PARCEL BOUNDARY	TELEPHONE LINE JUNCTION BOX	SILT FENCE
STEEL LATTICE TOWER	DISCRETE VOC SAMPLE LOCATION	POSSIBLE UNDERGROUND UTILITY
DECISION UNIT	STEP OUT SAMPLE LOCATION	TELEPHONE LINE
EXCAVATION EXTENT	2-FOOT ELEVATION CONTOURS	RETAINING WALL

NOTES:  
1. EXISTING CONDITIONS AND FEATURES SHOWN ON THIS PLAN ARE APPROXIMATE AND ARE BASED ON INFORMATION OBTAINED FROM THE TOWN OF ISLE LA MOTTE ONLINE GIS DATA, VERMONT GIS PARCEL LAYER, BLANK 2018 AERIAL PHOTOS, ADN FIELD WORK PERFORMED BETWEEN MAY 8 AND 11, 2023, AND AUGUST 3, 2023.  
2. SEE FIGURE 3 AND 4 FOR LEAD AND MERCURY RESULTS AND DELINEATION, RESPECTIVELY  
3. THE SOLE ABUTTING LANDOWNER CONSISTS OF MR. ROBERT CLARK, WHOSE PROPERTY ENCOMPASSES THE SITE.

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APPROXIMATE LEAD-CONTAMINATED SOIL EXCAVATION VOLUME

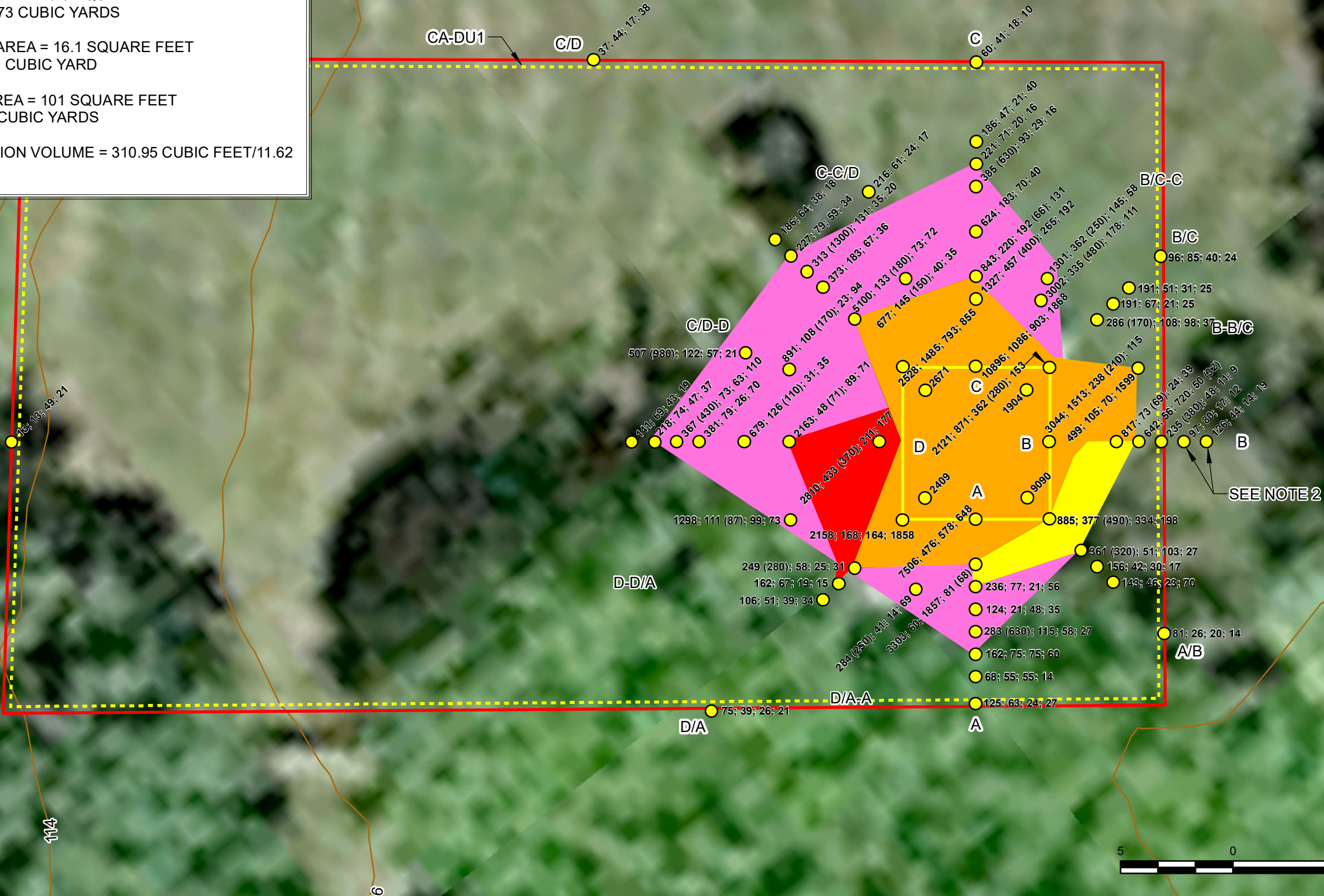
0.5-FOOT EXCAVATION DEPTH AREA = 130 SQUARE FEET  
130 X 0.5 = 65 CUBIC FEET/2.41 CUBIC YARDS

1-FOOT EXCAVATION DEPTH AREA = 19.8 SQUARE FEET  
19.8 X 1.0 = 19.8 CUBIC FEET/0.73 CUBIC YARDS

1.5-FOOT EXCAVATION DEPTH AREA = 16.1 SQUARE FEET  
16.1 X 1.5 = 24.15 CUBIC FEET/1 CUBIC YARD

2-FOOT EXCAVATION DEPTH AREA = 101 SQUARE FEET  
101 X 2 = 202 CUBIC FEET/7.48 CUBIC YARDS

APPROXIMATE TOTAL EXCAVATION VOLUME = 310.95 CUBIC FEET/11.62 CUBIC YARDS



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**FIGURE 3**  
**LEAD RESULTS AND DELINEATION**  
LAKE CHAMPLAIN AIDS TO NAVIGATION  
STEEL LATTICE TOWER  
LIGHT HOUSE POINT, ISLE LA MOTTE, VT

- SITE BOUNDARY
- STEEL LATTICE TOWER
- DECISION UNIT
- 2-FOOT ELEVATION CONTOURS
- RETAINING WALL
- 2-FOOT EXCAVATION
- 1.5-FOOT EXCAVATION
- 1-FOOT EXCAVATION
- 0.5-FOOT EXCAVATION
- STEP OUT SAMPLE LOCATION

NOTES:  
1. EXISTING CONDITIONS AND FEATURES SHOWN ON THIS PLAN ARE APPROXIMATE AND ARE BASED ON INFORMATION OBTAINED FROM THE TOWN OF ISLE LA MOTTE ONLINE GIS DATA, VERMONT GIS PARCEL LAYER, BLANK 2018 AERIAL PHOTOS, AND FIELD WORK PERFORMED BETWEEN MAY 8 AND 11, 2023.  
2. THE B-7 AND B-8 LOCATIONS WERE COMPLETED PRIOR TO LEARNING TRUE SITE BOUNDARY FROM OWNER.

APPROXIMATE MERCURY-CONTAMINATED SOIL EXCAVATION VOLUME

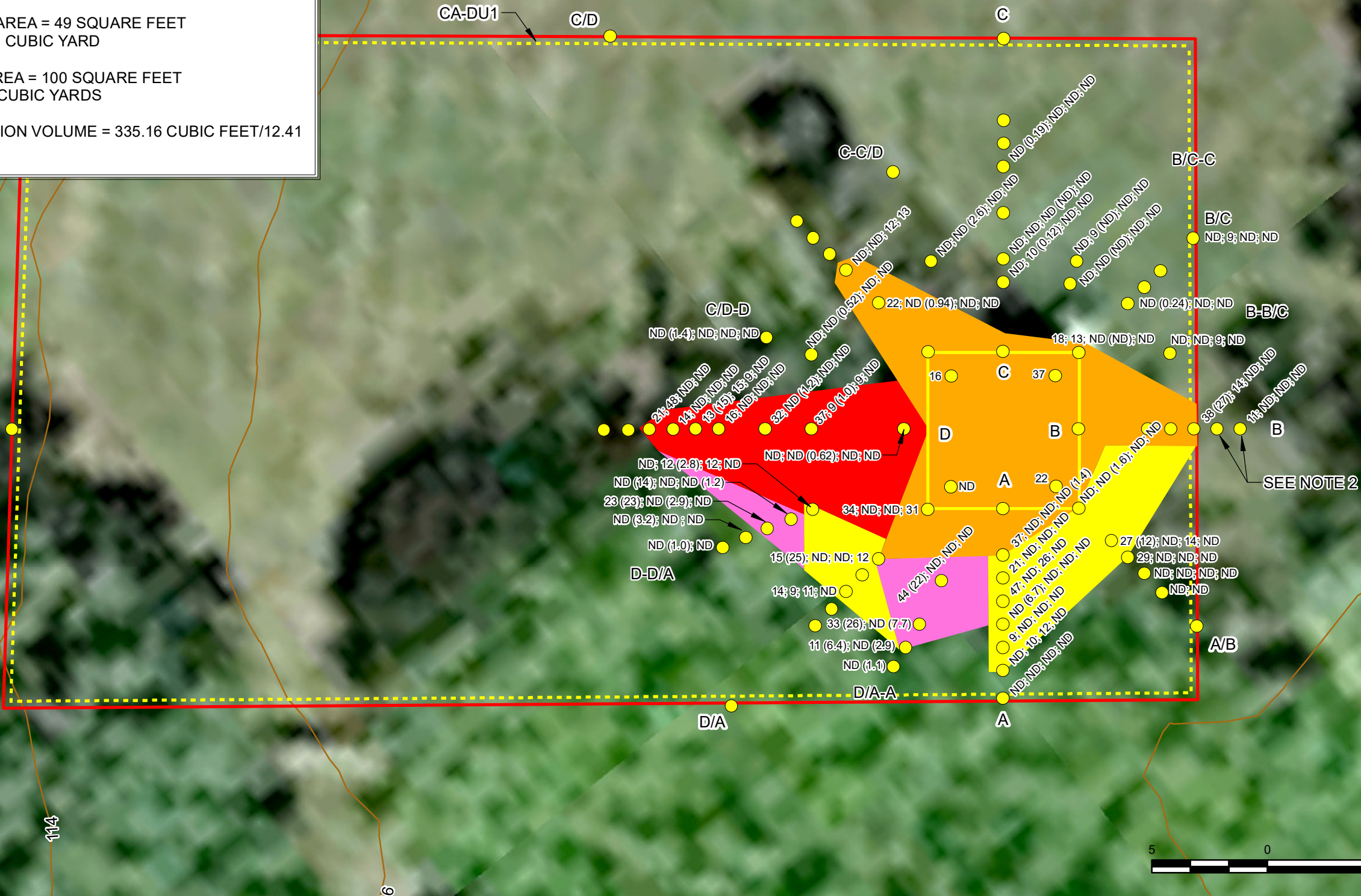
0.5-FOOT EXCAVATION DEPTH AREA = 23 SQUARE FEET  
23 X 0.5 = 11.5 CUBIC FEET/0.43 CUBIC YARDS

1-FOOT EXCAVATION DEPTH AREA = 50.16 SQUARE FEET  
50.16 X 1.0 = 50.16 CUBIC FEET/1.86 CUBIC YARDS

1.5-FOOT EXCAVATION DEPTH AREA = 49 SQUARE FEET  
49 X 1.5 = 73.5 CUBIC FEET/2.72 CUBIC YARD

2-FOOT EXCAVATION DEPTH AREA = 100 SQUARE FEET  
100 X 2 = 200 CUBIC FEET/7.41 CUBIC YARDS

APPROXIMATE TOTAL EXCAVATION VOLUME = 335.16 CUBIC FEET/12.41 CUBIC YARDS



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**FIGURE 4**  
**MERCURY RESULTS AND DELINEATION**

LAKE CHAMPLAIN AIDS TO NAVIGATION  
STEEL LATTICE TOWER  
LIGHT HOUSE POINT, ISLE LA MOTTE, VT

- SITE BOUNDARY

STEEL LATTICE TOWER

DECISION UNIT

2-FOOT ELEVATION CONTOURS

RETAINING WALL

2-FOOT EXCAVATION (MERCURY DELINEATION)

1.5-FOOT EXCAVATION (MERCURY DELINEATION)

1-FOOT EXCAVATION (MERCURY DELINEATION)

0.5-FOOT EXCAVATION (MERCURY DELINEATION)

STEPOUT SAMPLE LOCATION
- NOTES:

1. EXISTING CONDITIONS AND FEATURES SHOWN ON THIS PLAN ARE APPROXIMATE AND ARE BASED ON INFORMATION OBTAINED FROM THE TOWN OF ISLE LA MOTTE ONLINE GIS DATA, VERMONT GIS PARCEL LAYER, BLANK 2018 AERIAL PHOTOS, AND FIELD WORK PERFORMED BETWEEN MAY 8 AND 11, 2023, AND ON AUGUST 3, 2023.

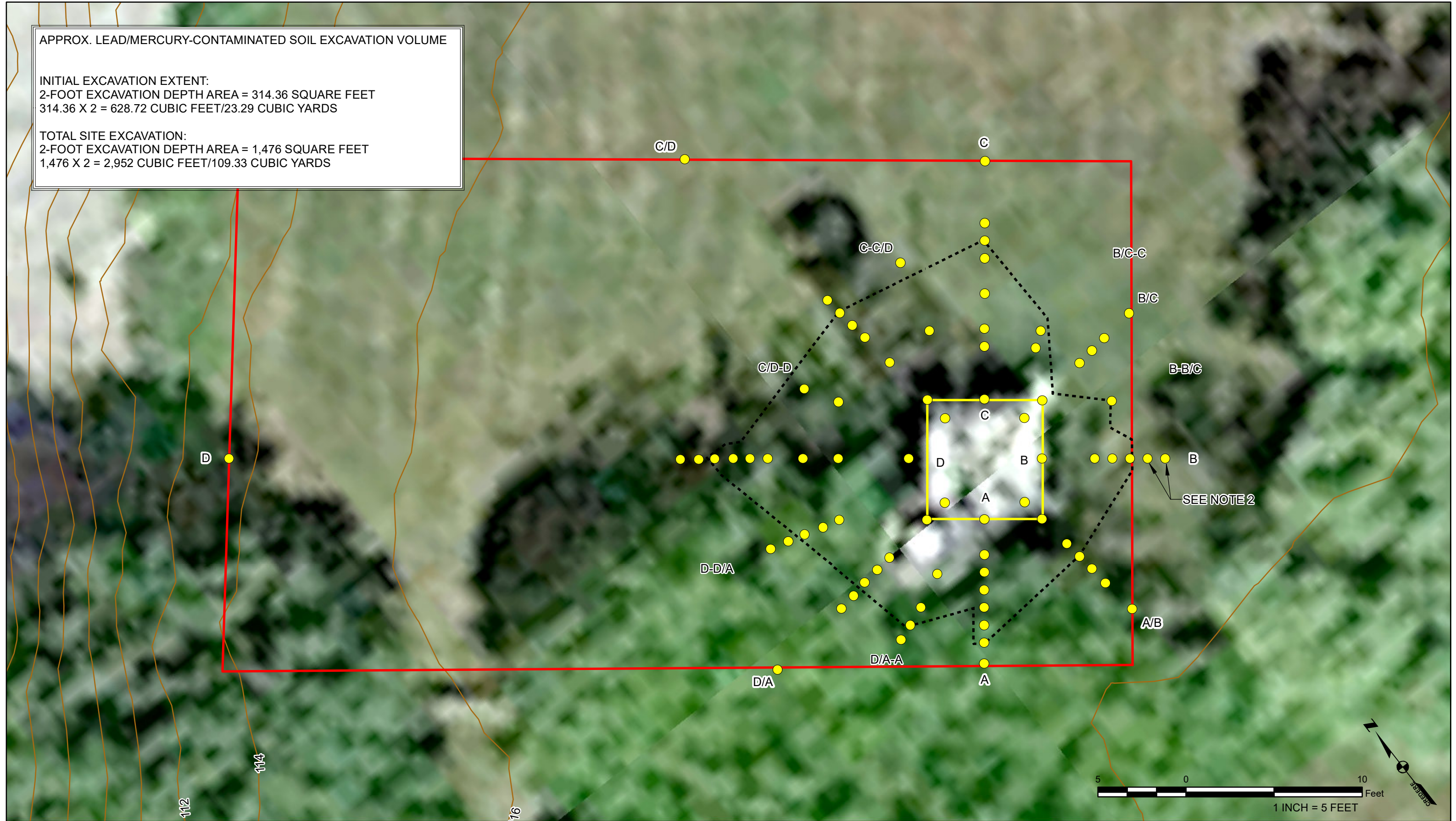
2. THE B-7 AND B-8 LOCATIONS WERE COMPLETED PRIOR TO LEARNING TRUE SITE BOUNDARY FROM OWNER.

3. MERCURY WAS NOT DETECTED BY XRF OR IN LAB SAMPLE FOR ANY STEP OUT SAMPLE LOCATION WITHOUT ASSOCIATED VALUES.
- BASEMAP SOURCE: GOOGLE EARTH
- Document Path: T:\Data\VT\Town\Isle La Motte\23001761 - USCG Steel Lattice Tower\Figure\_4\_Mercury Results.mxd

APPROX. LEAD/MERCURY-CONTAMINATED SOIL EXCAVATION VOLUME

INITIAL EXCAVATION EXTENT:  
2-FOOT EXCAVATION DEPTH AREA = 314.36 SQUARE FEET  
314.36 X 2 = 628.72 CUBIC FEET/23.29 CUBIC YARDS

TOTAL SITE EXCAVATION:  
2-FOOT EXCAVATION DEPTH AREA = 1,476 SQUARE FEET  
1,476 X 2 = 2,952 CUBIC FEET/109.33 CUBIC YARDS



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CHECKED BY: ASD

DATE: 08/14/2024  
PROJECT: 23001761

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**FIGURE 5**  
**CUMULATIVE LEAD AND MERCURY**  
**IN SOIL DELINEATION**

LAKE CHAMPLAIN AIDS TO NAVIGATION  
STEEL LATTICE TOWER  
LIGHT HOUSE POINT, ISLE LA MOTTE, VT

SITE BOUNDARY/EXCAVATION EXTENT

STEEL LATTICE TOWER

INITIAL EXCAVATION EXTENT

2-FOOT ELEVATION CONTOURS

RETAINING WALL

STEP-OUT SAMPLE LOCATION

NOTES:  
1. EXISTING CONDITIONS AND FEATURES SHOWN ON THIS PLAN ARE APPROXIMATE AND ARE BASED ON INFORMATION OBTAINED FROM THE TOWN OF ISLE LA MOTTE ONLINE GIS DATA, VERMONT GIS PARCEL LAYER, BLANK 2018 AERIAL PHOTOS, AND FIELD WORK PERFORMED BETWEEN MAY 8 AND 11, 2023.  
2. THE B-7 AND B-8 LOCATIONS WERE COMPLETED PRIOR TO LEARNING TRUE SITE BOUNDARY FROM OWNER.

## **APPENDIX A**

### **STATEMENT OF WORK AND MODIFICATION OF CONTRACT**

DEPARTMENT OF HOMELAND SECURITY  
UNITED STATES COAST GUARD  
SHORE INFRASTRUCTURE LOGISTICS CENTER

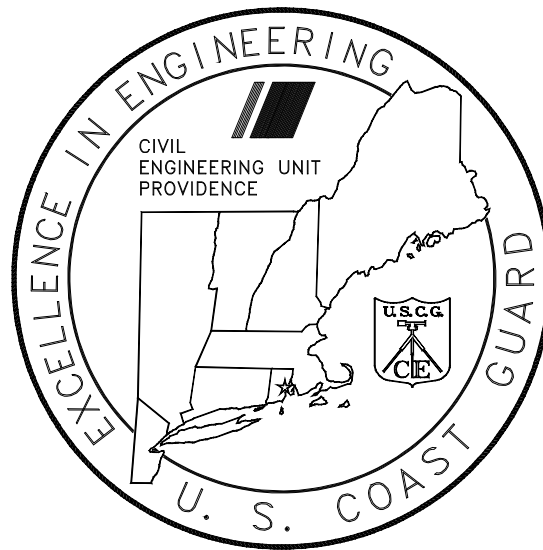
STATEMENT OF WORK

FOR

ENVIRONMENTAL SITE INVESTIGATION SERVICES  
SITE REMEDIATION AND RESTORATION  
MODIFICATION 2

PSN 6156736

LAKE CHAMPLAIN AIDS TO NAVIGATION STEEL LATTICE TOWER  
ISLE LA MOTTE, VT



C. EDMUNDS  
PROJECT ENGINEER

M. ANDREWS  
BRANCH CHIEF

COMMANDING OFFICER  
UNITED STATES COAST GUARD  
CIVIL ENGINEERING UNIT PROVIDENCE  
475 KILVERT STREET, SUITE 100  
WARWICK, RHODE ISLAND 02886

## **TABLE OF CONTENTS**

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### **2.0 WORKPLAN REVISIONS AND UPDATES**

### **3.0 EXECUTION OF THE SITE INVESTIGATION WORK PLAN (SIWP)**

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#### **B. REMEDIATE AND RESTORE CONTAMINATED SOILS**

### **4.0 POST REMEDIATION CLOSURE REPORT AND RISK ASSESSMENT**

### **5.0 SUBMITTALS**

## STATEMENT OF WORK

### SITE REMEDIATION/RESTORATION SERVICES MODIFICATION 2

Lake Champlain Aids to Navigation  
Steel Skeleton Tower with Associated Land  
Isle La Motte, VT  
PSN: 6156736

#### 1.0 GENERAL REQUIREMENTS

The contractor shall provide all professional services, equipment, tools, labor, and transportation necessary to remediate contamination identified in the revised Isle LaMotte Site Investigation Report (SIR). Actions necessary to complete this task are as follows:

- Dismantle steel lattice light tower and relocate onsite to a location determined by the Coast Guard and adjacent landowner. Dispose of all concrete steel lattice foundation/footings.
- Remove, replace, and dispose of all contaminated soils.
- Restore site to existing contaminant free conditions.

Effective 23 February 2024; VTDEC Environmental Protection Rules Chapter 35 *Investigation and Remediation of Contaminated Properties* Rule changed the residential limit for lead to 41 mg/kg. This rule now supersedes all previous versions. Due to these changes in regulations, it is necessary to further delineate the surveyed property and remove lead contaminated soils above 41 mg/kg.

Contractors shall be responsible for obtaining all necessary permits to accomplish work. Permits may include but not be limited to wetlands, solid/hazardous waste disposal etc.

The technical point of contact (POC) and the Contracting Officer's Representative (COR) at USCG Civil Engineering Unit (CEU) Providence is Mr. Craig Edmunds, Environmental Protection Specialist, Mr. Edmunds may be reached by telephone at (508) 962-8605 or by email at [Craig.A.Edmunds@uscg.mil](mailto:Craig.A.Edmunds@uscg.mil).

#### 2.0 WORKPLAN CREATION, REVISIONS AND UPDATES

The Contractor shall prepare a Remedial Action Workplan (RAWP) and other associated work plans in accordance with VTDEC requirements as necessary to be inclusive of the procedures proposed to satisfy all requirements in this contract modification. At a minimum, the RAWP shall also include but not be limited to:

- Proposed site preparation operations.
- Proposed schedules and timelines.
- Proposed notifications
- Procedures to ensure site integrity, erosion, dust and sediment controls while mobilized onsite.

- Procedures to promote safe work practices.
- Procedures necessary to dismantle and remove/relocate existing light tower and foundation.
- Procedures to prevent additional site contamination or off-site contamination during remedial actions via roadways, dust or other means.
- Procedures to excavate/remediate contaminated soils identified in the SIR.
- Procedures to restore all disturbed areas to contaminant free conditions. All clean soil transported to the property shall be laboratory tested and meet VTDEC residential criteria including but not limited to pesticides, petroleum compounds, metals, VOCs, SVOCs, etc.
- Procedures to ensure contaminated material are disposed of properly at a licensed facility.

### **3.0 EXECUTION OF THE REMEDIAL ACTION WORK PLAN (RAWP)**

Upon review and approval by the COR of the Final RAWP, the Contractor shall provide all materials, tools, labor and transportation to execute the fieldwork component of the plan. The Contractor shall provide a minimum of two weeks advance notice via email to the COR prior to initiating work on the site. Prior to mobilization, in accordance with the requirements listed in Section 1 above, the contractor shall provide all notifications and or reports to VTDEC and land abutters accordingly.

If the Environmental Professional/Contractor determine that site conditions warrant additional notification to VTDEC, the COR shall be notified immediately. The COR and Environmental Professional/Contractor shall discuss the notification and assess options to bring the site into compliance under the VTDEC regulations prior to notification to VTDEC. The Contractor shall be responsible for all VTDEC submission and notifications and fees, if applicable.

#### **A. DISMANTLE/REMOVE EXISTING TOWER AND CONCRETE FOOTINGS**

The contractor shall dismantle the existing steel lattice light tower and relocate to a mutually agreed location as determined by the Coast Guard. Care should be taken during removal so not to lose the integrity of the tower. All concrete/footings shall be excavated and removed from site and disposed of according to all federal, state and local regulations and requirements. The tower shall not be relocated until the proposed location is identified in writing from the COR and based on communications with the abutting property owner. The tower shall be laid on a heavy-duty plastic tarp and wrapped and taped for storage.

#### **B. REMEDIATE AND RESTORE CONTAMINATED SOIL**

The contractor shall provide removal, disposal, and restoration services to remove all contaminated soils and materials identified in the final SIR and new requirements and limits listed in the revised VTDEC Environmental Protection Rules Chapter 35 *Investigation and Remediation of Contaminated Properties* Rule.

- To accomplish this task and to successfully achieve the newly adopted lead in soil threshold limits of 41 mg/kg., the contractor shall perform additional field survey sampling while working in parallel with the remedial actions. Contractor shall use field survey equipment, hand augers and other necessary equipment and sample all areas within the property boundary as outlined in the SIR and RAWP.

- Starting at the target contaminated zones listed in the SIR and RAWP and to delineate the lateral extent of contamination, step-out sampling of soils shall be performed until XRF results indicated lead levels are no longer present above the 41 mg/kg screening criteria or if refusal is met. step-out sampling of soils shall be performed at 3-ft intervals outward from each sampling point until limits are achieved or property boundaries are met, whichever comes first.
- To delineate the vertical extent of contamination, contractor shall collect XRF samples at six (6) inch intervals from below the ground surface (0-6 inches below ground surface (bgs), 6-12 inches, 12-18, inches and 18-24, inches etc.) until XRF results indicated lead levels are no longer present above the 41 mg/kg screening criteria or refusal was met. Contractor may at their discretion, deviate from this conceptual plan as necessary as long as all contaminated materials above 41 mg.kg are identified, removed, and disposed of properly.
- Approximately 30 cubic yards of contaminated soil is anticipated to be removed and disposed of based on the results of the final SIR. Due to VTDEC new adopted rules, an additional 100 cubic yards are anticipated for removal and disposal, making a total of 130 cubic yards to be removed and disposed. Additional soil remediation volume beyond the contract volume of 130 cubic yards shall be authorized via contract modification. The Contractor shall dispose of all impacted soils at a licensed facility approved by the Coast Guard.
- All areas requiring remediation shall be restored to its original condition, graded, compacted with clean fill/loam, hydroseeded and initially watered prior to demobilization off-site. A minimum of 6" of clean topsoil is required in restored areas. Subsequent watering will be performed at the discretion of the Coast Guard. All fill material and loam shall be laboratory tested prior to ensure materials do not exceed the VTDEC. Standard of 41 mg/kg.
- Post-excavation confirmation soil sampling in the excavation sidewalls and bottoms shall be performed. XRF analysis may be used to field screen confirmation soil samples. However, all final samples shall be laboratory confirmed. For bidding purposes, assume 25 laboratory samples. If confirmation samples exceed 41 mg/kg VTDEC residential standards for lead, the Contractor shall notify the COR that additional excavation beyond the contract volume is required. The notification to the COR shall be via email and include a sketch of areas requiring further excavation and an estimate of the additional volume to be excavated to achieve compliance.
- The Contractor shall restore to original condition, any building components, and landscaped areas or paved/concrete surfaces that are disturbed during the site investigation work. The Contractor shall also be responsible for any subsurface utilities that are damaged or destroyed during this work.

#### **4.0 POST REMEDIATION CLOSURE REPORT AND RISK ASSESSMENT**

Upon completion of all field work, the Contractor shall prepare a Post Remediation Closure Report. The Closure Report shall detail the work performed including a post-remediation Risk Assessment of the affected property for lead mercury. The purpose of the Risk Assessment is to provide conclusive documentation indicating that the post-remediation condition of the

property is protective of human health for the anticipated future exposure scenarios and complies with VTDEC unrestricted use residential standard for lead of 41 mg/kg. The Contractor shall also submit a stand-alone letter signed by the environmental professional of record briefly summarizing the work and certifying that the property has been restored to a condition that is protective of human health and the environment.

## 5.0 PROJECT SCHEDULE/SUBMITTALS

Upon contract modification award, the Contractor shall prepare a project schedule using the suggested schedule below. Project schedule shall include required submittals, anticipated mobilization/demobilization times and anticipated contract completion.

SUBMITTAL NAME	SUGGESTED SCHEDULE
Project Schedule	30 business days after contract award
Site Visit Notification	30 business days prior to site visit
Draft Remedial Action Work plan	60 business days prior to site mobilization
Final Remedial Action Work Plan	5 business days after CG approval of draft
Draft Public Notice Abutters	30 business days prior to site mobilization
VTDEC Submission of Public Notice	10 business days after CG approval of draft
Site Mobilization, Remediation and Restoration	Within 45 business days after RAWP final approval
Draft Closure/Risk Assessment Report	30 days after completion of fieldwork
Final Closure/Risk Assessment Report/ Certification Letter	5 business days after CG approval of Draft
Contract Completion/Closeout	180 days after contract award

## **APPENDIX B**

### **VERMONT STANDARDS AND SPECIFICATIONS FOR EROSION PREVENTION & SEDIMENT CONTROL**

# The Vermont Standards and Specifications for Erosion Prevention & Sediment Control

-2019-



# Acknowledgements

The Vermont Standards and Specifications for Erosion Prevention and Sediment Control, adapted by: the New York State Standards and Specifications for Erosion and Sediment Control, prepared by: Donald W. Lake, Jr., P.E., CPESC, CPSWQ, Engineering Specialist, New York State Soil and Water Conservation Committee.

Information on Temporary and Permanent Critical Area Plantings, provided by: Sandra Primard, Agronomist, USDA-NRCS.

RECP Specifications, provided by: the Vermont Agency of Transportation.

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# Part 1 - Introduction

## **Purpose**

These standards and specifications have been developed to assist designers in creating Erosion Prevention and Sediment Control Plans (EPSC Plans) that meet the requirements of the Vermont Construction General Permit. With proper implementation, a well-designed EPSC Plan will protect against water quality and impacts due to construction activity by limiting sediment discharge and will reduce costs associated with maintenance of road ditches, storm sewers, streams, lakes, and wetlands.

The standards and specifications provide criteria on minimizing erosion and sediment impacts from construction activity involving soil disturbance. They show how to use the soil, water, plans and products to protect the quality of our environment. These standards and specifications were based largely on the New York State Standards and Specifications for Erosion and Sediment Control, developed in cooperation with the USDA Natural Resources Conservation Service, New York State Soil and Water Conservation Committee (NYSSWCC), and NYS DEC. Additional information was provided by Illinois USDA-NRCS. Materials from New York and Illinois were adapted by Vermont DEC to suit conditions within the state of Vermont and for consistency with Vermont regulatory requirements.

## **Scope and Authority**

The standards and specifications apply to projects that require a construction permit from Vermont DEC to discharge stormwater from construction sites and require the development of an EPSC plan. This includes projects on lands within Vermont where housing, industrial, institutional, recreational, road or highway construction and other land disturbances related to construction will occur. They are statewide in scope and, in some cases, are somewhat generalized due to variations in climate, topography, geology and soils.

## **How to Use This Manual**

This manual is organized into five main parts.

Part 1 provides a general overview of the manual contents, purpose, and scope and authority.

Part 2 examines the causes of erosion, the factors that influence the susceptibility of soil to erosion, discusses sediment transport, and provides an overview of the EPSC Plan.

Part 3 describes the planning process for developing EPSC Plans for construction projects and outlines the minimum EPSC Plan requirements.

Parts 4 and 5 cover technical standards and specifications for erosion prevention practices and sediment control practices, respectively. These are the technical standards required of EPSC Plans for use in obtaining coverage under the Vermont Construction General Permit. Described in each specification are the appropriate applications, design considerations, accepted construction specifications, as well as requirements for plans and specifications submitted as part of an application for coverage under a construction stormwater discharge permit.

# Part 2 - Erosion and Sediment Transport Overview

## 2.1 Introduction

### **Erosion on Construction Sites: Why is it a problem?**

On many construction sites, relatively large areas of soil can be exposed to the erosive effects of wind and rain due to extensive earthwork. Eroded sediment may be easily transported by stormwater runoff to streams, lakes, and wetlands. Rates of erosion on an uncontrolled construction site can far exceed that of the same land under a natural vegetative cover, meaning that the sediment generated over many years from forest or pasture could be produced in a single season on a poorly managed construction site.

The water quality of streams, lakes, and wetlands can be negatively impacted by the input of eroded sediment. Sediment entering streams can directly cause a harmful alteration of destruction of habitats of fish and other aquatic organisms. In addition, sediment serves as a vehicle for the transport of stormwater pollutants that diminish water quality. Phosphorus, for example, which can contribute to excessive algae growth, is commonly transported by being bound to mobile sediment.

Excessive sediment loading can also contribute to stream channel instability and streambank erosion, accelerating sediment build-up in streams and loss of storage in lakes, ponds, and reservoirs. The physical, chemical and biological impacts of eroded sediment in turn decrease the recreational value and our enjoyment of Vermont's waters.

### **Responsible Construction: Implementing an EPSC Plan**

An EPSC Plan is a set of documents which outlines the strategy for preventing erosion of disturbed soils by rain and runoff and for controlling movement off site of soil that does erode during construction. An EPSC Plan is developed based upon an analysis of the physical characteristics of the project area, the local climate, and the planned construction activities. The

resulting documents serve as a blueprint showing the location of best management practices (e.g. silt fence, check dams, mulching) that are required on-site providing details for proper installation and maintenance, and listing requirements for the routine inspection and maintenance of best management practices to ensure they are functioning as designed and implemented.

This Part describes the required components of a plan submission for review under the Vermont Construction General Permit (CGP) EPSC Plan preparation requires knowledge of soils, hydrology and vegetation establishment. This knowledge is best complemented by experience with construction and erosion prevention and first hand knowledge of EPSC practices on construction sites. Before developing an EPSC Plan for permit applications, plan preparers should be familiar with the permit requirements, any local erosion prevention and sediment control regulations, and these standards and specifications.

An EPSC Plan for constructing a house on a single subdivision lot will generally not need to be as complete as an EPSC Plan for a large development. EPSC Plans for projects distant from water resources and on relatively flat terrain will be less complex than those for similar projects near streams or on steep, erodible soils. By applying the principles described here, following the suggested plan format, and using these standards and specifications, a plan preparer will be able to develop a suitable EPSC Plan that can be readily confirmed as consistent with the requirements of the Construction General Permit.

Before delving into the development of an EPSC Plan, however, a basic understanding of what erosion is, how sediment moves once it is eroded, and what factors affect these processes is necessary.

## 2.2 An Overview of Soil Erosion and Sediment Transport

The pollution of surface waters with sediment discharged from construction sites happens in two

## Part 2 - Erosion and Sediment Transport Overview

steps: the detachment of sediment from the soil (erosion) and its delivery to the water body (sediment transport). To be effective, an EPSC Plan must address both of these steps. Projects that rely heavily on the prevention of erosion, however, are generally less expensive to implement, require less maintenance, and are more effective than projects with a focus primarily on controlling sediment transport once soil has eroded.

Erosion is defined as the wearing away of the earth's surface by the action of wind, water, ice, and gravity. This occurs when the erosive force acting on the particle exceeds the strength of attachment between the particle and the soil. On construction sites, this erosive force comes primarily from raindrop impact and stormwater runoff on the soil. At the small scale, all erosion prevention practices are aimed at preventing these forces from detaching the particle from the soil.

Once detached from the soil, the main modes of sediment transport on construction sites are by stormwater runoff, by wind, and by attachment to equipment that moves on and off site. The majority of sediment control practices detailed in the standards and specs are focused on the movement of sediment by stormwater runoff, as it is the principal mode of sediment transport off of construction sites and into surface waters.

A number of factors directly influence erosion by runoff on a construction site. For a given area these include the cover on the soil, the velocity of runoff, and the physical properties of the soil that determine its resistance to erosion. Each of these affects the balance of forces that needs to be tipped for erosion of a sediment particle to occur.

### **Factors that Influence Erosion -Flow Velocity-**

The potential ability to cause erosion, or erosivity, of moving water is directly related to its velocity, and there are several corresponding types of erosion

depending on the velocity of the water when it comes into contact with the soil (Figure 2.1). Splash erosion occurs when raindrops, which can reach the ground with a velocity of 25-35 feet per second, dislodges sediment particles on exposed soil. In the absence of preformed channels and at low velocities, water flows on the soil surface in a thin, broad layer or sheet, shearing off sediment particles at the surface of the soil interface. This is termed sheet erosion. As flow velocity increases, additional scour can occur, leading to fine channels of higher velocity flow. When these channels are several inches deep, the process is referred to as rill erosion. Gully erosion is the scouring of still deeper channels with generally greater flow velocities, while in-stream scouring of soil is known as channel erosion.

### **Factors that Influence Erosion -Soil Properties-**

The nature of disturbed soils is another important factor influencing erosion on construction sites. Erodibility, the inherent susceptibility of a soil to erosion, is determined by several physical characteristics of the soil. The texture of a soil is the relative composition of sand, silt and clay particles. Coarse sandy soils have relatively large sediment grain size and tend to drain water quickly, making them less susceptible to erosion. Fine clay particles, while very small, have charges that make them cohesive and resistant to erosion. Once eroded, however, they can take a very long time to settle out of suspension. Soils with substantial clay content also drain poorly, increasing the risk of erosion. Fine sands and silts are the most vulnerable to erosion by water, having little cohesiveness, and being readily transported (Figure 2.2).

The soil structure is the arrangement of the soil particles within the soil. Additional structure imparts increased strength to a soil, and provides a network of spaces that promote drainage of soil water. Increased water drainage decreases erosion by reducing the amount and velocity of water on the surface. Compaction of soil by machinery destroys

## Part 2 - Erosion and Sediment Transport Overview

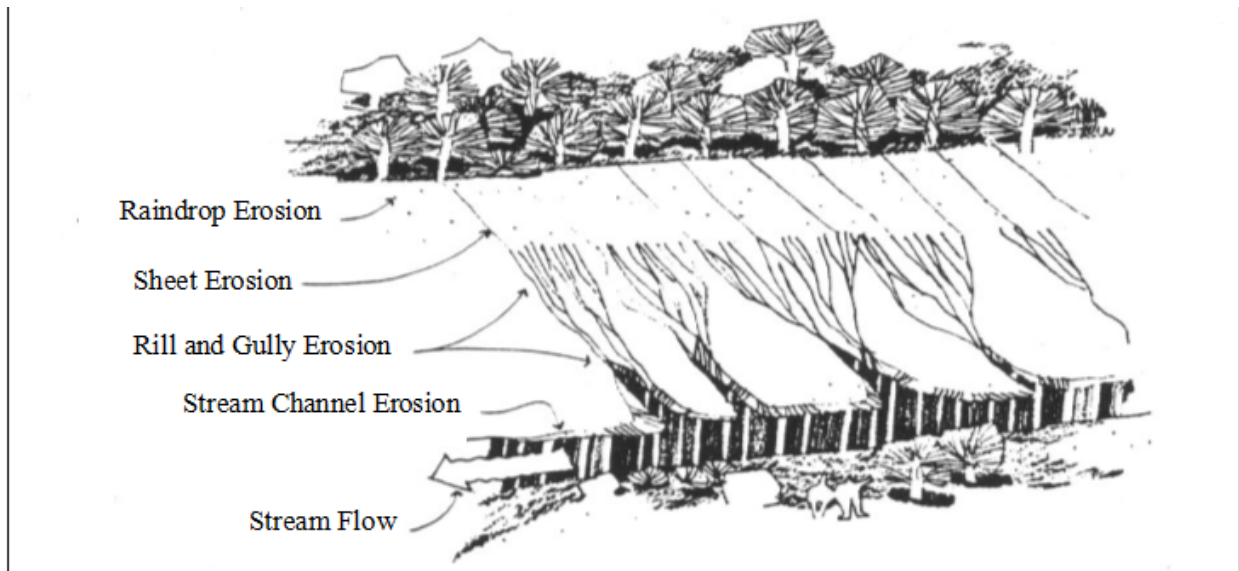


Figure 2.1 Four Types of Erosion by Water

Soil Type and Parameters	Slope%		
	0-5%	5-15%	>15%
Gravelly/Coarse Sand	Low	Low	Medium
Sandy (Fine)	Medium	High	High
Silty	Medium	High	Very High
Clay	Low	Medium	High
Dispersive Clay	High	Very High	Extreme

Figure 2.2 Erosion Risk Based on Soils and Slopes

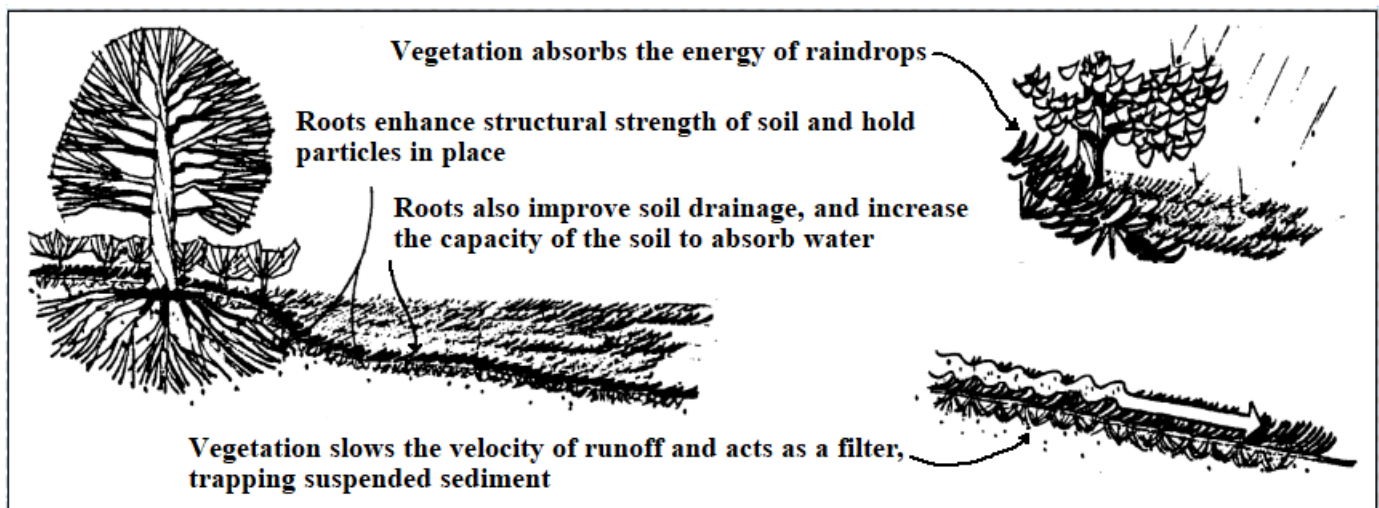


Figure 2.3 Protective Effects of Vegetation

## Part 2 - Erosion and Sediment Transport Overview

soil structure and can seal soils, preventing drainage of water through the soil profile.

Organic matter reduces erodibility because, like clay particles, organic matter has charges which increase the cohesiveness of soil particles. Organic matter also contributes to soil structure.

### **Factors that Influence Erosion -Topography-**

The topographical character of the land influences erosion in several ways. First, it determines the size of the drainage area that will direct runoff to a construction site. Second, the steepness of the land contributes to the velocity of the runoff and greater erosion rates. Third, the increase in velocity associated with a longer flow path results in flows of greater erosivity.

Minor topographical variations that alter the flow paths of runoff can also influence erosion. Irregularities in the surface of exposed soil that are perpendicular to the direction of the flow (i.e. along the contour), serve as tiny diversions, slowing and dispersing flow. Those along the length of a slope, however, can serve to channel sheet flows and encourage rills and gullies by increasing flow velocity in a particular path. topographic features that direct a wide area of sheet flow to one or two discharge locations can lead to localized areas of intense scour.

### **Factors that Influence Erosion -Vegetation-**

Vegetative ground cover is a critical influence on the erosivity of overland flows and raindrop impact. It protects soil in two general ways: by improving on soil strength and by reducing the amount and velocity of water reaching the soil (Figure 2.3). Establishing and maintaining vegetative cover is often the simplest and most effective means of preventing erosion on a construction site.

Vegetation and duff protect against raindrop erosion

by shielding the soil. Grasses and other dense vegetation near the ground also serve to slow the velocity of sheet flow, reducing erosivity of runoff and filtering out suspended sediment.

Plant root systems bolster soil strength by holding soil particles directly in place. Roots also promote soil structure and generally improve the infiltrative capacity of the soil. This resulting reduction in runoff volume and velocity reduces the risk of erosion.

### **Factors that Influence Erosion -Climate-**

Climate is also an important influence on erosion on construction sites. Rainfall characteristics for an area, including the intensity, duration, and frequency of storm events, help to determine the velocity of runoff that might be expected during a particular season. Such seasonal variations are particularly important in Vermont, as thunderstorms tend to cause large, short-duration amounts of runoff in the summer, whereas, in the spring, rain combined with melting snow can lead to long periods of flow on saturated, erodible, soils. The seasonal changes in vegetative cover are an indirect influence of climate on erosion.

### **Sediment Transport**

Once sediment has been dislodged from the surface of the soil, it is available for transport by runoff or wind. The susceptibility of sediment to transport depends on the energy of the runoff (as indicated by the velocity) and on the mass of the particles. Heavier particles, such as sand and gravel fall quickly out of suspension when flows slow, and are therefore not readily transported. Silt and fine sand are more easily transported, while clay, though more difficult to erode, can stay in suspension for long periods of time. Because of this, EPSC Plans that rely heavily on sediment control by settling of particles out of stormwater flows, are often unsuccessful.

Sediment control measures described in this volume are generally designed with the goal of slowing the velocity of runoff and allowing sediment to fall out of suspension.

# Part 3 - Preparing an EPSC Plan

## **3.1 Introduction**

Preventing sediment pollution of surface waters from construction sites requires balancing the time and space constraints of a construction project with the risk of sediment leaving the site and reaching streams, lakes, or wetlands. A well-developed EPSC Plan is the key to having the right balance, ensuring timely construction, minimizing pollution, and keeping costs down. Part 3 presents the Minimum EPSC Plan Requirements, Winter Construction Considerations and Winter EPSC Plan Requirements, and the Recommended Approach to EPSC Plan Development.

## **3.2 Minimum EPSC Plan Requirements**

Each EPSC Plan shall contain, at a minimum:

### **1. Project Description**

An overview of the proposed project. This may be in narrative or point form, may include tables or figures, and must include:

- a. The type of project (e.g., residential subdivision, town road, commercial building, etc.);
- b. A description of the major project components and the anticipated earth disturbance associated with each (e.g. roads, utilities, number of buildings, etc.);
- c. The total acreage of proposed earth disturbance;
- d. The intended sequence and timing of major project components that disturb soils at the site;
- e. The proposed pollution prevention strategies that will minimize the exposure of building materials, building products, construction wastes, trash, landscape materials, fertilizers, pesticides, herbicides, detergents, sanitary waste and other materials present on the site to precipitation and to stormwater. Minimization of exposure is not required in cases where the exposure to precipitation and to stormwater will not result in a discharge of pollutants, or where exposure of a specific material or product poses little risk of stormwater contamination (such as final products and materials intended for outdoor use); and
- f. The maximum concurrent earth disturbance used to score this project in Appendix A of Vermont's Construction General Permit or as otherwise proposed under an Individual Permit application;
- g. The use of vegetated buffers, if any, used to score this project in Appendix A of Vermont's Construction General Permit or as otherwise proposed under an Individual Permit application;
- h. The name of the receiving water(s), the number of discrete discharge points where collected stormwater flows are discharged from the construction site to the receiving water(s), the proximity of the proposed earth-disturbing activities to each of these discharge points, and a description of how stormwater flows from the construction site to the discharge point (e.g. vegetated swale, culvert, storm sewer). If no discrete discharge points, a description of the length, slope, and vegetative cover of the shortest overland flow path to receiving water from the limits of the proposed disturbance;
- i. The number of proposed stream crossings and whether a stream alteration permit is being obtained;
- j. The area of wetlands and wetland buffers that will be impacted by the proposed activities, their type, and whether a state wetlands permit or Army Corps of Engineers permit is being obtained for wetland impacts;
- k. A site-specific dewatering plan (if applicable) which shall include the minimum proposed distance to surface waters, a requirement that dewatering take place from the surface of any impoundments (unless infeasible), spoils disposal area (if applicable), detail/typical of dewatering structure, and any other aspect as so

## Part 3 - Preparing an EPSC Plan

requested by the Secretary;

- l. The need for off-site waste or borrow areas, if any, the anticipated amount of borrow or waste material to be transported, the nature of the material, and how these will be permitted (i.e. permitted as a part of the a current construction stormwater discharge permit application or under a separate application); and
- m. A statement about whether earth disturbing activities are anticipated during the winter construction period (October 15-April 15), the nature of these activities, the area of disturbance associated with these activities, and whether the EPSC Plan incorporates BMPs according to the Standards applicable to the winter construction period.
- n. A copy of the inspection form to be used by the On-Site Plan Coordinator (OSPC) in their weekly inspection (a copy of a form provided by the Secretary, if available, is sufficient if it will be utilized by the OSPC).

### 2. Location Map

A location map, in the form of a topographic map or aerial image, providing sufficient information to determine the location of the project and the receiving water;

### 3. Pre-Construction Plan / Existing Conditions

A map or maps of the proposed construction area and plan including the following information:

- a. The limits of the construction site including the proposed limits of disturbance, and the methods for their demarcation in the field;
- b. Existing contours based on site survey for the construction site and existing contours based on site survey or USGS topographical maps for the surrounding area 300 feet outside of the limits of disturbance;
- c. Existing water and drainage features (e.g.

streams, ponds, wetlands, channels, gullies, etc.).

- d. Existing vegetation;
- e. Location of soil types corresponding to NRCS Soil Maps;
- f. All sediment control measures (e.g. silt fence, sediment or dewatering basins, etc.) to be installed ahead of primary earth disturbance activities;
- g. Directions to complete installation of sediment control measures ahead of initiating the principal earthwork activities;
- h. Directions to complete stabilization of operational stormwater treatment practices before directing runoff to them, unless utilized during construction as sediment control measures, in which case directions for ensuring these features are modified and stabilized as necessary prior to construction completion such that operational stormwater treatment practices will meet applicable design requirements for the treatment and control of post-construction stormwater runoff;
- i. Identified buffers or setbacks from water bodies and conveyances to water bodies, with directions for avoiding impacts in these areas;
- j. North arrow and scale;
- k. A legend for all EPSC measures and all other features (e.g. wetlands, streams, property lines, etc.) included on the plan; and
- l. Date of last plan revision, name of plan designer, and name of plan.

### 4. Construction Plan

The Construction Plan shall include all information related to erosion prevention as well as sediment control measures to be implemented during the construction activity. These must be consistent with limits specified on the Notice of Intent and

## Part 3 - Preparing an EPSC Plan

completed Appendix A (e.g. vegetated buffer, limited concurrent disturbance, stabilization schedule) of Vermont's Construction General Permit, if applicable. It must include, where applicable:

- a. Property lines of the project;
- b. The proposed phase boundaries and sequencing of EPSC measures within each phase, the order of phases to be constructed, and the required items to complete before initiating the subsequent phase (e.g. complete stabilization of the prior phase);
- c. The limits of disturbance;
- d. Identified buffers or setbacks from water bodies and discrete conveyances to water bodies, with directions for avoiding impacts in these areas;
- e. Specific directions for limiting concurrent earth disturbance;
- f. Existing and proposed contours;
- g. Location of all erosion prevention measures;
- h. Location of all sediment control measures to be installed during the construction phase as well as sediment control measures implemented in the pre-construction phase;
- i. Construction details for each practice proposed, which shall include all applicable notes regarding the installation and maintenance of said practice;
- j. Consistent with the completed Appendix A, of Vermont Construction General Permit, as applicable, directions for stabilization of a given area within 14 days following initial disturbance: "All areas of earth disturbance must have temporary or final stabilization within 14 days of the initial disturbance. After this time, disturbed areas must be temporarily or permanently stabilized in advance of any runoff producing event.";

- k. A plan for dewatering activities, if anticipated, including the location of dewatering discharges consistent with this permit;
- l. Directions and location of practices employed for construction during the winter construction period (October 15-April 15), consistent with the Standards applicable to the winter construction period, if earthwork during this period is anticipated.
- m. The location of all existing and proposed structures (roads, utilities, buildings, drainage inlets, etc.);
- n. The location of all proposed stockpiles and directions for stabilizing and protecting stockpile areas consistent with the Standards;
- o. The location of all proposed staging areas;
- p. Directions for inspection frequency consistent with the permit;
- q. North arrow and scale;
- r. A legend for all EPSC measures and all other features (e.g. wetlands, streams, property lines, etc.) included on the plan; and
- s. Date of last plan revision, name of plan designer, and name of plan.

### 5. Stabilization Plan

The Stabilization Plan shall convey to contractors all the information necessary to implement temporary and final stabilization for the entire construction site. It shall include the following, consistent with the Standards:

- a. Property lines of the project;
- b. Finish grade contours;
- c. The location of all structures, existing and proposed;
- d. Temporary stabilization measures required for all areas of disturbance consistent with

## Part 3 - Preparing an EPSC Plan

the completed Appendix A of the Vermont's Construction General Permit, if applicable,

- e. Final stabilization measures required for all areas of disturbance where structures are not installed, including areas requiring stone, rolled erosion control products, hydromulching, seeding and mulching, etc.;
- f. Specifications for seed mixes, fertilization, and other soil amendments for areas to be stabilized with vegetation;
- g. Directions for completing seeding after April 15 and before September 15 for areas where final stabilization is not scheduled to occur prior to the winter construction period;
- h. Directions to remove all temporary erosion and sediment control practices within 30 days of achieving final stabilization;
- i. Dewatering plan details, if dewatering is anticipated;
- j. Directions for inspection frequency consistent with the permit, including an indication of when inspections may be discontinued;
- k. A legend for all EPSC measures included on the plan;
- l. Date of last plan revision, name of plan designer, and name of plan; and
- m. North arrow and scale.

### Special Requirements for Linear Projects

Requirements 1-5 in section 3.2 above also apply to linear projects such as roads, pipelines, and utility installations, except that:

1. The Pre-Construction Plan, Construction Plan, and Stabilization Plan may be combined into one plan.
2. A Phasing Plan shall be developed in accordance with The Vermont Standards and Specifications for Erosion Prevention and Sediment Control.

3. The location of all staging areas away from the project shall be shown with appropriate EPSC measures and accompanying location map.

### 3.3 Winter Construction Considerations

Managing construction sites to minimize erosion and prevent sediment discharges to waters is a year-round challenge. In Vermont, this challenge becomes even greater during the late fall, winter, and early spring months. 'Winter construction' as discussed here, describes the period between October 15 and April 15, where the erosion prevention and sediment control is significantly more difficult.

Rains in late fall, thaws throughout the winter, and spring melt and rains can produce significant flows over frozen and saturated ground, greatly increasing the potential for erosion. At the same time as the erosion risk increases, the "toolbox" available to the planner and on-site plan coordinator shrinks significantly over this period (Table 3.4). In particular, establishing vigorous vegetation during winter construction is not possible. How an EPSC Plan addresses winter conditions depends upon the nature of the construction site activities over this period.

### **EPSC Plan Requirements for -Winter Shutdown-**

There are specific requirements for sites that conduct earth disturbance during the defined winter construction period and for sites where disturbed areas have not reached final stabilization by October 15.

For projects or areas of a site that will have completed earth disturbance activities prior to the winter period (October 15), the following requirements must be adhered to:

1. For areas to be stabilized for the winter through the establishment of vegetation, seeding and mulching shall be completed no later than September 15 to

## Part 3 - Preparing an EPSC Plan

ensure adequate growth and cover before the start of the winter period.

2. If seeding is not completed by September 15, additional non-vegetative protection must be used to stabilize the site or the winter period. Areas of disturbance not seeded and mulched by September 15 are required to temporarily stabilize by one of the following methods:

- a. Implement Rolled Erosion Control Products (e.g. Matting) over the areas of earth disturbance.
- b. Apply 2" mulch layer to areas of earth disturbance, equivalent to double the standard rate. Mulch should be tracked in open areas vulnerable to wind.
- c. Seeding with winter rye is recommended to allow for early germination during wet spring conditions.

### EPSC Plan Requirements for -Winter Construction-

It is important that the EPSC Plan contain clear direction for the intended use and limitations of season-sensitive practices, even if no earth disturbance is initially planned for the winter period.

If construction activities involving earth disturbance continue past October 15 or begin before April 15, the following requirements apply:

1. Enlarged access points, stabilized to provide for snow stockpiling.
2. Snow shall be managed with adequate storage and control of meltwater, requiring cleared snow to be stored down slope of all the areas of disturbance and out of stormwater treatment structures.
3. For areas of disturbance within 100 ft of a waterbody, the following must be installed across the slope, down gradient of the earth disturbance:
  - a. A combination of one practice from group A

placed in front of a practice from group B, or

- b. Two group B practices, or
- c. A single row of Reinforced Silt Fence

Group A	Group B
Filter Socks	Silt Fence
Straw Wattles	Erosion Control Berms

4. Drainage structures must be kept open and free of snow and ice dams.
5. Silt fence and other practices requiring earth disturbance must be installed ahead of frozen ground.
6. Mulch used for temporary stabilization must be applied at a minimum of 2 inches with an 80-90% cover.
7. To ensure cover of disturbed soil in advance of a precipitation or melt event, areas of disturbed soil must be stabilized prior to any runoff producing event.
  - Stabilization is not required if the work is occurring in a self-contained excavation (e.g. no outlet) with a depth of 2 feet or greater (e.g. house foundation excavation, utility trenches), provided any dewatering, if necessary, is conducted as required.
8. Prior to stabilization, snow or ice must be removed to the extent practicable.
9. Use stone to stabilize areas such as the perimeter of buildings under construction or where construction vehicle traffic is anticipated. Stone paths should be sufficient width to accommodate vehicle or equipment traffic.

### **3.4 Recommended Approach to EPSC Plan Development**

Developing a strategy for preventing erosion and controlling sediment transport requires

## Part 3 - Preparing an EPSC Plan

understanding the nature of the construction site and its surroundings. This involves identifying areas of increased erosion risk (e.g. areas with a well established vegetated buffer). With a thorough knowledge of the site and the proposed construction activities, the next step is to select erosion prevention practices that are most suitable (such as phased disturbance, rapid stabilization). Once an erosion prevention strategy is developed, sediment control practices are selected and located in areas where erosion might still be expected and at discharge points from the project.

This process of preparing a complete EPSC Plan can be broken down to four distinct steps:

### **Step 1 -Project Reconnaissance-**

A thorough knowledge of the qualities of the construction site, its surroundings, and the climate are necessary to develop an EPSC Plan appropriate to the proposed construction activities. This requires field data collection and obtaining relevant documents.

#### **1. Soil Survey**

Review the soil survey maps for the site and determine the erodibility rating for the soils to be disturbed. County soil surveys and soil fact sheets are published by the Natural Resources Conservation Service (NRCS). These provide detailed information on the nature of the soils that may be expected on-site, including the NRCS index (K) which quantifies the susceptibility of soil to water erosion (erodibility).

#### **2. Map Review**

Review a topographic map, GIS map or aerial imagery and identify the project boundaries, property lines and all potential receiving waters, including wetlands.

#### **3. On-Site Evaluation**

Once basic resource information has been gathered, a thorough investigation of the site is needed.

During the site visit, compare the information from the resource maps and any surveys with the actual conditions. Items to identify include:

1. Types and locations of existing vegetation.
2. Existing structures (roads, buildings, etc.).
3. Existing slopes for all areas of proposed disturbance
4. Drainage patterns, on-site drainage swales, ditches, and streams, discrete discharge points and areas of sheet flow.
5. Locations of unmapped wetlands.
6. Existing stormwater treatment and drainage facilities.
7. Location of diversions, drop inlets, and open or closed drainage conveyances.

### **Step 2 -Erosion Prevention Strategy-**

Once areas of potential erosion problems have been identified, a suitable strategy for erosion prevention may be developed. Erosion prevention strategies may be divided into three basic areas, related to the factors that influence erosion: minimizing disturbance, managing runoff, and stabilizing promptly.

A variety of approaches may be suitable for a given site. For example; if there is a cut slope to be protected from erosion, the strategies may be to protect the ground surface, divert water from the slope, or shorten it. If no rainfall except that which falls on the slope has the potential to cause erosion, and if the slope is relatively short, protecting the soil surface is often all that is required to prevent problems.

Figures 3.1 through 3.3 provide planning flow charts for strategies and practices for particular erosion problems. These figures are not inclusive of all available strategies in the standards and specifications but may serve as guidance in the development of

## Part 3 - Preparing an EPSC Plan

an EPSC Plan. For each area with potential erosion problems identified, refer to these figures to identify the strategy that can be taken to solve the problem. The three categories of erosion prevention strategy are related to the factors that influence erosion:

### 1. Minimize Disturbance

By minimizing the area of erodible soil exposed to the erosive forces of rain, wind, and runoff, the potential for erosion is reduced considerably. Stripping and rough grading of many acres is not a suitable approach in most cases. Several management practices may be selected by a plan designer to minimize disturbance.

#### A. Maintain Existing Topography

Where feasible, making use of the existing lay of the land will minimize soil disturbance by avoiding the need for large cuts, fills, or grading operations. Delineate and avoid disturbing wetlands and buffers, streams, and to the extent practicable, steep slopes and other environmentally sensitive areas. Minimize impacts by maintaining vegetative buffer strips between disturbed and nearby sensitive areas.

Planning of streets and lots should relate to site conditions. Streets laid out at right angles to contours often have excessive grades that increase erosion hazards and sediment pollution.

#### B. Phase Major Disturbance Activities

A phasing plan that requires EPSC practices to be installed and the soil stabilized as disturbance progresses should be developed. Ideally, this plan is devised in consultation with the construction site operator to ensure the feasibility of the approach.

Phasing plans should show the sequence and limits of each phase of consecutive disturbance, and provide clear direction as to the requirement for stabilization of one phase before another begins (e.g. “complete temporary stabilization of phase 1 must occur before earthwork on phase 2 can begin”). Note that in the

standards, phasing refers to distinct project sections, done separately over time, while sequencing is providing a specific order for the installation and use of management practices relative to the progress of the earth disturbance work.

#### C. Maintain Existing Vegetation

As discussed in Part 2, existing vegetation shields soil from erosive rain and runoff, and extensive root systems help to hold soil in place. Where possible, existing vegetation should be maintained. Specify on plans areas of grass, trees, vegetated buffers on water bodies, etc. that should not be disturbed. Include a requirement for in-field demarcation of barriers (e.g. with orange construction fence) to prevent inadvertent intrusion on protected areas by vehicles and equipment.

### 2. Control Runoff

Where extensive disturbance cannot be avoided, stormwater run-on should be managed to prevent erosion. This can be accomplished by diverting runoff around the disturbance, by providing a stable conveyance through the disturbance, or by dispersing concentrated flows through stable outlet structures. Dispersing concentrated flows through stable outlet structures. Diversion of surface water away from exposed soils provides the most economic and effective erosion control possible since it is more advantageous to control erosion at the source than to design controls to trap suspended sediment. Figure 3.1 provides a summary of the variety of runoff control practices that are included in the standards and specifications.

### 3. Stabilize Promptly

For those areas where soil disturbance is necessary, erosion can be minimized by ensuring that disturbance operations take place as quickly as possible, followed by prompt stabilization of the disturbed soils. Depending upon the size of the

## Part 3 - Preparing an EPSC Plan

disturbed area, and the risk to water quality, this might require limiting concurrent disturbance to an area small enough to allow for quick stabilization of the site in advance of predicted rain events.

Another management option is placing a maximum duration for earthwork in any one area before temporary stabilization is required (e.g. “All areas must be at least temporarily stabilized within 14 days of initial disturbance”). Whatever approach is selected, it is important that directions be clear and specific. Avoid including statements such as “all areas to be stabilized within 48 hours” that are open to interpretation. The standards and specifications includes several soil stabilization practices. Figure 3.2 provides a summary of the variety of soil stabilization practices that are included in the standards and specifications.

### Step 3

#### -Select Sediment Control Practices-

Once areas of erosion risk have been identified and an erosion prevention strategy specified, sediment control practices may be appropriately selected. The goal of their use is to capture sediment that escapes the construction area despite the use of erosion prevention practices. Sediment control practices typically do not offer complete capture of eroded sediment, and must not be used as a primary tool to prevent sediment pollution from the construction site. Instead, the aim should be to complement the selected erosion prevention strategy with thoughtful selection and placement of practices suited to the local risk of erosion.

Sediment control practices fall generally into two categories, those that retain eroded sediment on the construction site, and those that convey sediment to retaining practices.

Sediment retention practices most commonly rely upon slowing the velocity of runoff that contains sediment to a point where particles fall out of suspension. Silt fence, for example, when properly employed, serves to pond runoff upslope of the fence, slowing the flow and allowing for settling of sediment.

On a larger scale, sediment basins provide the settling volume directly, and can retain water for a longer period of time.

Sediment control practices should be selected for all areas where there is an increased risk of erosion, and for all areas where there is the potential for a discharge (direct or indirect) to a water body.

In selecting sediment control practices, it is important to adhere to the design requirements found in the standards and specifications. Many small scale practices (e.g. silt fence) are appropriate for a drainage area or slope, whereas larger practices (e.g. Sediment basin) must be specifically sized to the on-site conditions. Figure 3.3 provides a summary of the variety of sediment control practices that are included in the standards and specifications.

### Step 4

#### -Prepare EPSC Plans-

The last step in erosion and sediment control planning is completing final design. This involves applying any control measure within a group to solve the specific erosion and sediment control problem. From available erosion prevention and sediment control measure in the standards and specifications, the one measure which is most economical, practical, efficient and adaptable to the site should be chosen. While the standards and specifications are not intended to prescribe design for all projects, it is generally expected that practices from the subcategories or erosion prevention and sediment control standards (e.g. limit disturbance, small area sediment control) will be included for a given drainage area.

EPSC Plans should include all information necessary for the contractor to properly implement the chosen strategy. Multiple plan sheets may be required to reflect sequential phases, particularly if there are overlapping areas of disturbance between phases. Plan sheets should cover pre-construction, construction, and post-construction, these roughly corresponding to initial sediment control measures, erosion prevention during construction, and final stabilization.

## Part 3 - Preparing an EPSC Plan

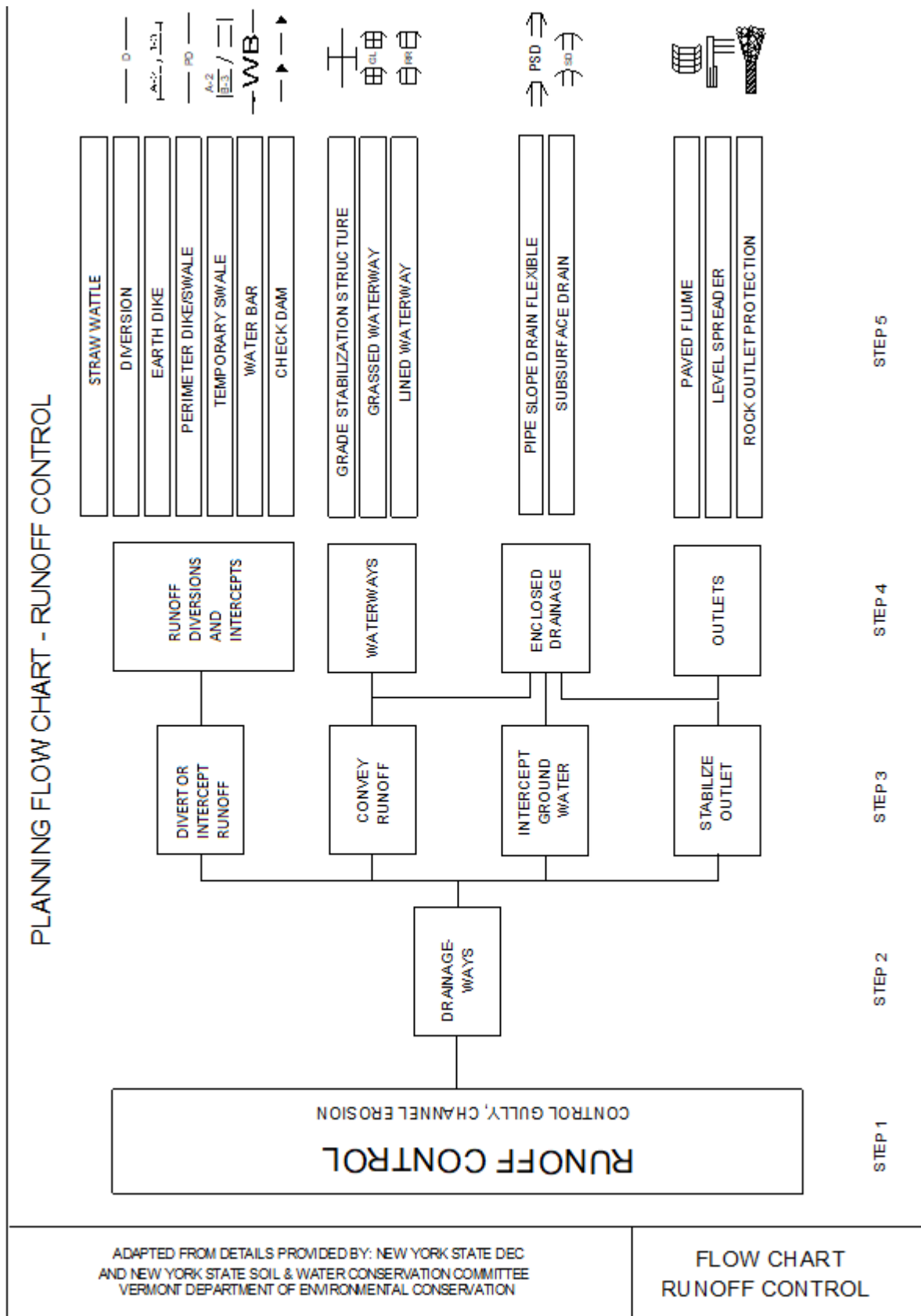


Figure 3.1 Planning Flow Chart - Runoff Control

## Part 3 - Preparing an EPSC Plan

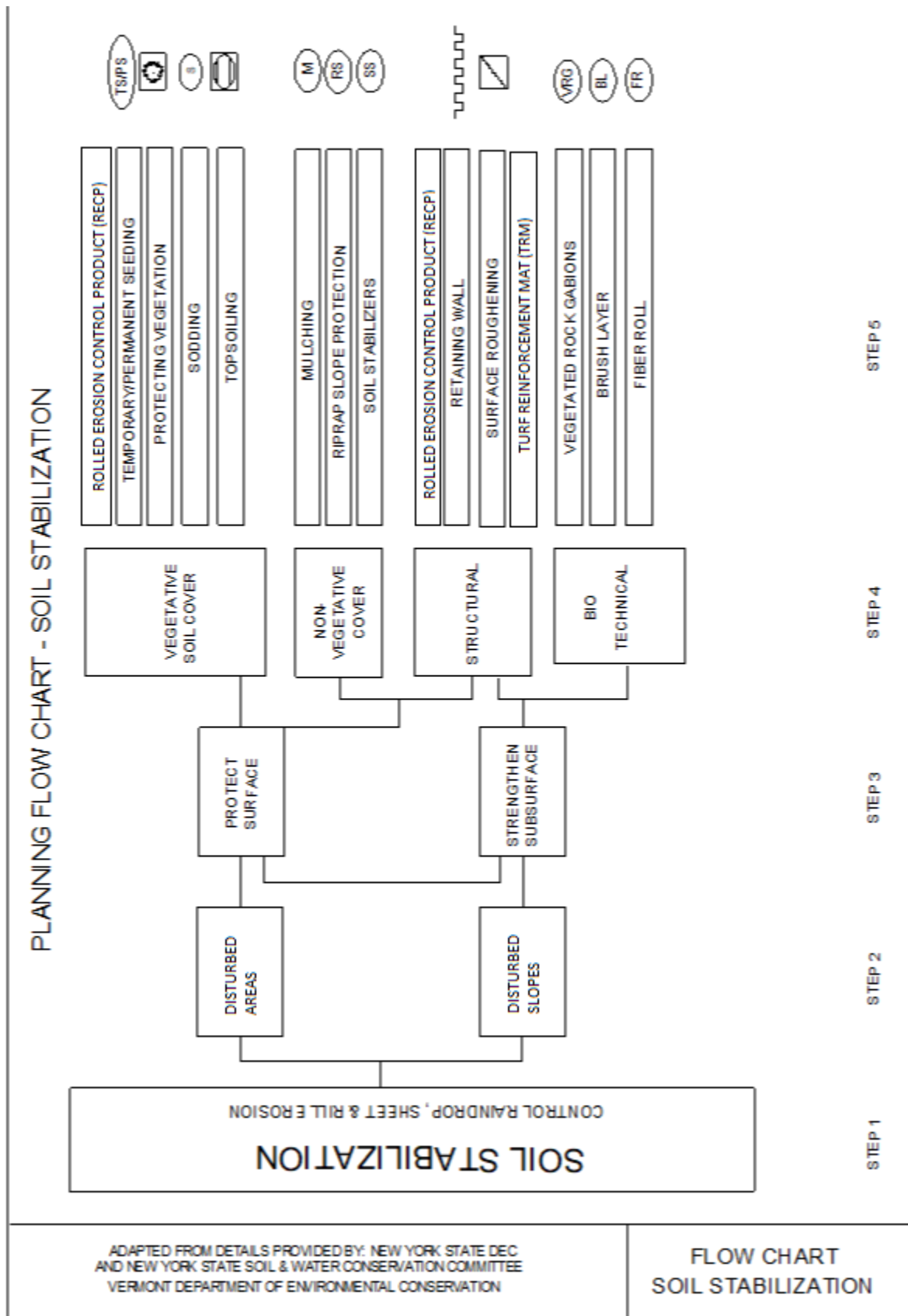


Figure 3.2 Planning Flow Chart - Soil Stabilization

## Part 3 - Preparing an EPSC Plan

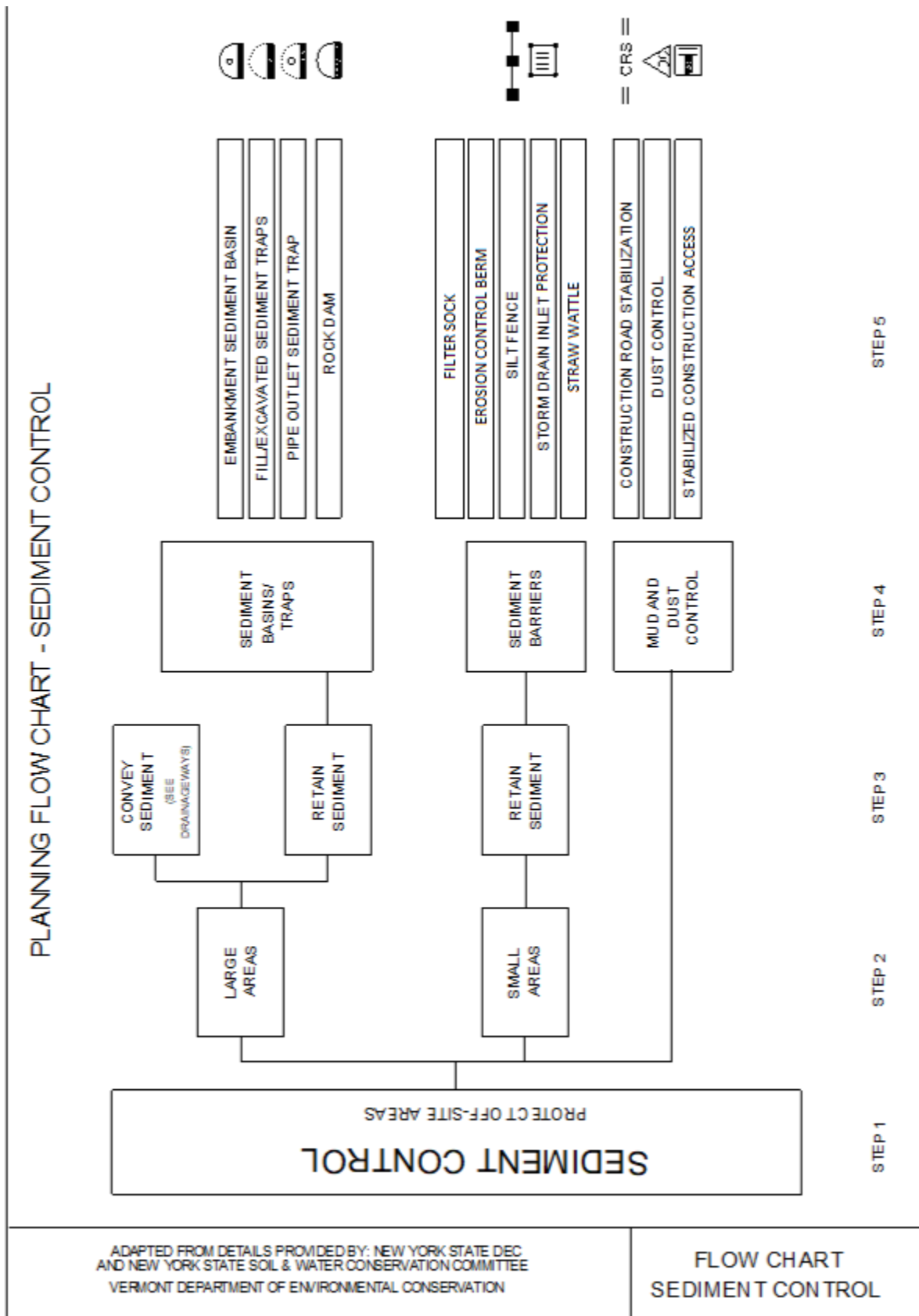


Figure 3.3 Planning Flow Chart - Sediment Control

## Part 4 - Limits of Disturbance Demarcation

### Definition

Defining and demarcating the boundaries of soil disturbance in the field.

### Purpose

To limit the extent of disturbed soils by confining earth disturbing activities to the appropriate areas. To directly protect waters of the state and vegetated buffers surrounding them from unnecessary disturbance.

### Condition Where Practice Applies

Where the boundary of authorized disturbance borders areas of existing vegetation or around the perimeter of the construction site within 100' of waters of the state.

### Design Criteria

Limits of disturbance (LODs) should be the first construction item implemented on a construction site.

All disturbance areas should be demarcated with a barrier appropriate to the location.

Flagging Ribbon / Paint: For use where proposed disturbance borders established wooded areas where inadvertent disturbance by machinery is not possible. Mark trees along limit of clearing with flagging ribbon or paint corresponding to clearing limits on the authorized EPSC Plan.

Barrier Tape / Rope: For use where proposed disturbance borders non-wooded areas. Barrier tape is high visibility fiber-glass tape, minimum 3" in width. Barrier tape and rope should be attached to stakes, at a minimum height of 4' from the ground.

Construction Fence / Snow Fence / Boulders: Fence should be continuous and prevent access to buffer areas by machinery. Boulders must be spaced closely so as to prevent machinery access.

### Considerations

Limits of disturbance are dynamic, changing with the progression of earth disturbing activities. They should reflect distinct phases and clearly indicate where disturbance is warranted. Limits of disturbance should be maintained until final stabilization in an area has been implemented.

### Plans and Specifications

Plans and specifications for installing limits of disturbance shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items on EPSC Plans:

1. Location of all limits of disturbance.
2. Description of method of demarcation.
3. Legend showing various demarcation methods.
4. Construction detail for any method requiring specification.

# Part 4 - Protecting Vegetation During Construction

## Definition

The protection of trees, shrubs, ground cover and other vegetation from damage by construction equipment.

## Purpose

To preserve existing vegetation determined to be important for soil erosion control, water quality protection, shade, screening, buffers, wildlife habitat, wetland protection, and other values.

## Condition Where Practice Applies

On planned construction sites where valued vegetation exists and needs to be preserved.

## Design Criteria

### Planning Considerations:

#### 1. Inventory:

Vegetation that is desirable to preserve because of its value for screening, shade, critical erosion control, endangered species, aesthetics, etc., should be identified and marked on the pre-construction plan.

#### 2. Planning:

- a. Areas to be seeded and planted should be identified on the post-construction plan. Remaining vegetation should blend with their surroundings and/or provide special function such as filter strip, buffer zone, or screen.
- b. Trees to be cut should be marked on the plans.
- c. The vigor of remaining trees may be improved by a selective thinning. A forester should be consulted for implementing this practice.

### Measures to Protect Vegetation:

1. Limit soil placement over existing tree and shrub roots to a maximum of 3". Soils with loamy texture and good structure should be used.
2. Use retaining walls and terraces to protect roots of trees and shrubs when grades are lowered. Lowered grades should start no closer than the dripline of the tree. For narrow-canopied trees and shrubs, the stem diameter in inches is converted to feet and doubled, such that a 10" tree should be protected to 20'.
3. Trenching across tree root systems should be the same minimum distance from the trunk, as above "2". Tunnels under root systems for underground utilities should start 18" for deeper below the normal grounds surface. Tree root which must be severed should be cut clean. Backfill material that will be in contact with the roots should be topsoil or a prepared planting soil mixture.
4. Construct sturdy fences, or barriers, of wood, steel, or other protective material around valuable vegetation for protection from construction equipment. Place barriers far enough away from trees so that tall equipment such as backhoes and dump trucks do not contact tree branches.
5. Construction limits should be identified and clearly marked to exclude equipment.
6. Obstructive and broken branches should be pruned properly. The branch collar on all branches whether living or dead should not be damaged. The 3 or 4 cut method should be used on all branches larger than 2" at the cut. First cut about one-third the way through the underside of the limb (about 6-12" from the tree trunk). Then (approximately an inch further out) make a second cut through the limb from the upper side. When the branch is removed, there is not splintering of the main tree trunk. Remove the stub with the third cut. If the branch is larger than 5 or 6" in diameter, use the four cut system. Cuts 1 and 2 remain the same and cut 3

## Part 4 - Protecting Vegetation During Construction

should be from the underside of the limb, on the outside of the branch collar. Cut 4 should be from the top and in alignment with the 3rd cut. Cut 3 should be 1/4 to 1.3 the way through the limb. This will prevent the bark from peeling down the trunk. Do not paint the cut surface.

7. Penalties for damage to valuable trees, shrubs and herbaceous plants should be clearly spelled out in the contract.

### Plans and Specifications

Plans and specifications for protecting existing vegetation shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Call out specific trees to be protected within the limits of disturbance.
2. Specify limits of disturbance and distance from trees to be protected.
3. Include narrative directions from this standard on plan details as appropriate.

# Part 4 - Topsoiling

## Definition

Spreading a specified quality and quantity of topsoil materials on graded or constructed subsoil areas.

## Purpose

To provide acceptable plant cover growing conditions, thereby reducing erosion; to reduce irrigation water needs; and to reduce the need for nitrogen fertilizer application.

Ensuring soil depth and quality provides greater stormwater function in the post-development landscape, provides increased treatment of pollutants and sediments that result from the development, and minimizes the need for some landscaping chemicals, thus reducing pollution through prevention. When applicable, a project may be required to meet the 2017 Vermont Stormwater Management Manual Rule and Design Guidance Section 3.0 Post-Construction Soil Depth and Quality Standard when placing topsoil.

## Conditions Where Practice Applies

Topsoil is applied to subsoils that are droughty (low available moisture for plants), stony, slowly permeable, salty or extremely acid. It is also used to backfill around shrub and tree transplants. This standard does not apply to wetland soils.

## Design Criteria

1. Preserve existing topsoil in place where possible, thereby reducing the need for added topsoil.
2. Conserve by stockpiling topsoil and friable fine textured subsoils that must be stripped from the excavated site and applied after final grading where vegetation will be established.
3. Refer to NRCS soil surveys or soil interpretation record sheets for further soil texture information for selecting appropriate design topsoil depths.

## Site Preparation

1. As needed, install erosion control practices such as diversions, channels, sediment traps, and stabilizing measures, or maintain if already installed.
2. Complete rough grading and final grade, allowing for depth of topsoil to be added.
3. Scarify all compact, slowly permeable, medium and fine textured subsoil areas. Scarify at approximately right angles to the slope direction in soil areas that are steeper than 5%. Areas that have been overly compacted shall be decompacted to a minimum depth of 12" with a deep ripper or chisel plow prior to topsoiling.
4. Remove refuse, woody plant parts, stones over 3" in diameter, and other litter prior to topsoiling.

## Topsoil Materials

1. Topsoil shall have at least 6% by weight of fine textured stable organic material, and no greater than 20%. Muck soil shall not be considered topsoil.
2. Topsoil shall have not less than 20% fine textured material (passing the NO. 200 sieve) and not more than 15% clay.
3. Topsoil treated with soil sterilants or herbicides shall be so identified to the purchaser.
4. Topsoil shall be relatively free of stones over 1.5" in diameter, trash, noxious weeds such as nut sedge and quackgrass, and shall have less than 10% gravel.
5. Topsoil containing soluble salts greater than 500 parts per million shall not be used.

## Application and Grading

1. Apply topsoil in the following amounts:

## Part 4 - Topsoiling

Site Conditions	Intended Use	Minimum Topsoil Depth
1. Deep Sand or Loamy Sand	Mowed Lawn.	6"
	Tall Legumes, Unmowed.	2"
	Tall Grass, Unmowed.	1"
2. Deep Sandy Loam	Mowed Lawn.	5"
	Tall Legumes, Unmowed.	2"
	Tall Grass, Unmowed.	None
3. 6" or More: Silt Loam, Loam, or Silt	Mowed Lawn.	4"
	Tall Legumes, Unmowed.	1"
	Tall Grass, Unmowed.	1"

matter content, friable consistence (soil aggregates can be easily crushed with only moderate pressure), its available water holding capacity, and its nutrient content. Most often it is superior to subsoil in these characteristics. The texture and friability of topsoil are usually much more conducive to seedling germination, emergence, and root growth.

- In addition to being a better growth medium, topsoil is often less erodible than subsoil, and the coarser texture of topsoil increases infiltration capacity and reduces runoff.
- Although topsoil may provide in improved growth medium, there may be disadvantages to its use in certain situations. Stopping, stockpiling, hauling, and spreading topsoil or importing topsoil may not be cost-effective. Handling may be difficult if large amounts of branches or rocks are present or if the terrain is too rough. Most topsoil contains weed seeds, which compete with desirable species.
- In site planning, compare the options of topsoiling with preparing a seedbed in the available subsoil. The clay content of many subsoils retains moisture. When properly limed and fertilized, subsoil may provide a satisfactory growth medium, which is generally free of weed seeds.
- Topsoiling is normally recommended where ornamental plants or high-maintenance turf will be grown. It may also be required to establish vegetation on shallow soils, soils containing potentially toxic materials, stony soils, and soils of critically low pH (highly acid).

- Topsoil shall be distributed to a uniform depth over the area.
- Topsoil shall not be placed with it is partly frozen, muddy, or on frozen slopes or over ice, snow, or standing water puddles.
- Topsoil shall be applied and graded as referenced in the 2017 Vermont Stormwater Management Manual Rule and Design Guidance section 3.0 Post-Construction Soil Depth and Quality Standard.

### Considerations

- Topsoil is the surface layer of the soil profile, generally characterized as darker than the subsoil due to the enrichment with organic matter. It is the major source of root development and biological activity. Microorganisms that enhance plant growth thrive in this layer. Topsoil can usually be differentiated from subsoil by texture as well as color. Clay content usually increases in the subsoil. Where subsoils are high in clay, the topsoil layer may be significantly coarser in texture. The depth of natural topsoil may be quite variable. On severely eroded sites it may be gone entirely.
- Advantages of topsoil include its higher organic

### Plans and Specifications

The plans and specifications for installing topsoiling shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

- Stockpile location and method of stabilization prior to its use.
- Site preparation plans and method of application, distribution and compaction.

# Part 4 - Surface Roughening

## Definition

Roughening a bare soil surface whether through creating horizontal grooves across a slope, stair-stepping, or tracking with construction equipment.

## Purpose

To aid the establishment of vegetative cover from seed, to reduce runoff velocity and increase infiltration, and to reduce erosion and provide for trapping of sediment.

## Conditions Where Practice Applies

All construction slopes require surface roughening to facilitate stabilization with vegetation, particularly slopes steeper than 3:1.

## Design Criteria

There are many different methods to achieve a roughened soil surface on a slope. No specific design criteria is required. However, the selection of the appropriate method depends on the type of slope. Methods include tracking, grooving, and stair-stepping. Steepness, mowing requirements, and/or a cut or fill slope operation are all factors considered in choosing a roughening method. (See Figure 4.1).

## Construction Specifications

### 1. Cut Slope, No Mowing.

- a. Stair-step guide or groove cut slopes with a gradient steeper than 3:1.
- b. Use stair-step grading on any erodible material soft enough to be ripped with a bulldozer. Slopes of soft rock with some soil are particularly suited to stair-step grading.
- c. Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the "step" to the vertical wall.

- d. Do not make vertical cuts more than 2' in soft materials or 3' in rocky materials.
- e. Grooving uses machinery to create a series of ridges and depressions that run perpendicular to the slope following the contour. Groove using any appropriate implement that can be safely operated on the slope, such as disks, tillers, spring harrows, or the teeth of a front-end loader bucket. Do not make the grooves less than 3" deep or more than 15" apart.

### 2. Fill Slope, No Mowing.

- a. Place fill to create slopes with a gradient steeper than 3:1 in lifts 9" or less and properly compacted. Ensure the face of the slope consists of loose, uncompacted fill 4 to 6" deep. Use grooving as described above to roughen the slope, if necessary.
- b. Do not blade or scrape the final slope face.

### 3. Cuts/Fills, Mowed Maintenance.

- a. Make mowed slopes no steeper than 3:1.
- b. Roughen these areas to shallow grooves by normal tilling, disking, harrowing, or use of cultipacker-seeder. Make the final pass of such tillage equipment on the contour.
- c. Make grooves at least 1" deep and a maximum of 10" apart.
- d. Excessive roughness is undesirable where mowing is planned.
- e. Tracking should be used primarily in sandy soils to avoid undue compaction of the soil surface. Tracking is generally not as effective as the other roughening methods described, and is more suited as a method to anchor mulch. Operate tracked machinery up and down the slope to leave horizontal depressions in the soil. Do not back-blade during the final grading operation.

## Part 4 - Surface Roughening

### Considerations

Rough slope surfaces are preferred because they aid in the establishment of vegetation, improve water filtration, and decrease runoff velocity. Graded areas with smooth, hard surfaces may be initially attractive, but such surfaces increase the potential for erosion. A rough, loose soil surface gives a mulching effect that protects lime, fertilizer and seed. Nicks in the surface promote cooler temperatures and provide more favorable moisture conditions than hard, smooth surfaces; this aids seed germination.

There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

Stair-step grading may be carried out on any material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.

Grooves may be made with any appropriate implement that can be safely operated on the slope and which will not cause significant compaction. Suggested implements include offset discs, tillers, spring harrows, chisel rippers, and the teeth on a front-end loader bucket.

For areas that will be mowed, surface roughening should consist of shallow grooves created by normal tilling, disking, harrowing, or use of a culti-packer seeder. The final pass of any such implement shall be on the contour.

Tracking is generally not as effective as other roughening methods described since the soil surface is more likely to be compacted which results in less infiltration runoff.

### Plans and Specifications

Plans and specifications for surface roughening shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Directions on the plans to employ surface roughening, specific to site conditions.
2. Surface roughening detail.
3. Method and equipment needed.

## Part 4 - Surface Roughening

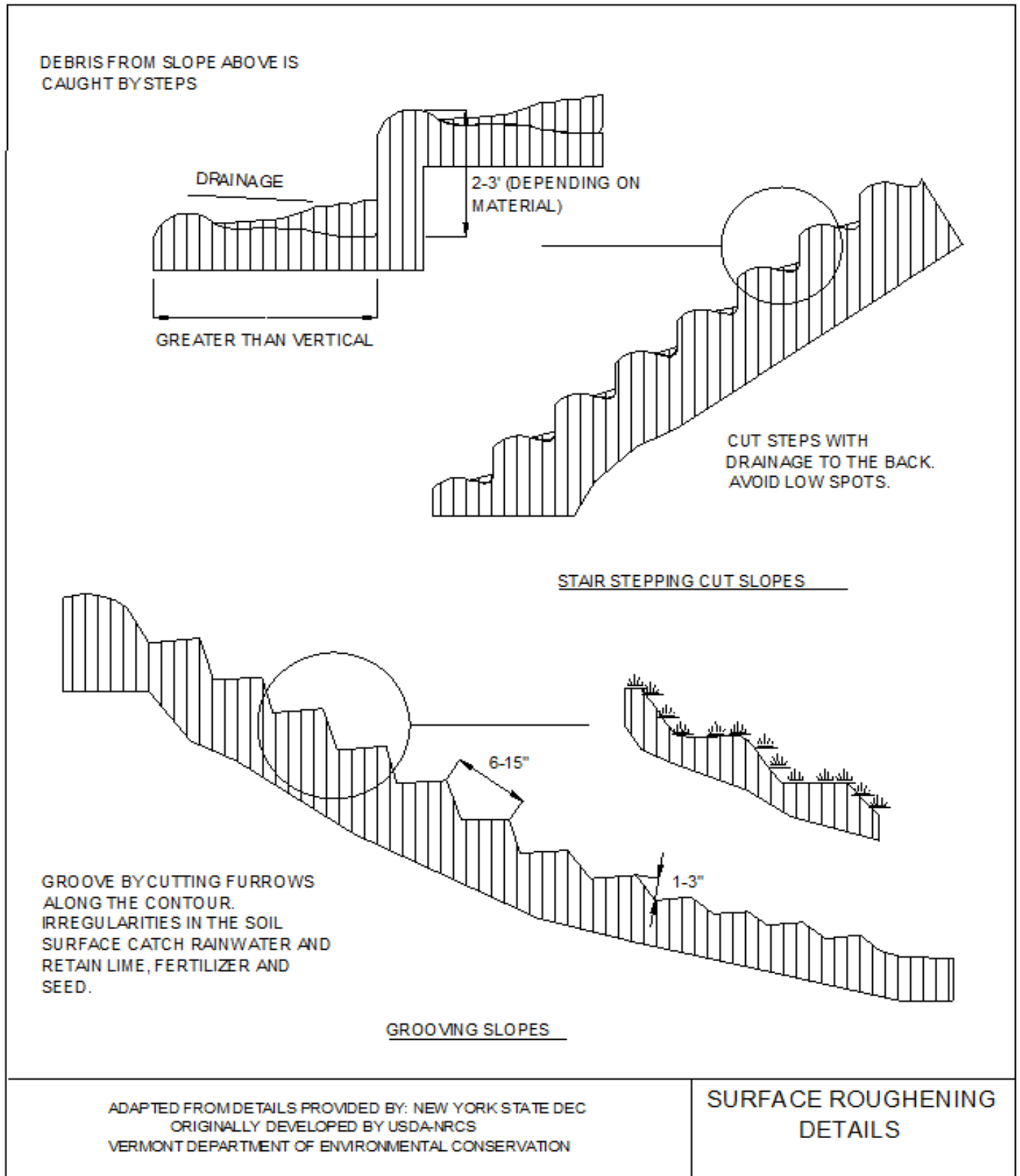


Figure 4.1 Surface Roughening

## **Part 4 - Surface Roughening**

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# Part 4 - Mulching

## Definition

Applying coarse plant residue or chips, or other suitable materials, to cover the soil surface.

## Purpose

The primary purpose is to provide initial erosion control while a seeding or shrub planting is establishing. Mulch will conserve moisture and modify the surface soil temperature and reduce fluctuation of both. Mulch will prevent soil surface crusting and aid in weed control. Mulch is also used alone for temporary stabilization in non-growing months.

## Conditions Where Practice Applies

On disturbed soils to achieve temporary stabilization.

## Design Criteria

Site preparation prior to mulching requires the installation of necessary erosion control or water management practices and drainage systems.

Slope, grade and smooth the site to fit the needs of selected mulch products.

Remove all undesirable stones and other debris to meet the needs of the anticipated land use and maintenance required.

Apply mulch in accordance with the requirements of the General Permit (see Figure 4.2 and 4.3) in reference to Vermont's Construction General Permit.

Select appropriate mulch material and application rate.

Select appropriate mulch anchoring material.

NOTE: The best combination for grass/legume establishment is straw (cereal grain) mulch applied at 2 ton/acre (90 lbs./1000sq.ft.) and anchored with

wood fiber mulch (hydromulch) at 500-700 lbs./acre (11-17 lbs./1000 sq.ft.). The wood fiber mulch must be applied through a hydroseeder immediately after mulching.

## Considerations

Organic mulches are the most effective mulch materials. Hydro fiber mulches are effective when used in combination with grass hay and cereal grain straw. Chemical soil binders are less effective than organic mulches.

## Plans and Specifications

Plans and specifications for mulching shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Type(s) of mulch material used.
2. Thickness and percent cover and/or weight of mulch material required.
3. Timing of application (refer to Part 3).
4. Listing of netting, tackifiers, or method of anchoring.

## Part 4 - Mulching

Mulch Material	Quality Standards	Per 1000 Sq.Ft.	Per Acre	Depth of Application	Remarks
Wood chips, shavings, or stump grindings	Air-dried. Free of objectionable coarse material.	500-900 lbs.	10-20 tons	2-7"	Used primarily around shrub and tree plantings and recreation trails to inhibit weed competition. Resistant to wind blowing. Decomposes slowly.
Wood fiber cellulose (partly digested wood fibers)	Made from natural wood usually with green dye and dispersing agent.	50 lbs.	2000 lbs.	—	Apply with hydromulcher. No tie down required. Less erosion control provided than 2 tons of hay or straw.
Gravel, or crushed stone	Washed; size 2B or 3A - 1.5".	9 cu.yds.	405 cu.yds.	3"	Excellent mulch for short slopes and around plants and ornaments. Use 2B where subject to traffic. (approximately 2,000 lbs./cu./yd.). Frequently used over filter fabric for better weed control.
Hay or straw	Air dried; free of undesirable seeds and coarse materials.	90-100 lbs. or 2-3 bales	2 tons or 100-120 bales	Cover about 90% surface	Use small grain straw where mulch is maintained for more than 3 months. Subject to wind blowing unless anchored. Most commonly used mulching material. Provides the best micro-environment for germinating seeds.
Compost	up to 3" pieces, moderately to highly stable.	3-9 cu.yds.	134-402 cu.yds.	1-3"	Coarser textured mulches may be more effective in reducing weed growth and wind erosion.

**Figure 4.2 Guide to Mulch Materials, Rates, and Uses**

Anchoring Method or Material	Kind of Mulch to be Anchored	How to Apply
1. Peg and twine	Hay or straw	After mulching divide areas into blocks approximately 1 sq.yd. in size. Drive 4-6 pegs per block to within 2" to 3" of soil surface. Secure mulch to surface by stretching twine between pegs in criss-cross pattern on each block. Secure twine around each peg with 2 or more tight turns. Drive pegs flush with soil. Driving stakes into ground tightens the twine.
2. Mulch netting	Hay or straw	Staple the light weight paper, jute, wood fiber, or plastic nettings to soil surface according to manufacturer's recommendations. Should be biodegradable. Most products are not suitable for foot traffic. To avoid wildlife entanglement, netting with fused joints is not approved. Refer to Figure 4.4 for RECP specifications.
3. Wood cellulose fiber	Hay or straw	Apply with hydroseeder immediately after mulching. Use 500 lbs. wood fiber per acre. Some products contain an adhesive material ("tackifier"), possibly advantageous.
4. Mulch anchoring tool	Hay or straw	Apply mulch and pull a mulch anchoring tool (blunt straight discs) over mulch as near to the contour as possible. Mulch material should be "tucked" into soil surface about 3".
5. Tackifier	Hay or straw	Mix and apply polymeric and gum tackifiers according to manufacturer's instructions. Avoid application during rain. A 24-hour curing period and a soil temperature higher than 45 degrees Fahrenheit are required.

**Figure 4.3 Mulch Anchoring**

# Part 4 - Rolled Erosion Control Product (RECP)

## Definition

A preformed protective blanket of straw or other plan residue, or plastic fibers formed into a mat, with a supporting mesh framework on one or both sides. Approved RECP applications include three sub-categories:

### 1. Mulch Control Netting:

A temporary biodegradable RECP composed of planar woven natural fiber.

### 2. Erosion Control Blanket:

A temporary biodegradable rolled erosion control product composed of processed natural fibers to form a continuous matrix.

### 3. Permanent Erosion Matting:

Permanent erosion matting includes long-term non-degradable RECP composed of UV stabilized, non-degradable, synthetic fibers, filaments, nettings and/or wire mesh processed into three dimensional reinforcement matrices.

Mulch Control Netting and Erosion Control Blanket are to be used where natural vegetation will be the final stabilization. Permanent Erosion Matting is to be used where vegetation alone will not provide sufficient long-term erosion protection (for example in drainage ditches with high design flow velocities).

## Purpose

The purposes of this practice are to protect the soil surface from raindrop impacts and overland flow during the establishment of grass or other vegetation, and to reduce soil moisture loss due to evaporation.

## Conditions Where Practice Applies

This practice applies where the protection of newly seeded areas is critical; on slopes greater than 3:1 (H:V) or where specified in the EPSC Plan. This is especially important where flowing water may occur before the grass is established. The most common application of RECP is on the bottom of small channels and on steep embankments.

## Design Criteria

The RECP shall be in close contact with the soil. It shall be anchored per the manufacturer's recommendations with the proper number and spacing of wire staples. The staples shall be the proper width and length to meet the manufacturer's recommendations.

On slopes and in small drains the RECP shall be unrolled upstream to downstream parallel to the direction of flow. The upstream end of each RECP shall be anchored in a minimum 6-inch deep anchor trench. These RECPs, when laid side by side, shall overlap a minimum of 4 inches. When more than one RECP length is needed, the material shall be overlapped 12" over the downstream piece. All edges shall be stapled as per manufacturer's recommendation.

Temporary RECP materials shall conform to the specification and corresponding properties in Figure 4.4. Permanent RECP materials shall conform to the specifications and corresponding properties in Figure 4.5.

## Considerations

RECP will be located as part of the site development plan. They protect the ground surface from raindrop impacts and flowing water. They also retain moisture on seeded areas thus increasing the potential for germination and survival of the vegetation. Mulch Control Netting and Erosion Control Blanket materials will break down over time. They should be

## Part 4 - Rolled Erosion Control Product (RECP)

chosen so that they last long enough for the grass or other vegetation to become established.

RECP product installations have the potential to ensnare animals, such as snakes and birds, which can lead to injury or fatality. This has been observed to be most problematic in products with welded joints in the supporting mesh, including products with plastic mesh, whether bio- or photo-degradable or not. Accordingly, only woven and interlinked products are approved for use in temporary RECP applications (see Figures 4.4 and 4.5 for full specifications for accepted RECP).

### Plans and Specifications

Plans and specifications for installing erosion blankets shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Location of the RECP.
2. Type of RECP (must meet the criteria in Figures 4.4 and 4.5).
3. Location and cross section of anchor trenches.
4. Construction detail, with manufacturer's recommendations if available.

## Part 4 - Rolled Erosion Control Product (RECP)

Product Description	Material Composition	Longevity (months)	Slope Applications*		Channel Applications*	Minimum Tensile Strength <sup>1</sup> <i>kN/m(lbs/ft)</i>
			Maximum Gradient (h:v)	C Factor <sup>2,5</sup>	Maximum Shear Stress <sup>3,4,6</sup> <i>Pg (lbs/ft<sup>2</sup>)</i>	
Mulch Control Nets	Mesh or woven biodegradable natural fiber netting.	3	5:1	≤ 0.10	12 (0.25)	0.073 (5)
		12	5:1	≤ 0.10	12 (0.25)	0.073 (5)
		24	5:1	≤ 0.10	12 (0.25)	0.36 (25)
Netless Rolled Erosion Control Blankets	Natural fibers mechanically interlocked together to form a RECP.	3	4:1	≤ 0.10	24 (0.5)	0.073 (5)
		12	4:1	≤ 0.10	24 (0.5)	0.073 (5)
Single-net Erosion Control Blankets	Processed biodegradable natural fibers mechanically bound together by a single, natural fiber netting of processed natural yarns or twines woven into a continuous matrix.	3	3:1	≤ 0.15	72 (1.5)	0.73 (50)
		12	3:1	≤ 0.15	72 (1.5)	0.73 (50)
Double-net Erosion Control Blankets	Processed biodegradable natural fibers mechanically bound together between two natural fiber nettings of processed natural yarns or twines woven into a continuous matrix.	3	2:1	≤ 0.20	84 (1.75)	1.09 (75)
		12	2:1	≤ 0.20	84 (1.75)	1.09 (75)
		24	1.5:1	≤ 0.25	96 (2.00)	1.45 (100)
		36	1:1	≤ 0.25	108 (2.25)	1.82(125)

\* "C" factor and shear stress for mulch control nettings must be obtained with netting used in conjunction with pre-applied mulch material.

1. Minimum Average Roll Values, Machine direction using Erosion Control Technology Council (ECTC) Mod. ASTM D5085.

2. "C" Factor calculated as ratio of soil loss from RECP protected slope (tested at specified or greater gradient, h:v) to ratio of soil loss from unprotected (control) plot in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions using ECTC Test Method # 2.

3. Required minimum shear stress RECP (unvegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in) soil loss) during a 30-minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using ECTC Test Method #3.

4. The permissible shear stress levels established for each performance category are based on historical experience with products characterized by Manning's roughness coefficients in the range of 0.01 - 0.05.

5. Acceptable large-scale test methods may include ASTM D 6459, ECTC Test Method #2, or other independent testing deemed acceptable by DEC.

6. Recommended acceptable large-scale testing protocol may include ASTM D 6460, ECTC Test Method #3 or other independent testing deemed acceptable by the DEC.

Figure 4.4 Specifications for Temporary Rolled Erosion Control Products

## Part 4 - Rolled Erosion Control Product (RECP)

Type	Product Description	Material Composition	Slope Applications	Channel Applications	Minimum Tensile Strength <sup>2,3</sup> <i>kN/m(lbs/ft)</i>
			Maximum Gradient (h:v)	Maximum Shear Stress <sup>4,5</sup> <i>Pq(lbs/ft<sup>2</sup>)</i>	
A	Turf Reinforcement Mat	Non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness. TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. Note: TRMs are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.	0.5:1	288(6.0)	1.82(125)
B	Turf Reinforcement Mat		0.5:1	384(8.0)	2.19(150)
C	Turf Reinforcement Mat		0.5:1	480(10.0)	2.55(175)

PERMANENT<sup>1</sup>-All categories of Turf Reinforcement Mat (TRM) must have a minimum thickness of 6.35 mm(0.25 inches) per ASTM D 6525 and U.V. stability of 80% per ASTM D 4355 (500 hours exposure).

1. For TRMs containing degradable components, all property values must be obtained on the non-degradable portion of the matting alone.

2. Minimum Average Roll Values, machine direction only for tensile strength determination using ASTM D 6818 (Supersedes Mod. ASTM D 5085 for RECPs)

3. Field conditions with high loading and/or high survivability requirements may warrant the use of a TRM with a tensile strength of 44 kN/m(3,000 lb/ft) or greater.

4. Required minimum shear stress TRM (fully vegetated) can sustain without physical damage or excess erosion (>12.7 mm(0.5 in.) soil loss) during a 30-minute flow event in large scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using ECTC Test Method #3.

5. Acceptable large-scale testing protocol may include ASTM D 6460, ECTC Test Method #3, or other independent testing deemed acceptable by DEC.

Figure 4.5 Specifications for Permanent Erosion Control Products

## Part 4 - Rolled Erosion Control Product (RECP)

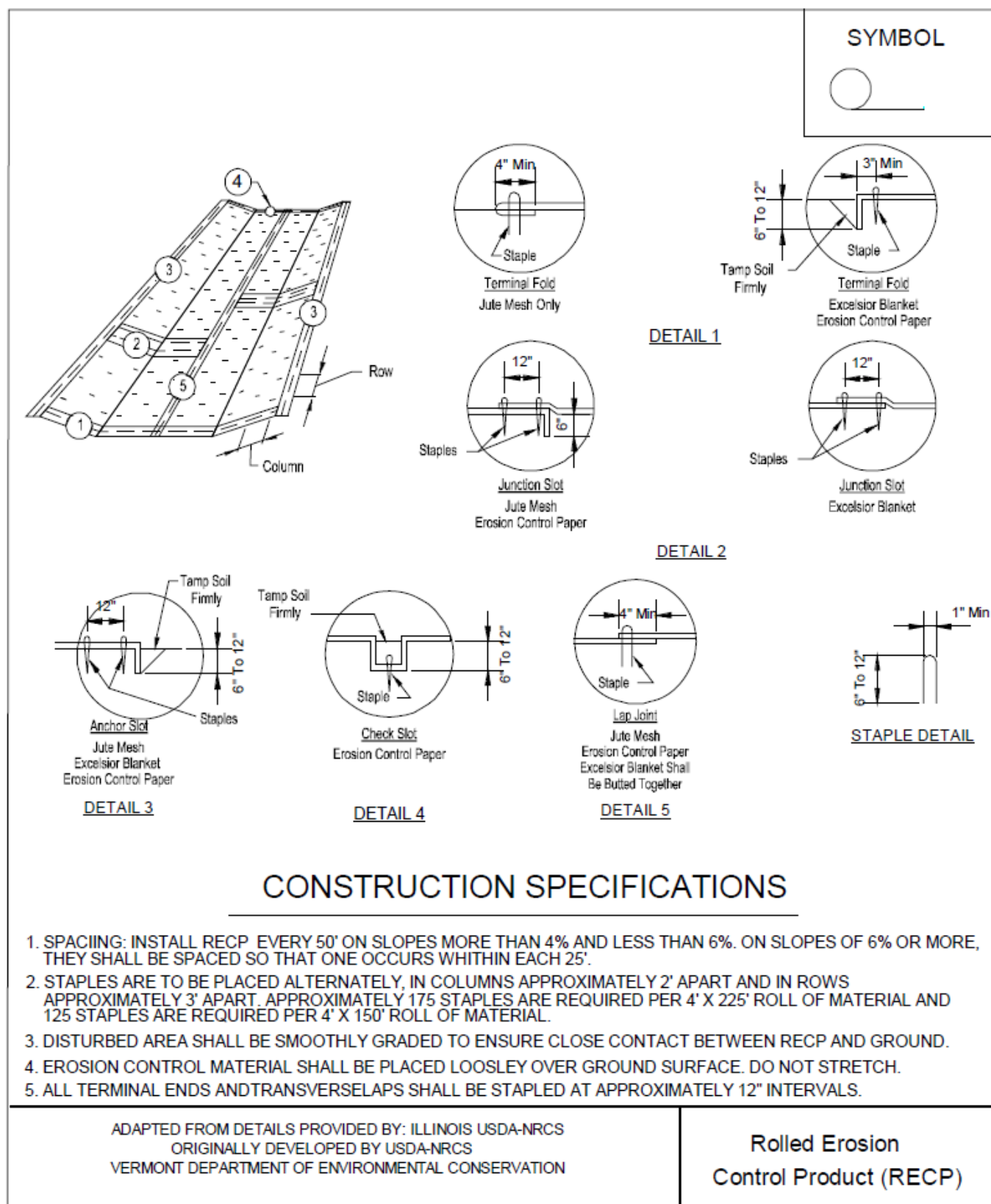


Figure 4.6 Rolled Erosion Control Product (RECP)

# Part 4 - Temporary Stabilization Through Seeding

## Definition

Providing erosion control protection to a disturbed area for an interim period.

## Purpose

To provide temporary erosion and sediment control. Temporary control is achieved by covering all bare ground areas that exist as a result of construction or a natural event.

## Conditions Where Practice Applies

Temporary seedings may be necessary on construction sites to protect an area, where final grading is complete, when preparing for winter work shutdown, or to provide cover when permanent seedings are likely to fail due to mid-summer heat and drought. The intent is to provide temporary protective cover during temporary shutdown of construction and/or while waiting for optimal planting time.

## Design Criteria

Water management practices must be installed as appropriate for site conditions. The area must be rough graded and slopes physically stable. Large debris and rocks are usually removed. Seedbed must be seeded within 24 hours of disturbance or scarification of the soil surface will be necessary prior to seeding. Fertilizer or lime are not typically used for temporary plantings.

IF: Spring or summer or early fall, then seed the area with ryegrass (annual or perennial) at 20 lbs. per acre (approximately 0.5 lb./1000 sq. ft. or use 1 lb./1000 sq. ft.).

IF: Late fall or early winter, then seed Certified 'Aroostook' winter rye (cereal rye) at 90 lbs. per acre (2.0 lbs./1000 sq. ft.).

Any seeding method may be used that will provide uniform application of seed to the area and result in relatively good soil to seed contact.

Mulch the area with hay or straw at 2 tons/acre (approximately 90 lbs./1000 sq. ft. or 2 bales / 1000 sq. ft.). Quality of hay or straw mulch allowable will be determined based on long term use and visual concerns. Mulch anchoring will be required where wind or areas of concentrated water are of concern. Wood fiber hydromulch or other sprayable products approved for erosion control may be used if applied according to manufacturers' specification. Caution is advised when using nylon or other synthetic products. They may be difficult to remove prior to final seeding.

## Considerations

Native species or mixes that are adapted to the site and have multiple values should be considered. Avoid species that may harbor pests. Species diversity should be considered to avoid loss of function due to species-specific pests.

Evaluate the need for structural practices to stabilize a critically eroding site or prevent off site movement of undesirable materials. Consider the long-term maintenance needs for the site.

## Plans and Specifications

Plans and specifications for use of temporary critical area plantings shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Location of the temporary critical area plantings.
2. Specifications for appropriate seed type.
3. Directions for seeding and mulching trees.
4. Directions for irrigation if applicable.

## Part 4 - Permanent Stabilization Through Seeding

### Definition

Establishing grasses with other forbs and/or shrubs to provide perennial vegetative cover on disturbed areas.

### Purpose

To reduce erosion and sediment transport.

### Conditions Where Practice Applies

This practice applies to all disturbed areas that will be permanently stabilized with vegetation, cover to prevent erosion and sediment transport.

### Design Criteria

All water control measures will be installed as needed prior to final grading and seedbed preparation. Any severely compacted sections will require chiseling or disking to provide an adequate rooting zone, to a minimum depth of 12". The seedbed must be prepared to allow good soil to seed contact, with the soil not too soft and not too compact. Adequate soil moisture must be present to accomplish this. If surface is powder dry or sticky wet, postpone operations until moisture changes to a favorable condition. If seeding is accomplished within 24 hours of final grading, additional scarification is generally not needed, especially on ditch or stream banks. Remove all stones and other debris from the surface that are greater than 4 inches, or that will interfere with future mowing or maintenance.

Soil amendments should be incorporated into the upper 2" of soil when feasible. The soil should be tested to determine the amounts of amendments needed. Apply ground agricultural limestone to attain a pH of 6.0 in the upper 2" of soil. If soil must be fertilized before the results of a soil test can be obtained to determine fertilizer needs, apply commercial fertilizer at 600 lbs. per acre of 5-10-10 or equivalent. If manure is used, apply a quantity to meet the nutrients of the above fertilizer. This requires an appropriate manure analysis prior to applying to the

site. Do not use manure on sites to be planted with birdsfoot trefoil or in the path of concentrated water flow.

Seed mixtures may vary depending on location within the state and time of seeding. Generally, warm season grasses should only be seeded during early spring, April to May. These grasses are primarily used for vegetating excessively drained sands and gravels. Other grasses may be seeded any time of the year when the soil is not frozen and is workable. When legumes such as birdsfoot trefoil are included, spring seedings are preferred.

### General Seed Mix:

	Variety	lbs./acre	lbs.1000 sq. ft.
Birdsfoot Trefoil <sup>1</sup> OR	Empire/ Pardee	5 <sup>2</sup>	0.10
Common White Clover	Common	8	0.20
PLUS			
Tall Fescue	KY-31/ Rebel	10	0.25
PLUS			
Redtop OR	Common	2	0.05
Ryegrass (Perennial)	Pennfine/ Linn	5	0.10

<sup>1</sup> Add inoculant immediately prior to seeding

<sup>2</sup> Mix 2.5 lbs each of Empire and Pardee OR 2.5 lbs. of Birdsfoot and 2.5 lbs. white clover per acre.

### Time of Seeding:

The optimum timing for the general seed mixture is early spring. Permanent seedings may be made any time of year if properly mulched and adequate moisture is provided. Late June through early August is not a good time to seed, but may facilitate covering the land without additional disturbance if construction is completed. Portions of the seeding fail due to drought and heat. These areas may need reseeding in late summer/fall or the following spring.

## Part 4 - Permanent Stabilization Through Seeding

### Method of Seeding:

Broadcasting, drilling, cultipack type seeding, or hydroseeding are acceptable methods. Proper soil to seed contact is key to successful seedings.

2. Specifications for appropriate seed type.
3. Directions for seeding and mulching rates.
4. Directions for irrigation if applicable.

### Mulching:

Mulching is essential to obtain a uniform stand of seeded plants. Optimum benefits of mulching new seedlings are obtained with the use of small grain straw applied at a rate of 2 tons per acre, and anchored with a netting or tackifier. See the mulch standard and specification for choices and requirements.

### Irrigation:

Watering may be essential to establish a new seeding when a drought condition occurs shortly after a new seeding emerges. Irrigation is a specialized practice and care must be taken not to exceed the application rate for the soil or subsoil. When disconnecting irrigation pipe, be sure pipes are drained in a safe manner, not creating an erosion hazard.

### Considerations

Native species or mixes that are adapted to the site and have multiple values should be considered. Avoid species that may harbor pests. Species diversity should be considered to avoid loss of function due to species-specific pests.

Evaluate the need for structural practices if needed to stabilize a critically eroding site or prevent off site movement of undesirable materials. Consider the long-term maintenance needs for the site.

### Plans and Specifications

Plans and specifications for use of permanent critical area plantings shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Location of the permanent critical area plantings.

## Part 4 - Stabilization With Sod

### Definition

Stabilizing disturbed areas by establishing long term stands of grass with sod.

### Purpose

To stabilize the soil; reduce damage from sediment and runoff to downstream areas; enhance natural beauty.

### Conditions Where Practice Applies

On exposed soils where a quick vegetative cover is desired. Moisture, either applied or natural, is essential to success.

### Design Criteria

1. Sod shall be suitable to the location, bluegrass or a bluegrass/red fescue mixture or a perennial ryegrass for average sites. (CAUTION: Perennial ryegrass has limited cold tolerance and may winter kill.) Use turf type cultivars of tall fescue for shady, droughty, or otherwise more critical areas.
2. Sod shall be machine cut at uniform soil thickness of 3/4", plus or minus 1/4". Measurement for thickness shall exclude top growth and thatch.
3. Sod shall not be harvested or transplanted when moisture content (excessively dry or wet) may adversely affect its survival.
4. Sod shall be harvested, delivered, and installed within a period of 36 hours. Sod not transplanted within this period shall be inspected and approved by their designated representative prior to its installation.

### Site Preparation

Fertilizer and lime application rates shall be determined by soil tests. Under unusual circumstances where there is insufficient time for a complete soil

test and the contracting officer agrees, fertilizer and lime materials may be applied in amounts shown in subsection 2 below. Slope land such as to provide good surface water drainage. Avoid depressions or pockets.

1. Prior to sodding, the surface shall be smoothed and cleared of all trash, debris, and all of roots, brush, wire, grade stakes and other objects that would interfere with planting, fertilizing or maintenance operations.
2. The soil should be tested to determine the amounts of amendments needed. Where the soil is acidic or composed of heavy clays, ground limestone shall be spread to raise the pH to 6.5. If the soil must be fertilized before results of a soil test can be obtained to determine fertilizer needs, apply commercial fertilizer at 20 lbs. of 5-10-10 (or equivalent) and mix into the top 3 inches of soil with the required lime for every 1000 sq. ft. Soil should be moist prior to sodding. Arrange for temporary storage of sod to keep it shaded and cool.

### Sod Installation

1. For the operation of laying, tamping, and irrigating for any areas, sod shall be completed within 8 hours. During periods of excessively high temperature, the soil shall be lightly moistened immediately prior to laying the sod.
2. The first row of sod shall be laid in a straight line with subsequent rows placed parallel to, and tightly wedged against, each other. Lateral joints shall be staggered to promote more uniform growth and strength. Ensure that sod is not stretched or overlapped and that all joints are butted tight in order to prevent voids which would cause air drying of the roots. On sloping areas where erosion may be a problem, sod shall be laid with the long edges parallel to the contour and with staggered joints.
3. Secure the sod by tamping and pegging, or other approved methods. As sodding is completed in

## Part 4 - Stabilization With Sod

any one section, the entire area shall be rolled or tamped to ensure solid contact of roots with the soil surface.

4. Sod shall be watered immediately after rolling or tamping until the underside of the new sod pad and soil surface below the sod are thoroughly wet. Keep sod moist for at least 2 weeks.

### Sod Maintenance

1. In the absence of adequate rainfall, watering shall be performed daily, or as often as deemed necessary during the first week and in sufficient quantities to maintain moist soil to a depth of 4". Watering should be done in the morning. Avoid excessive watering during applications.
2. After the first week, sod shall be watered as necessary to maintain adequate moisture and ensure establishment.
3. If the soil must be fertilized before results of a soil test can be obtained to determine fertilizer needs, apply fertilizer three to four weeks after sodding, at a rate of 1 lb nitrogen/1000 sq. ft. Use a complete fertilizer with a 2-1-1 ratio.

# Part 4 - Construction Road Stabilization

## Definition

The stabilization of temporary construction access routes, on-site vehicle transportation routes, and construction parking areas.

## Purpose

To control erosion on temporary construction routes and parking areas.

## Conditions Where Practice Applies

All traffic routes and parking areas for temporary use by construction traffic.

## Design Criteria

Construction roads should be located to reduce erosion potential, minimize impact on existing site resources, and maintain operations in a safe manner. Highly erosive soils, wet or rocky areas, and steep slopes should be avoided. Roads should be routed where seasonal water tables are deeper than 18". Surface runoff and control should be in accordance with other standards. A 4" layer of crushed gravel or dense graded crushed stone for sub-base (subsection 704.04-704.06 VT AOT Standards and Specifications for Construction).

## Construction Specifications

1. Clear and strip roadbed and parking areas of all vegetation, roots, and other objectionable material.
2. Locate parking areas on naturally flat areas as available. Keep grades sufficient for drainage.
3. Provide surface drainage and divert excess runoff to stabilized areas.
4. Maintain cut and fill slopes to 2:1 or flatter and stabilize with vegetation as soon as grading is accomplished.
5. Spread a 4" layer of sub-base material evenly over

the full width of the road and smooth it to avoid depressions.

6. Provide appropriate sediment control measures to prevent off-site sedimentation.

## Maintenance

Inspect construction roads and parking areas periodically for condition of surface. Top dress with new gravel as needed. Check ditches for erosion and sedimentation after rainfall events. Maintain vegetation in a healthy, vigorous condition. Areas producing sediment should be treated immediately.

## Considerations

Areas graded for construction vehicle transport and parking purposes are especially susceptible to erosion. The exposed soil is continually disturbed, eliminating the possibility of stabilization with vegetation. The prolonged exposure of the roads and parking areas to surface runoff can create severe rill erosion and/or sedimentation, requiring regrading before paving. The soil removed during this process may enter streams and other waters of the state, compromising water quality. Additionally, because unfinished roads become so unstable, erosion may limit access, and cause delays in construction.

## Plans and Specifications

Plans and specifications for use of construction road stabilization shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Location of the construction road stabilization.
2. Specifications for preparation of road.
3. Directions for maintenance.

## Part 4 - Riprap Slope Protection

### Definition

A layer of stone designed to protect and stabilize areas subject to erosion.

### Purpose

To protect the soil surface from erosive forces and/or improve the stability of soil slopes that are subject to seepage or have poor soil structure.

### Conditions Where Practice Applies

Riprap is used for cut and fill slopes subject to seepage, erosion, or weathering, particularly where conditions prohibit the establishment of vegetation. Riprap is also used for channel side slopes and bottoms, streambanks, grade sills, on shorelines subject to erosion, and at inlets and outlets to culverts, bridges, slope drains, grade stabilization structures, and storm drains.

### Design Criteria

**Gradation** - Riprap should be a well-graded mixture with 50% by weight larger than the specified design size. The diameter of the largest stone size in such a mixture should be 1.5 times the  $d_{50}$  size with smaller sizes grading down to 1". The designer should select the size or sizes that equal or exceed that minimum size based on riprap gradations commercially available in the area.

**Thickness** - The minimum layer thickness should be 1.5 times the maximum stone diameter, but in no case less than 6".

**Quality** - Stone for riprap should be hard, durable field or quarry materials. They should be angular and not subject to breaking down when exposed to water or weathering. The specific gravity should be at least 2.5.

**Size** - The sizes of stones used for riprap protection are determined by purpose and specific site conditions:

1. **Slope Stabilization** - Riprap stone for slope stabilization not subject to flowing water or wave action should be sized for the proposed grade. The gradient of the slope to be stabilized should be less than the natural angle of repose of the stone selected. Angles of repose of riprap stones may be estimated from Figure 4.7.

Riprap used for surface stabilization of slopes does not add significant resistance to sliding or slope failure and should not be considered a retaining wall. Slopes approaching 1.5:1 may require special stability analysis. The inherent stability of the soil must be satisfactory before riprap is used for surface stabilization.

2. **Outlet Protection** - Design criteria for sizing stone and determining dimensions of riprap aprons are presented in the standards and specifications for Rock Outlet Protection.

**Filter Blanket** - A filter blanket is a layer of material placed between the riprap and the underlying soil to prevent soil movement into or through the riprap. A suitable filter may consist of a well-graded gravel or sand-gravel layer or a synthetic filter fabric manufactured for this purpose. The design of a gravel filter blanket is based on the ratio of particle size in accordance with the criteria below. Multiple layers may be designed to affect a proper filter if necessary.

A gravel filter blanket should have the following relationship for a stable design:

$$\begin{aligned} \frac{d_{15} \text{ filter}}{d_{85} \text{ base}} &\leq 5 \\ 5 < \frac{d_{15} \text{ filter}}{d_{50} \text{ base}} &\leq 40 \\ \text{and} \quad \frac{d_{50} \text{ filter}}{d_{50} \text{ base}} &\leq 40 \end{aligned}$$

## Part 4 - Riprap Slope Protection

Filter refers to the overlying material while base refers to the underlying material. These relationships must hold between the base and filter and the filter riprap to prevent migration of material. In some cases, more than one filter may be needed. Each filter layer should be a minimum of 6 inches thick, unless acceptable filter fabric is used.

A synthetic filter fabric may be used with or in place of gravel filters. The following particle size relationships should exist:

1. Filter fabric covering a base containing 50% or less by weight of fine particles (#200 sieve size):
  - a.  $d_{85} \text{ base (mm)} \text{ EOS}^* \text{ filter fabric (mm)} > 1$
  - b. Total open area of filter fabric should not exceed 36%
2. Filter fabric covering other soils:
  - a. EOS is no larger than 0.21 mm (#70 sieve size)
  - b. Total open area of filter fabric should not exceed 10%.

\*EOS - Equivalent opening size compared to a U.S. standard sieve size.

No filter fabric should have less than 4% open area or an EOS less than U.S. Standard Sieve #100 (0.15 mm). The permeability of the fabric must be greater than that of the soil. The fabric may be made of woven or non-woven monofilament yarns and should meet the following minimum requirements:

1. Thickness 20-60 mils
2. Grab strength 90-120 lbs.
3. Conform to ASTM D-1682 or ASTM D-177

Filter blankets should always be provided where seepage is significant or where flow velocity and

duration of flow or turbulence may cause underlying soil particles to move through the riprap.

### Construction Specifications

**Subgrade Preparation** - Prepare the subgrade for riprap and filter to the required lines and grades shown on the plans. Compact any fill required in the subgrade to a density approximating that of the undisturbed material or overfill depressions with riprap. Remove brush, trees, stumps, and other objectionable material. Cut the subgrade sufficiently deep so that the finished grade of the riprap will be at the elevation of the surrounding area. Channels should be excavated sufficiently to allow placement of the riprap in a manner such that the finished inside dimensions and grade of the riprap meet design specifications.

**Sand and Gravel Filter Blanket** - Place the filter blanket immediately after the ground foundation is prepared. For gravel, spread filter stone in a uniform layer to the specified depth. Where more than one layer of filter material is used, spread the layers with minimal mixing.

**Synthetic Filter Fabric** - Place the cloth directly on the prepared foundation. Overlap the edges by at least 2', and space the anchor pins every 3' along the overlap. Bury the upper and lower ends of the cloth a minimum of 12" below ground. Take precautions not to damage the cloth by dropping the riprap. If damage occurs, remove the riprap and repair the sheet by adding another layer of filter fabric with a minimum overlap of 12" around the damaged area. Where large stones are to be placed, a 4" layer of fine sand or gravel is recommended to protect the filter cloth. Filter fabric is not recommended as a filter on slopes steeper than 2 horizontal to 1 vertical.

**Stone Placement** - Placement of the riprap should follow immediately after placement of the filter. Place riprap so that it forms dense, well-graded mass of stone with a minimum of voids. The desired distribution of stones throughout the mass may

## Part 4 - Riprap Slope Protection

be obtained by selective loading at the quarry and controlled dumping during final placement. Place riprap to its full thickness in one operation. Do not place riprap by dumping through chutes or other methods that cause segregation of stone sizes. Be careful not to dislodge the underlying base or filter when placing the stones.

The toe of the riprap should be keyed into a stable foundation at its base as shown in Figure 4.7. Typical Riprap Slope Protection Detail. The toe should be excavated to a depth of 2'. The design thickness of the riprap should extend a minimum of 3' horizontally from the slope. The finished slope should be free of pockets of small stone or clusters of large stones. Hand placing may be necessary to achieve proper distribution of stone sizes to produce a relatively smooth, uniform surface. The finished grade of the riprap should blend with the surrounding area.

### Maintenance

Riprap should be inspected periodically for scour or dislodged stones. Control weed and brush growth as needed.

### Considerations

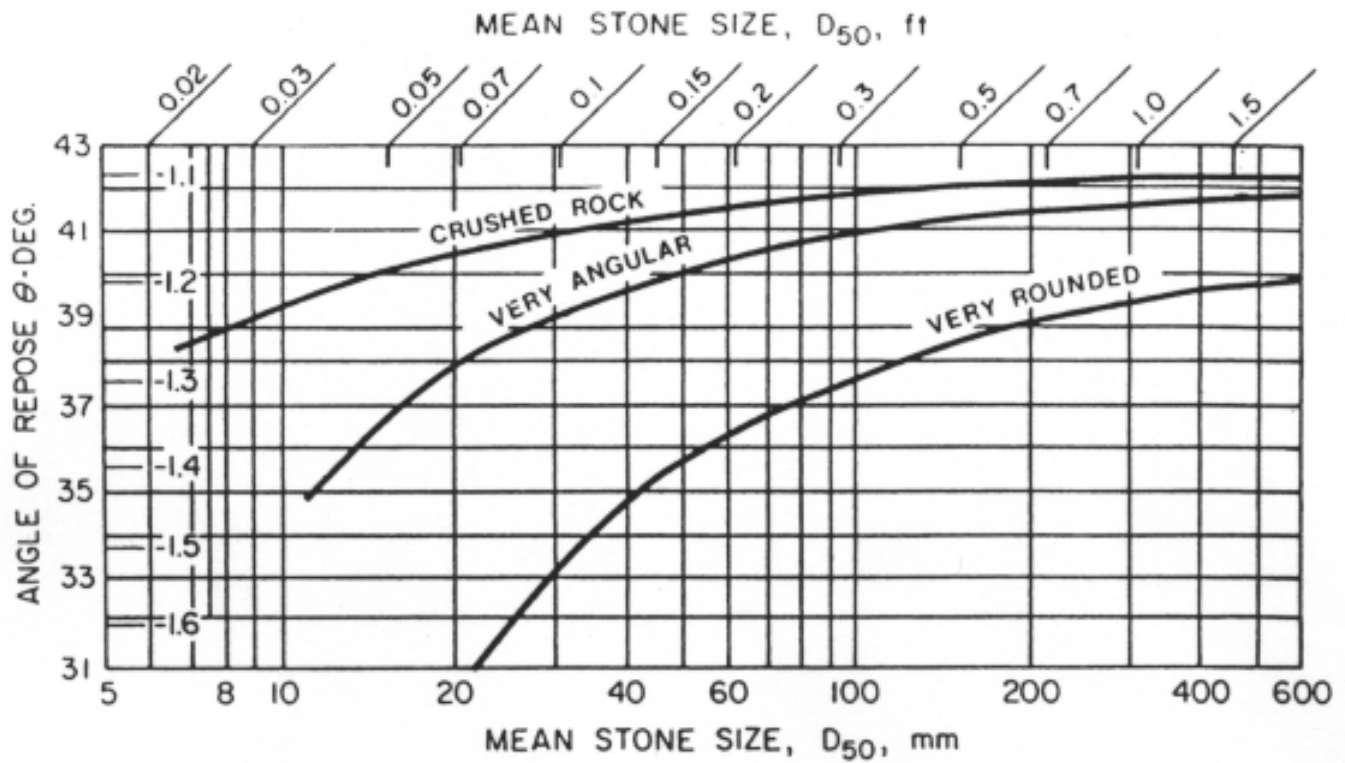
Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum delay. Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance.

### Plans and Specifications

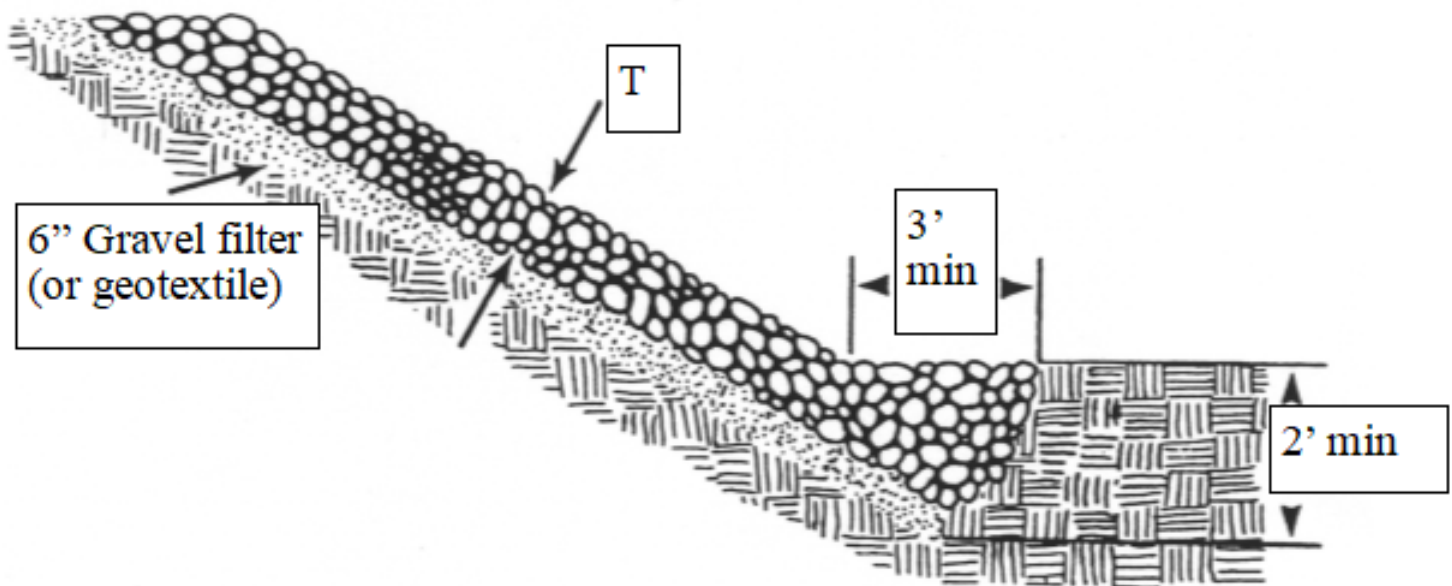
Plans and specifications for use of riprap slope protection shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Location of the riprap slope protection.
2. Riprap slope protection detail.
3. Specified angle of repose.
4. Construction specifications consistent with this standard.

## Part 4 - Riprap Slope Protection



Angle of Repose for RipRap Stoens (FHWA)



Typical Riprap Slope Protection Detail

Figure 4.7 Riprap Slope Protection

# Part 4 - Retaining Walls

## Definition

A structural wall constructed and located to prevent soil movement.

## Purpose

To retain soil in place and prevent slope failures and movement of material down steep slopes.

## Conditions Where Practice Applies

A retaining wall may be used where site constraints will not allow slope shaping and seeding to stabilize an area. Slope areas that demonstrate seepage problems or experience erosive conditions at the toe can utilize retaining walls to help stabilize these areas. Retaining walls can be built from mortared block or stone, cast-in-place concrete, railroad ties, gabions, and more recently, precast concrete modular units and segmented walls that form a gravity retaining wall. See figure 4.8 and 4.9. These precast units allow for ease and quickness of installation while their granular backfill provides drainage. Selection of materials and type of wall should be based on hazard potential, load conditions, soil parameters, groundwater conditions, site constraints, and aesthetics.

## Design Criteria

The design of any retaining wall structure must address the aspects of foundation bearing capacity, sliding, overturning, drainage and loading systems. These are complex systems and all but the smallest retaining walls should be designed by a licensed engineer.

**Bearing Capacity** - A minimum factor of safety of 1.5 should be maintained as the ratio of the ultimate bearing capacity to the designed unit loading. Spread footers and other methods may be used to meet factor requirements.

**Sliding** - A minimum factor of safety of 2.0 should be maintained against sliding. This factor can be reduced

to 1.5 when passive pressures on the front of the wall are ignored.

**Overturning** - A minimum factor of safety of 1.5 should be used as the ratio of the resisting moment (that which tends to keep the wall in place) to the overturning moment.

**Drainage** - Unless adequate provisions are made to control both surface and groundwater behind the retaining wall, a substantial increase in active pressures tending to slide or overturn the wall will result. When backfill is sloped down to a retaining wall, surface drainage should be provided. Drainage systems with adequate outlets should be provided behind retaining walls that are placed in cohesive soils. Drains should be graded or protected by filters so soil material will not move through the drainfill.

**Load Systems** - Several different loads or combination of loads need to be considered when designing a retaining wall. The minimum load is the level backfill that the wall is being constructed to retain. Its unit weight will vary depending on its composition. Additional loads such as line loads, surcharge loads, or slope fills, will add to make the composite design load system for the wall.

## Construction Specifications

### Concrete Walls:

1. Foundation will be prepared by excavating to the lines and grades shown on the drawings and removing all objectionable material.
2. Subgrade will be compacted and kept moist at least 2 hours prior to placement of concrete.
3. Steel reinforcing will be in accordance with the schedule on the drawings and kept free of rust, scale, or dirt.
4. Exposed edges will be chamfered  $\frac{3}{4}$  inches.
5. Drainfill will meet the gradations shown on the drawings.

## Part 4 - Retaining Walls

6. Weep holes will be provided as drain outlets as shown on the drawings.
7. Concrete will be poured and cured in accordance with American Concrete Institute (ACI) specifications.

### Precast Units:

1. Foundation will be prepared by excavating to the lines and grades shown on the drawings.
2. Subgrade will be compacted and trimmed to receive the leveling beam.
3. Precast units will be placed in accordance with the manufacturers recommendation.
4. Granular fill placed in the precast bins shall be placed in 3-foot lifts, leveled off and compacted with a plate vibrator.

### Segmented Walls:

1. Foundation will be prepared by excavating to the lines and grades shown on the drawings.
2. Sub-grade will be compacted and screeded to form the base for the first course of wall units.
3. Units will be placed in accordance with the manufacturers recommendations, with each succeeding lift anchored and pinned as specified.
4. Granular fill will be placed behind the segmented wall to provide drainage. It shall be compacted with a plate vibrator. A drainage outlet will be provided as specified on the construction drawings.

### Gabions

1. Foundation will be prepared by excavating to the lines and grades shown on the drawings.
2. Subgrade will be compacted and leveled to receive first layer of gabions. The first row will be keyed into the existing grade at the toe, a minimum of 1.5 feet.

3. Gabions will be placed according to the manufacturers recommendations.
4. Gabions will be filled with stone or crushed rock from 4 to 8 inches in diameter.
5. In corrosive environments, gabion wire should be coated with Poly Vinyl Chloride (PVC).

### Maintenance

Once in place, a retaining wall should require little maintenance. They should be inspected annually for signs of tipping, clogged drains, or soil subsidence. If such conditions exist, they should be corrected immediately.

### Plans and Specifications

Plans and specifications for use of retaining walls shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Location of the retaining wall.
2. Construction detail.

## Part 4 - Retaining Walls

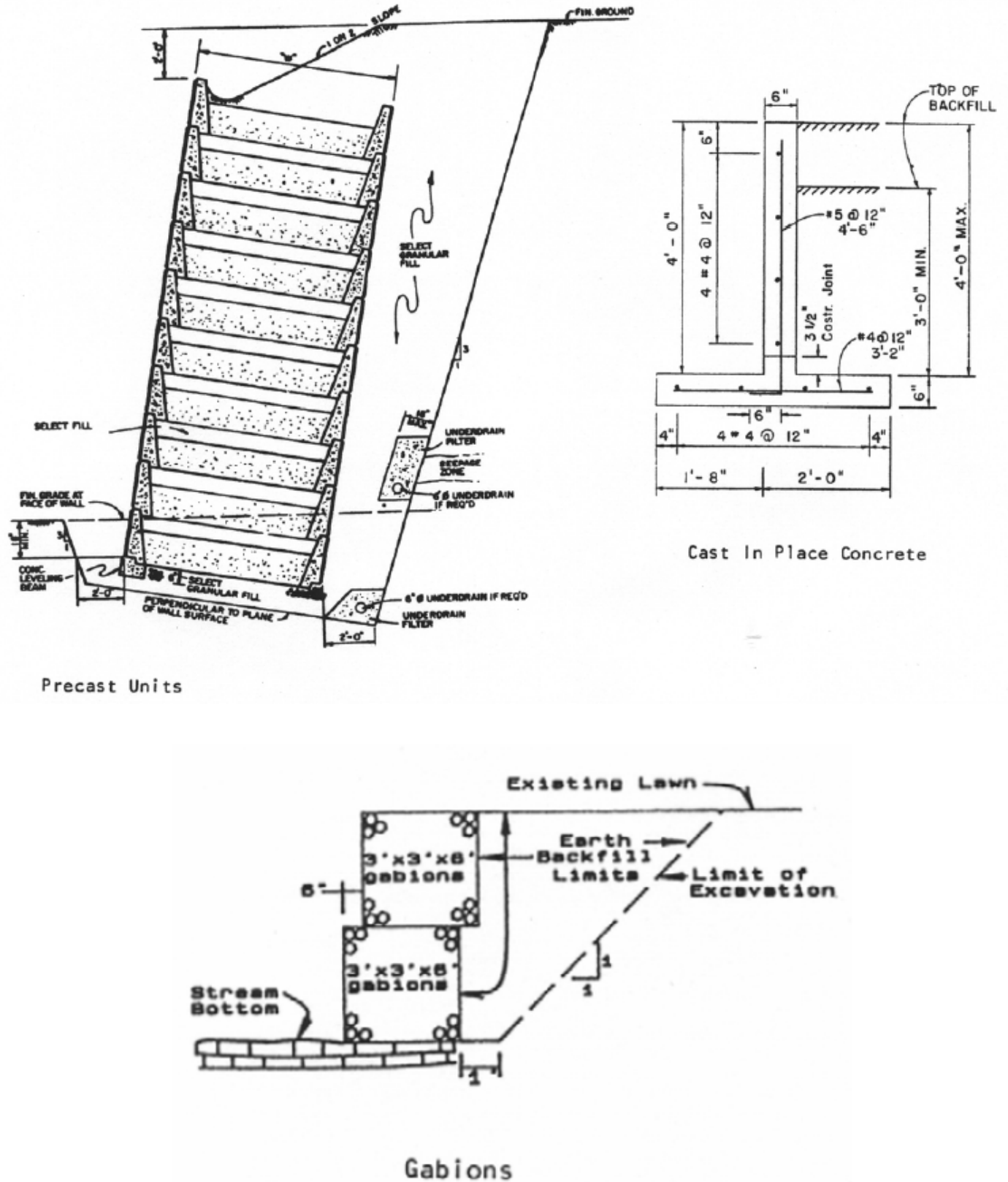


Figure 4.8 Retaining Wall Examples

## Part 4 - Retaining Walls

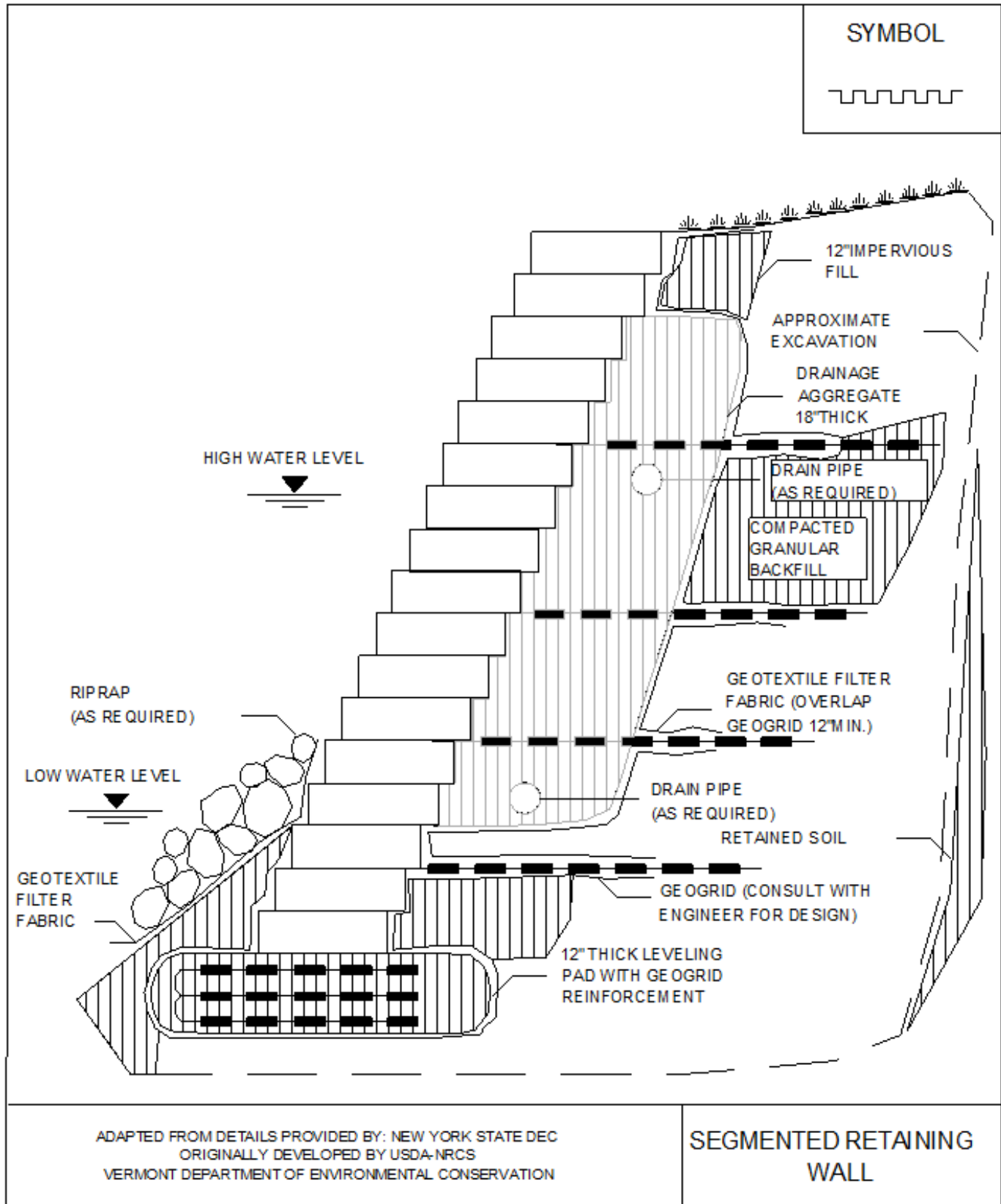


Figure 4.9 Segmented Retaining Wall

# Part 4 - Biotechnical Slope Protection Measures for Erosion and Sediment Control

## Introduction

Biotechnical slope protection is the specialized use of woody plant materials to stabilize soil. As noted in Part 2, one of the factors that affects erosion is vegetative cover. The more cover soil has, the more protected it is from the attacking forces of rainfall and runoff. Also working to hold the soil in place is the root mass that vegetation produces. Biotechnical measures generally combine basic engineering principles with plant science to create a system of stability for critical areas such as streambanks or roadside slopes. These systems may combine structural measures with woody plants and shrubs to effect a strengthening of the soil structure and improved vegetative cover to resist surface erosion.

There are many advantages to biotechnical slope protection measures:

1. They are often less expensive to install
2. They do not require specialized skills to install
3. Generally, heavy equipment is not required
4. They are environmentally compatible
5. They provide a natural aesthetic appearance
6. They provide wildlife habitat and cover
7. They can be self repairing during and after stress
8. They use natural/native materials

On the other hand, there are some disadvantages to these measures:

1. Higher risk due to less control with vegetation compared to structural practices
2. Require higher maintenance attention
3. Need an establishment period
4. More sensitive to seasonal changes

Biotechnical slope protection is actually an old technology. These techniques have been practiced for centuries in Europe. The Natural Resource Conservation Service used and promoted this technology in the 1940's in Vermont on the Winooski River and also in New York on Buffalo Creek, where plant materials (willows) were used in combination with rock riprap, concrete slabs, pinned rock, and cellular modules to halt streambank erosion.

## Principles of Biotechnical Slope Protection

Generally a biotechnical slope protection system consists of both a structural or mechanical element and vegetative elements working together to stabilize a site-specific condition. Structural components are employed to allow establishment of vegetative elements, while at the same time providing a level of protection for stability. The vegetative components are not just landscaping plantings for a structural project; they also perform a functional role in preventing erosion by protecting the surface, while also stabilizing soil by preventing shallow mass movements.

Woody plant materials (usually dormant shrub willow branches) are placed into the soil in ways that provide an immediate degree of stability to the slope. As the branches take root and grow, the slope becomes more and more resistant to failure by shallow mass movements due to:

1. Mechanical reinforcement from the root system,
2. Soil moisture depletion through transpiration and interception, and
3. Buttressing and soil arching action from embedded stems.

## Part 4 - Biotechnical Slope Protection Measures for Erosion and Sediment Control

The vegetation also tends to prevent surficial (surface or rainfall) erosion by:

1. Binding and restraining soil particles in place,
2. Filtering soil particles from runoff,
3. Intercepting raindrops,
4. Retarding velocity of runoff, and
5. Maintaining infiltration.

As the stability improves, native vegetation will volunteer, helping to blend the site into the surroundings.

There are many techniques used in biotechnical work. Some of the most common are:

Vegetated Rock Gabions - This is a combination of vegetation and rock gabions generally used for slope stabilization. Live branch cuttings are layered through the rock gabion structure to anchor in select earthfill. The cuttings protrude beyond the face of the gabion.

Live Fascines - This technique uses bundles of branches which are staked into shallow trenches, then filled with soil. They are oriented along the contour and are placed in multiple rows to help stabilize a slope. See Standard and Specifications for Live Fascines.

Brush Mattress - This method uses hardwood brush layered as a mattress and anchored in place with a grid of stakes and wire. The toe below the waterline is anchored by rock. This living blanket acts as a mulch for seedlings and plantings established in the bank. It also prevents erosion of sloped surfaces.

Live Staking - These are large stakes or poles sharpened at the bottom end and forced vertically into the soft earth along the waterline, usually about 1' apart. Depending on the size of the poles and the composition of the streambank, machinery may be

required to force them into the ground or to prepare holes for planting. The poles will grow forming a very thick barrier to flow.

Brush Layering- This technique is generally used to stabilize slope areas on cut and fill slopes. It involves the use of long branches that are placed with cut ends into the slope on bulldozed terraces. The tops protrude outside the finished slope. A layer usually includes three layers of brush separated with a thin (3") layer of soil. On this layer a "lift" of 3-5' of soil is placed to form the next terrace and so forth.

Branchpacking - This technique alternates live branch cuttings with tamped backfill to repair small, localized slumps and holes in slopes. The alternating layers of branches and soil are placed between long posts driven in to the ground for support. This method is inappropriate for areas larger than 4' deep or 6' wide.

Fiber Roll - A fiber roll is a coconut fiber, straw, or excelsior woven roll encased in netting of jute, nylon, or burlap used to dissipate energy along bodies of water and provide a good medium for the introduction of herbaceous vegetation. This technique works best where water levels are relatively constant. The roll is anchored into the bank and, after suitable backfill is placed behind the roll, herbaceous or woody vegetation can be planted.

Properly designed structural measures may be necessary to help protect the toe or face of a slope against scour or erosion from moving water and against mass-moving of soil. These structures are generally capable of resisting much higher lateral earth pressures and higher shear values than vegetation. They can be natural, such as fieldstone, rock and timbers; or, they can be artificial like concrete and steel. Some structural measures can be a combination like gabions, which are wire baskets containing stone. Gabions can be used as retaining walls, grade stabilization structures and slope protection. Many of these types of structures can be planted or vegetated with materials to strengthen the system.

# Part 4 - Biotechnical Slope Protection Measures for Erosion and Sediment Control

## Planning Considerations

There are many facets that need to be considered when designing a biotechnical system for a site:

Method – What is the appropriate method for the particular problem encountered?

Materials – What type should be selected? How much is needed to do the job? Where can they be obtained?

Schedule – When is the best time to maximize the successful rooting or germination of materials?

Equipment – Since this process is somewhat labor intensive, it is necessary to make sure the proper type and amount of tools, such as shovels, pick axes, tile spades, hammers, etc. are available for proper installation of material.

Site Characteristics – The need for engineering structures will depend on potential hazards, management of site water, soil conditions, and site access. Aesthetics and follow-up maintenance are also important considerations. Protection from livestock is mandatory.

## Plant Materials

Plant materials for biotechnical slope protection may be obtained in two basic ways. One method is to locate stands of appropriate species and obtain easements to harvest materials from these stands for incorporation into the project. Criteria for selecting native species are: easy rooting; long, straight, flexible whips; and plentiful supply near the site.

A second method is to grow and harvest materials from managed production beds that are maintained for commercial distribution. This allows selection of cultivars that have proven performance records and high survival rates.

The most popular materials in use today are the shrub willows. Willows have a tremendous ability to sprout roots and stems when in contact with moist soil. Willows are found growing in all parts of the world, so biotechnical slope protection techniques employ them more than any other group of plants. Two of the tested, proven willow cultivars in the Northeast are:

1. 'Streamco' purpleosier willow (*Salix purpurea*)
2. 'Bankers' dwarf willow (*Salix cottetii* – hybrid)

'Streamco' and 'Bankers' willow are both shrubs. 'Streamco' has an ultimate height of 15-20', while 'Bankers' is limited to 6-8'. Commercial and state nurseries in the Northeast are producing supplies of both species.

In addition to willows, red osier dogwood and poplars are other groups of plants effective for use in biotechnical systems. Species such as elderberry or forsythia can also be used to add biodiversity to a site.

All plant materials should be installed on site within 8 hours of cutting, unless provisions for proper storage are made. Materials should be fresh, dormant, and non-desiccated when installed.

## Part 4 - Brush Layer

### Definition

A brush layer is a horizontal row of live branch cuttings placed in soil with other similar rows, spaced a specific vertical distance apart.

### Purpose

To stabilize cut and fill slope areas by reinforcing the soil with unrooted branch stems, trap debris on slope, dry excessively wet sites, and redirect adverse slope seepage by acting as horizontal drains.

### Conditions Where Practice Applies

Generally applicable to stabilize slope areas on cut and fill slopes. Brush layers can be used on slopes up to 2:1 in steepness and 20' in height.

### Design Criteria

The spacing requirements for brush layer rows is dependent on the slope steepness and moisture content. Spacing shall conform with the following table.

Slope Distance Between Layers (feet):

Slope H:V	Wet Slope	Dry Slope	Max Slope Length
2 to 2.5:1	3'	3'	15'
2.5 to 3.5:1	3'	4'	15'
3.5 to 4.0:1	4'	5'	25'

Brush layer cuttings shall be 1/2-2" in diameter and be from dormant plants. No leaf buds shall have initiated growth beyond 1/4" and the cambium layer shall be moist, green, and healthy. The cuttings shall be long enough to contact the back of the bench with the growing tips protruding out of the slope face.

Care shall be taken not to severely damage the live branch cuttings during installation. Damaged cuttings will be replaced prior to backfilling.

Starting at the toe of the slope, excavate benches along the contour of the slope. The benches shall range from 2-3' wide and the surface of the bench shall be angled so the front edge is higher than the back of the bench. See figure 4.10. The benches shall be spaced according to the previous table.

Live branch cuttings shall be placed on the bench in a crisscross or overlapping configuration in layers 3 - 4 inches thick. Backfill shall be placed on top of the live branch cuttings and tamped in 6 inch lifts. Small plate compactors may be used to settle the soil. Areas between the rows of brush layers shall be stabilized by seeding or other appropriate erosion control method.

### Maintenance

Due to the susceptibility of plant materials to the physical constraints of the site, climate conditions, and animal populations, it is necessary to inspect installations frequently. This is especially important during the first year or two of establishment. Plant materials missing or damaged should be replaced as soon as possible. Sloughs or breaks in drainage pattern should be reestablished for the site as quickly as possible to maintain stability.

### Plans and Specifications

Plans and specifications for installing a brush layer shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the brush layer will be installed.
2. Construction detail.

## Part 4 - Brush Layer

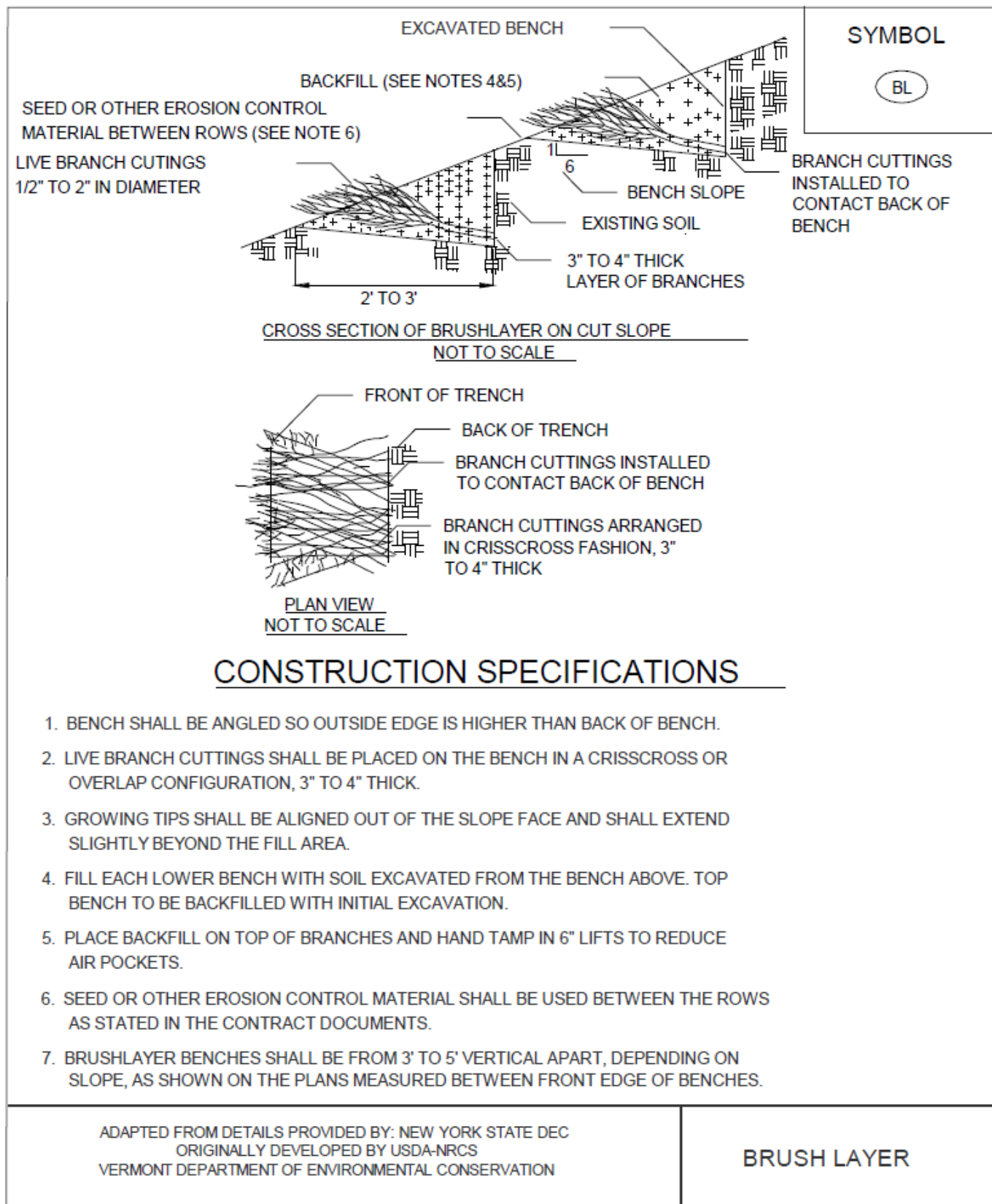


Figure 4.10 Brush Layer

## Part 4 - Live Fascines

### Definition

The placement of groups or bundles of twigs, whips, or branches in shallow trenches, on the contour, on either cut or fill slopes.

### Purpose

To stabilize slopes by slowing water movement down the slope, increasing infiltration, trapping slope sediments, and increasing soil stability with root systems.

### Conditions Where Practice Applies

On sloping areas such as road cuts, slumped areas, road fills, and gullies subject to erosion, seepage, or weathering, which have a low to medium hazard potential should slope failure occur. Slopes must be 1:1 or flatter.

### Design Criteria

Vertical Spacing - The spacing of the contours for the fascines is dependent on the degree of erosion or potential erosion at the site. Factors include slope steepness, soil type, drainage, and existing ground cover. The following is a general guide to selecting contour interval:

Slope	Contour Interval
1:1	3'
1.5:1	3'
2:1	4'
2.5:1	4'
3:1	5'
3.5:1	5'
4:1	6'
6:1	8'

See Figure 4.12 for details.

Materials - Shall be a native or nursery grown cultivar that is capable of performing the intended function.

Fascines - Shall be made by forming the bundles 8-15' long, 4" minimum in diameter, from stems no more than 1" in diameter.

Overlap - Fascines should be overlapped at the tapered ends a minimum of 1'.

### Construction Specifications

1. Fascines shall be 4" minimum in diameter.
2. Prior to placing the fascines, the slope shall be smoothed and graded with obstructions removed. Any structural measures for revetment, drainage, or surface water management will be installed first.
3. Working from the bottom of the slope to the top, excavate the fascine trench. Place fascines in trench and anchor with stakes spaced at 24". Cover fascines with soil leaving about 10% exposed to view. Fascines shall be overlapped 12" minimum in the trench.
4. Soil shall be worked into the fascine and compacted by walking on the fascine being covered.
5. All disturbed areas should be seeded upon completion of fascine placement.

### Maintenance

Regular inspection and maintenance of fascine installations should be conducted especially during the first year of establishment. Loose stakes should be reset and settled fill areas should be brought back to grade.

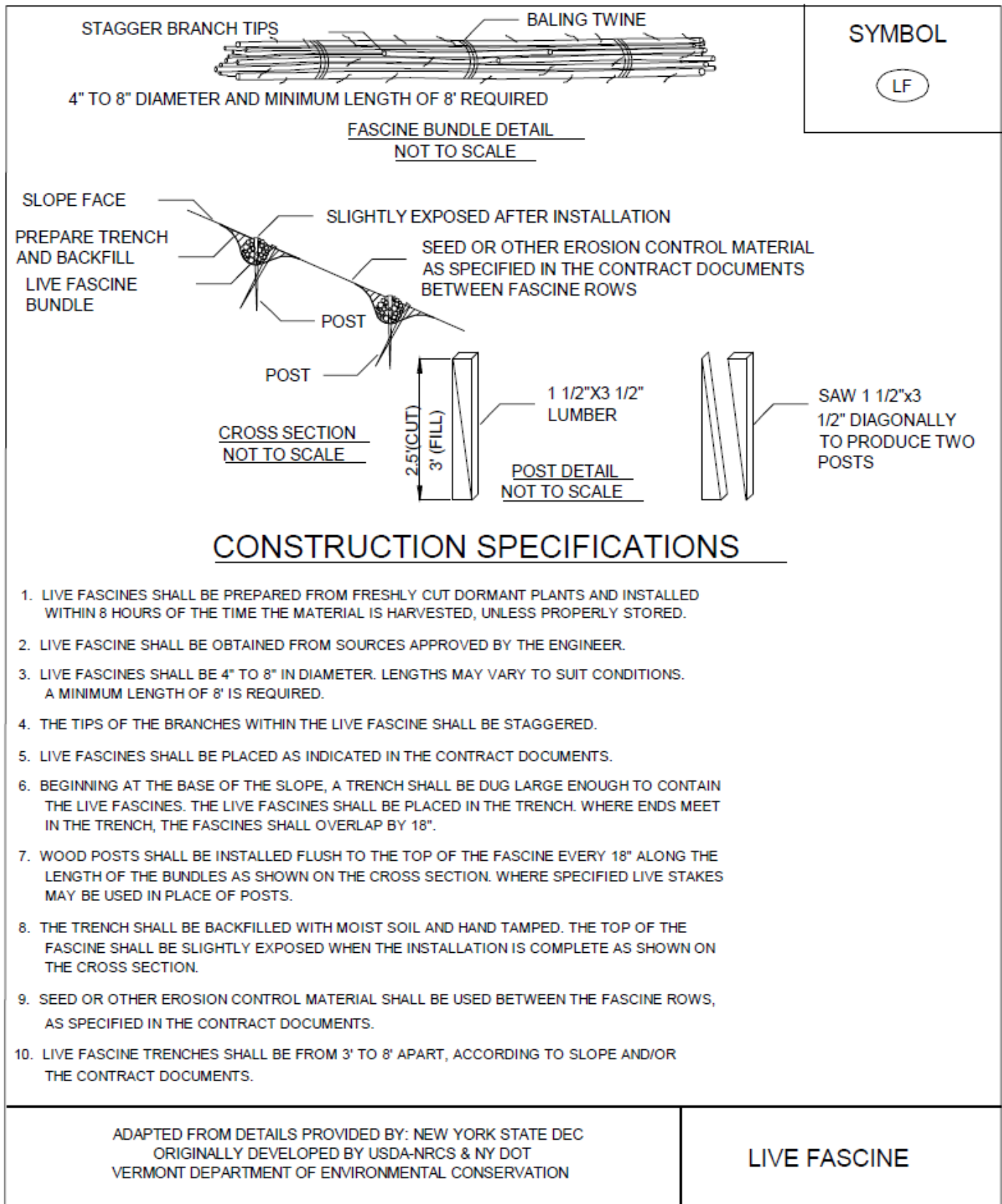
### Plans and Specifications

Plans and specifications for installing fascine rolls shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

At a minimum include the following:

1. Location where the live fascine will be installed.
2. Construction detail.

## Part 4 - Live Fascines



**Figure 4.11 Live Fascine**

# Part 4 - Live Stakes

## Definition

A stake or pole fashioned from live woody material.

## Purpose

To create a living root mat that stabilizes the soil by reinforcing and binding soil particles together and by contributing to the reduction of excess soil moisture.

## Conditions Where Practice Applies

Live stakes are an appropriate technique for repair of small earth slips and slumps that are frequently wet. This technique is for relatively uncomplicated site conditions when construction time is limited and an inexpensive vegetative method for stabilization is derived. It is not intended where structural integrity is required nor to resist large, lateral earth pressures. See Figure 4.12.

## Design Criteria

1. Live stakes shall be 1-2" in diameter and 2-6' long, depending on site application.
2. No leaf buds shall have initiated growth beyond 1/4" and the cambium layer shall be moist, green and healthy.
3. All material shall be maintained in a continuously cool, covered, and moist state prior to use and be in good condition when installed.
4. Materials harvested on site shall be installed the same day they are prepared. Nursery grown material shall be maintained in a moist condition until installed.
5. Installation Details
  - a. The lengths of live cuttings/live stakes depends upon the application. If through riprap, the length shall extend through the surface of the stone fill. At least half the length shall be inserted into the soil, below the stone fill.

- b. A minimum of 2-4" and two live buds of the live stake shall be exposed above the stone filling.
- c. Live stakes shall be cut to a point on the basal end for insertion in the ground.
- d. Use a dead blow hammer to drive stakes into the ground. The hammer head should be filled with shot or sand. A dibble, iron bar, or similar tool shall be used to make a pilot hole to prevent damaging the material during installation.
- e. Live cuttings shall be inserted by hand into pilot holes.
- f. When possible, tamp soil around live stakes.
- g. Care shall be taken not to damage the live stakes during installation. Those damaged at the top during installation shall be trimmed back to undamaged condition.

## Maintenance

Due to the susceptibility of plant materials to the physical constraints of the site, climate conditions, and animal populations, it is necessary to inspect installations frequently. This is especially important during the first year or two of establishment. Plant materials missing or damaged should be replaced as soon as possible. Sloughs or breaks in drainage pattern should be reestablished for the site as quickly as possible to maintain stability.

## Plans and Specifications

Plans and specifications for installing live stakes shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

At a minimum include the following:

1. Location where the live stakes will be installed.
2. Construction detail.

## Part 4 - Live Stakes

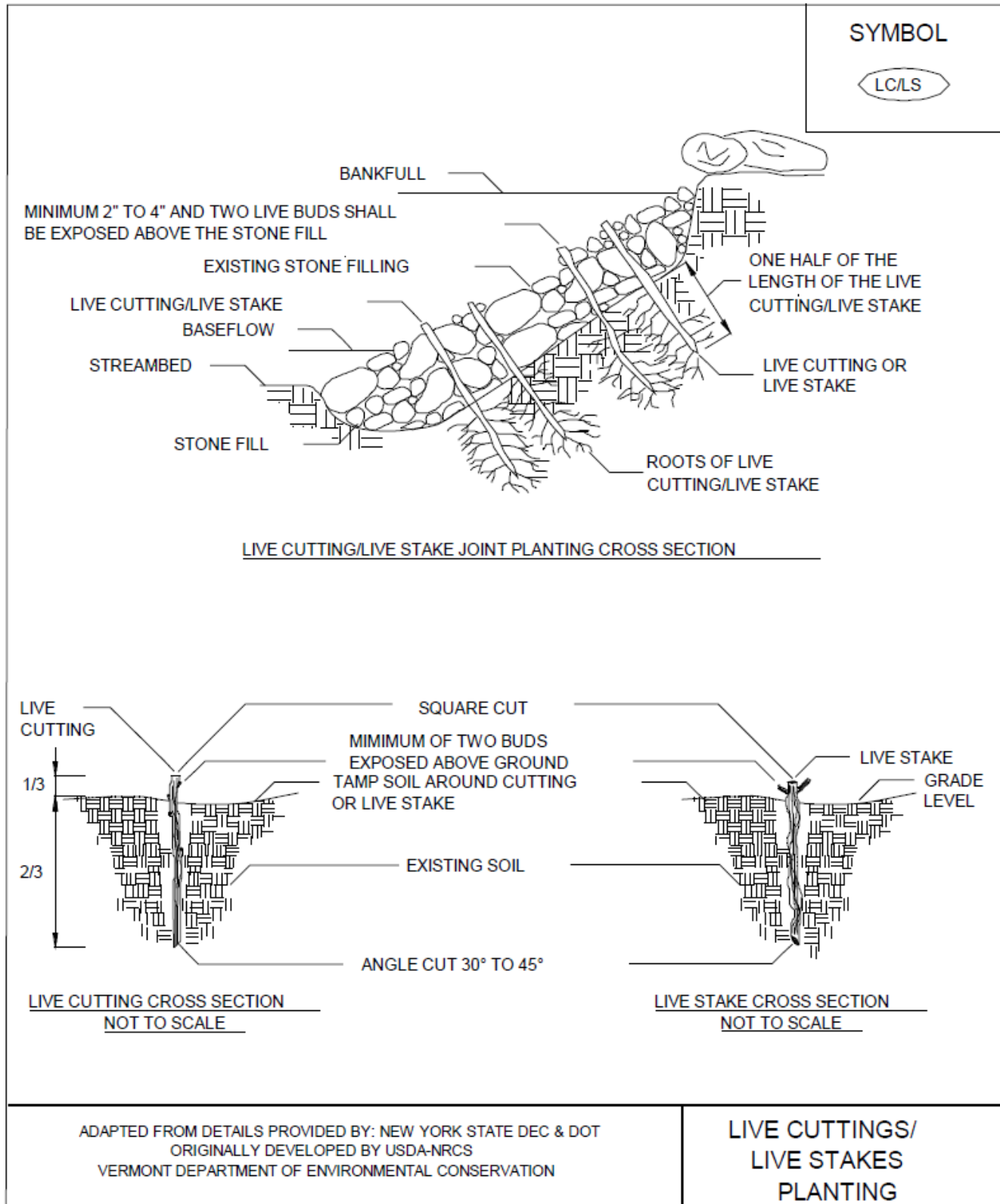


Figure 4.12 Cuttings / Live Stakes Planting

# Part 4 - Branchpacking

## Definition

Branchpacking consists of alternate layers of live branch cuttings and tamped backfill to repair small, localized slumps and holes in slopes.

## Purpose

The purpose of branchpacking is to provide repair to existing slopes that have small slips or slumps by filling in the failed area with plant materials and soil.

## Conditions Where Practice Applies

This is an appropriate technique for repairing slip areas that do not exceed 4' deep or 6' wide. It should not be used as a slope stability measure if structural embankment support is needed. See figure 4.13 Branchpacking.

## Design Criteria

1. The live branch cuttings shall be 1/2-2" in diameter and long enough to touch the undisturbed soil at the back of the area to be repaired. They should extend 4-6" beyond the finished backfill grade.
2. Wooden posts should be used to secure the plant material in place. They should be 6-8' long and 3-4" in diameter. If lumber is used, it shall be a minimum standard two by four.
3. Wooden posts shall be driven vertically 3' deep and placed in a grid pattern 1-2' apart.
4. Beginning at the bottom of the slip area, 4-6" layers of live branch cuttings are placed in angled layers, 1.5-3' apart. Compacted moist soil is placed between the layers.

## Maintenance

Due to the susceptibility of plant materials to the physical constraints of the site, climate conditions, and animal populations, it is necessary to inspect

installations frequently. This is especially important during the first year or two of establishment. Plant materials missing or damaged should be replaced as soon as possible. Sloughs or breaks in drainage pattern should be reestablished for the site as quickly as possible to maintain stability.

## Plans and Specifications

Plans and specifications for installing branchpacking shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the branchpacking will be used.
2. Construction detail.

## Part 4 - Branchpacking

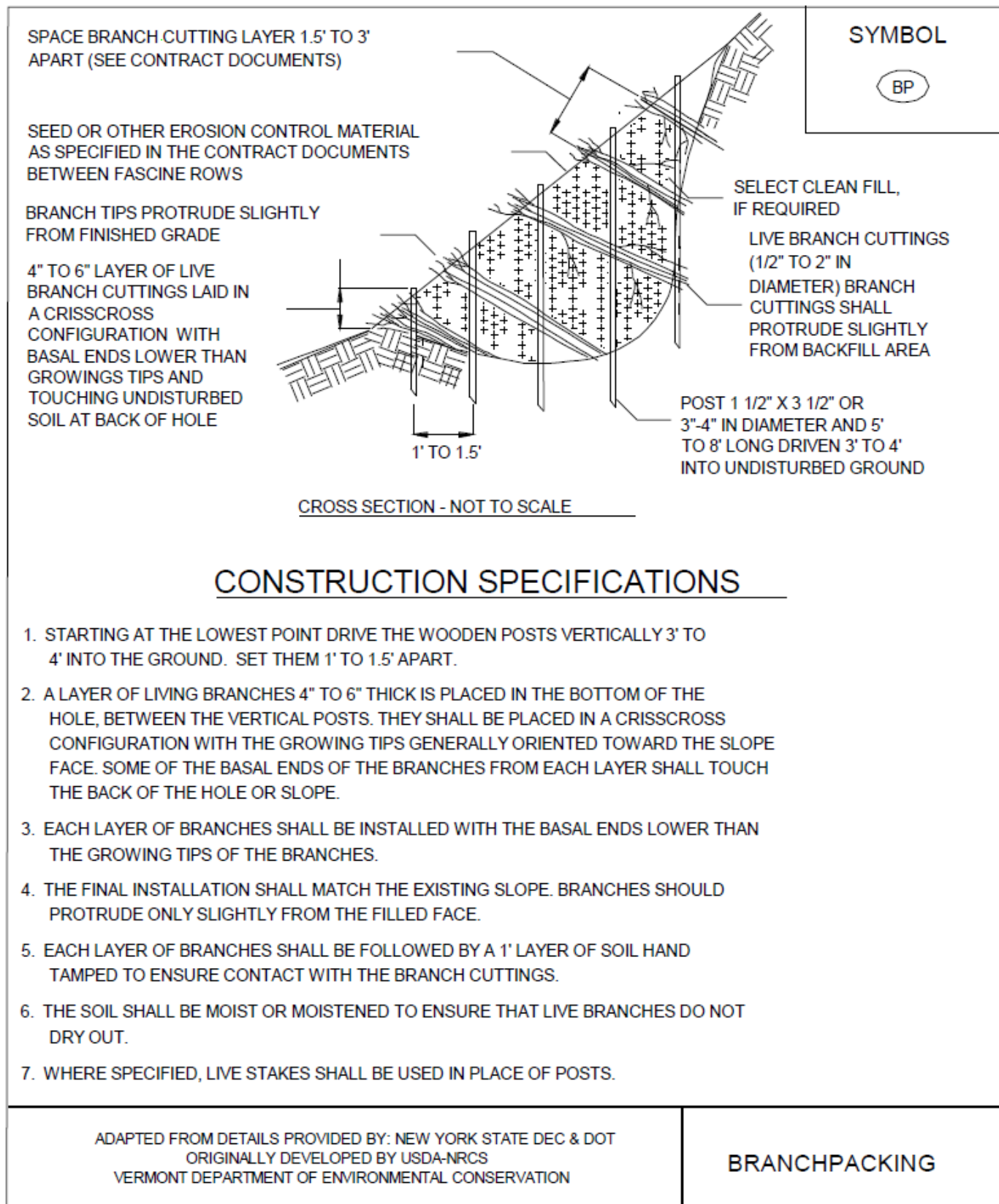


Figure 4.13 Branchpacking

# Part 4 - Fiber Roll

## Definition

A fiber roll is a coir (coconut fiber), straw, or excelsior woven roll encased in netting of jute, nylon, or burlap.

## Purpose

To dissipate energy along channels and bodies of water and reduce sheet flow on slopes.

## Conditions Where Practice Applies

Fiber rolls are used where the water surface levels are relatively constant. The rolls provide a good medium for the introduction of herbaceous vegetation.

Planting in the fiber roll is appropriate where the roll will remain continuously wet.

## Design Criteria

1. The roll is placed in a shallow trench dug below baseflow or in a 4" trench on the slope contour and anchored by 2" x 2", 3' long posts driven on each side of the roll. See Figure 4.14.
2. The roll is contained by a 9-gauge non-galvanized wire placed over the roll from post to post. Braided nylon rope (1/8" thick) may be used.
3. The anchor posts shall be spaced laterally 4' on center on both sides of the roll, staggered, and driven down to the top of the roll.
4. Soil is placed behind the roll and planted with suitable herbaceous or woody vegetation. If the roll will be continuously saturated, wetland plants may be planted into voids created in the upper surface of the roll.
5. Where water levels may fall below the bottom edge of the roll, a brush layer of willow should be installed so as to lay across the top edge of the roll.

## Maintenance

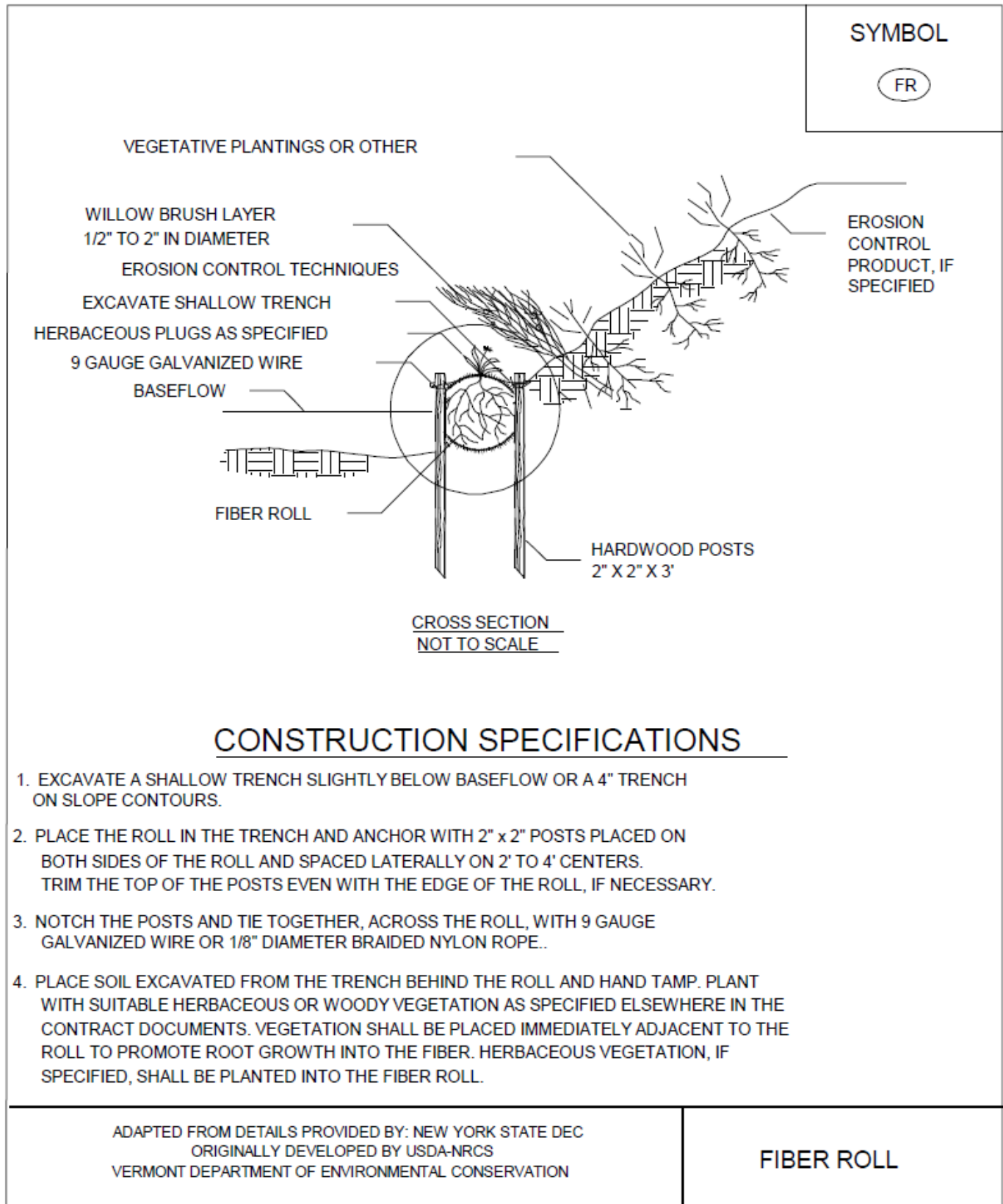
Due to the susceptibility of plant materials to the physical constraints of the site, climate conditions, and animal populations, it is necessary to inspect installations frequently. This is especially important during the first year or two of establishment. Plant materials missing or damaged should be replaced as soon as possible. Sloughs or breaks in drainage pattern should be reestablished for the site as quickly as possible to maintain stability.

## Plans and Specifications

Plans and specifications for installing fiber rolls shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the fiber rolls will be installed.
2. Construction detail.

## Part 4 - Fiber Roll



**Figure 4.14 Fiber Roll**

## Part 4 - Straw Wattle

### Definition

Straw wattles are cylinders of compressed, weed free straw, generally 8 to 12 inches in diameter and 10 to 25 feet long. They are encased in a durable netting such as jute, nylon, or other photo degradable materials.

### Purpose

Straw wattles are installed in a shallow trench forming a continuous barrier along the contour (across the slope) to intercept stormwater running down a slope and may serve as perimeter control beyond the limits of construction or for containment of soil stockpiles. Multiple rows of straw wattles may also be installed on slopes to break up slope lengths and reduce velocity of overland flow.

### Conditions Where Practice Applies

Straw wattles may be used where perimeter control is required, provided contributing drainage area does not exceed capacity of the wattle installation. Straw wattles are also effective at breaking up slope lengths on long slopes where overland flow has the potential to collect and cause rill erosion before vegetation is established. Straw wattles are not appropriate for use on impervious surfaces such as asphalt, concrete or ledge.

### Design Criteria

1. Begin at the location where the straw wattle is to be installed by excavating a 2-3" deep X 9" wide trench (or wider for larger wattles) along the contour of the slope for wattle placement. Excavated soil shall be placed up-slope from the trench.
2. Place the straw wattle in the trench so that it contours to the soil surface. Compact soil from the excavated trench against the wattle on the uphill side. Adjacent wattles shall overlap.
3. Secure the straw wattle with 18-24" stakes every

4' and with a stake on each end. Stakes shall be driven through the middle of the wattle leaving at least 2-3" of stake extending above the wattle. Stakes shall be driven perpendicular to the slope face.

4. For slope break installations: To maximize sediment containment, place the initial straw wattle at the top/crest of the slope if significant runoff is expected from above. If no runoff is expected to contribute from above the slope, the initial straw wattle can be installed at the appropriate distance downhill from the top/crest of the slope, per "Straw Wattle Spacing on Slope Gradient" table below. The final structure shall be installed at or just beyond the bottom/toe of the slope. Straw wattles shall be installed perpendicular to the primary direction of overland flow.

### Straw Wattle Spacing on Slope Gradient

Slope Gradient (H:V)	Wattle Spacing (ft.)
< 6:1	50
4:1 - 6:1	10
> 4:1 - 2:1	20
> 2:1 - 1:1	10
> 1:1	5

### Maintenance

Accumulated sediment behind straw wattles shall be removed when accumulation reaches half the height of the wattle. Removed material shall be placed in an upland location and stabilized as necessary.

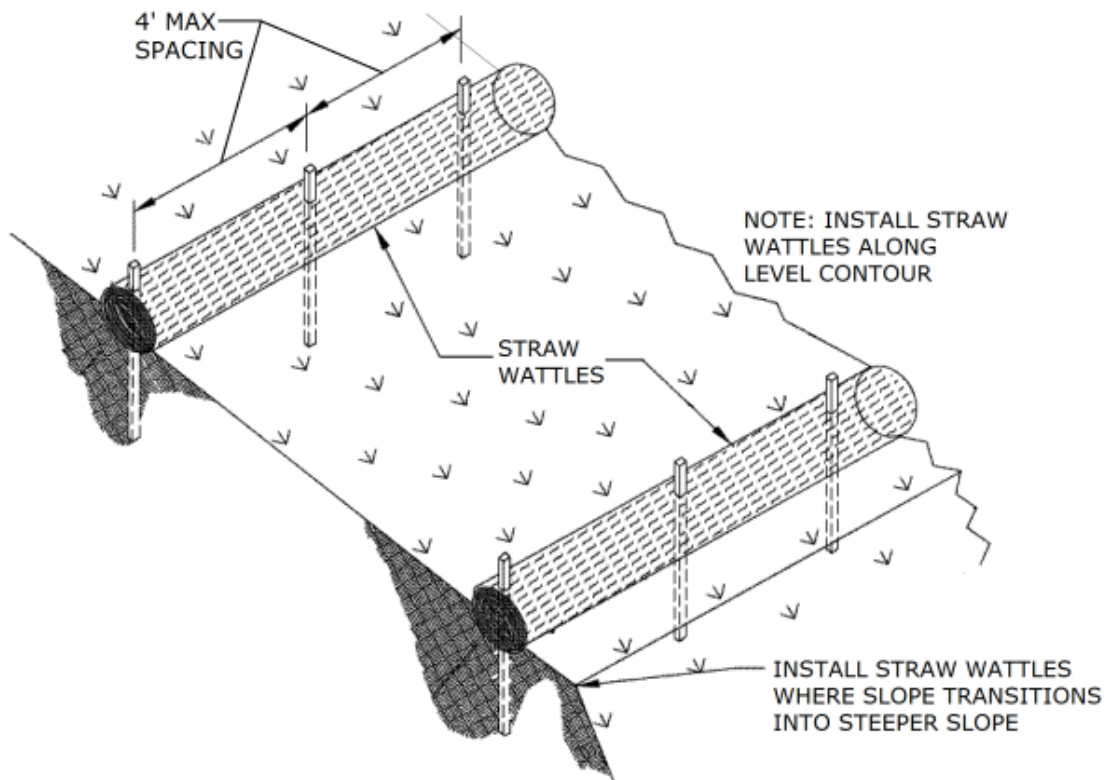
Straw wattles shall be reshaped or replace if they become flattened, cakes with sediment, or otherwise are no longer effective for runoff or sediment control.

### Plans and Specifications

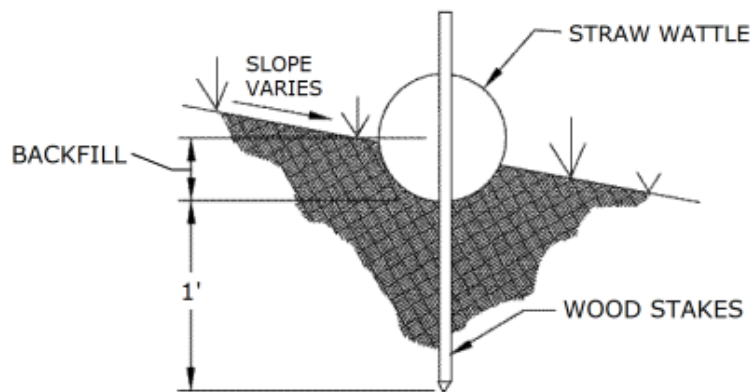
Plans and specifications for installing straw wattles shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the straw wattles will be installed.
2. Construction detail.

## Part 4 - Straw Wattle



TYPICAL STRAW WATTLE INSTALLATION



ENTRENCHMENT INSTALLATION

STRAW WATTLE DETAIL

Figure 4.15 Straw Wattle

# Part 4 - Water Bar

## Definition

A ridge or ridge and channel constructed diagonally across a sloping road or utility right-of-way that is subject to erosion.

## Purpose

To limit the erosive velocity of water by diverting surface runoff at pre-designed intervals.

## Conditions Where Practice Applies

Where runoff protection is needed to prevent erosion on sloping access right-of-ways or long, narrow sloping areas generally less than 100' in width.

## Design Criteria

1. The design height shall be minimum of 12" measured from channel bottom to ridge top.
2. The side slopes shall be 2:1 or flatter, and no steeper than 4:1 where vehicles cross.
3. The spacing of the water bars shall be as follows:

Slope (%)	Spacing (ft)
<5	125
5-10	100
10-20	75
20-35	50
>35	25

4. The grade of the water bar shall not exceed 2%.  
A crossing angle of approximately 60 degrees is preferred.
5. Once diverted, water must be conveyed to a stable system (i.e. vegetated swale or storm sewer system).  
Water bars should have stable outlets, either natural or constructed.

## Plans and Specifications

Plans and specifications for installing water bars shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the water bars will be installed.
2. Dimensions of the water bars.
3. Type and location of stable outlet.
4. Construction detail.

## Part 4 - Water Bar

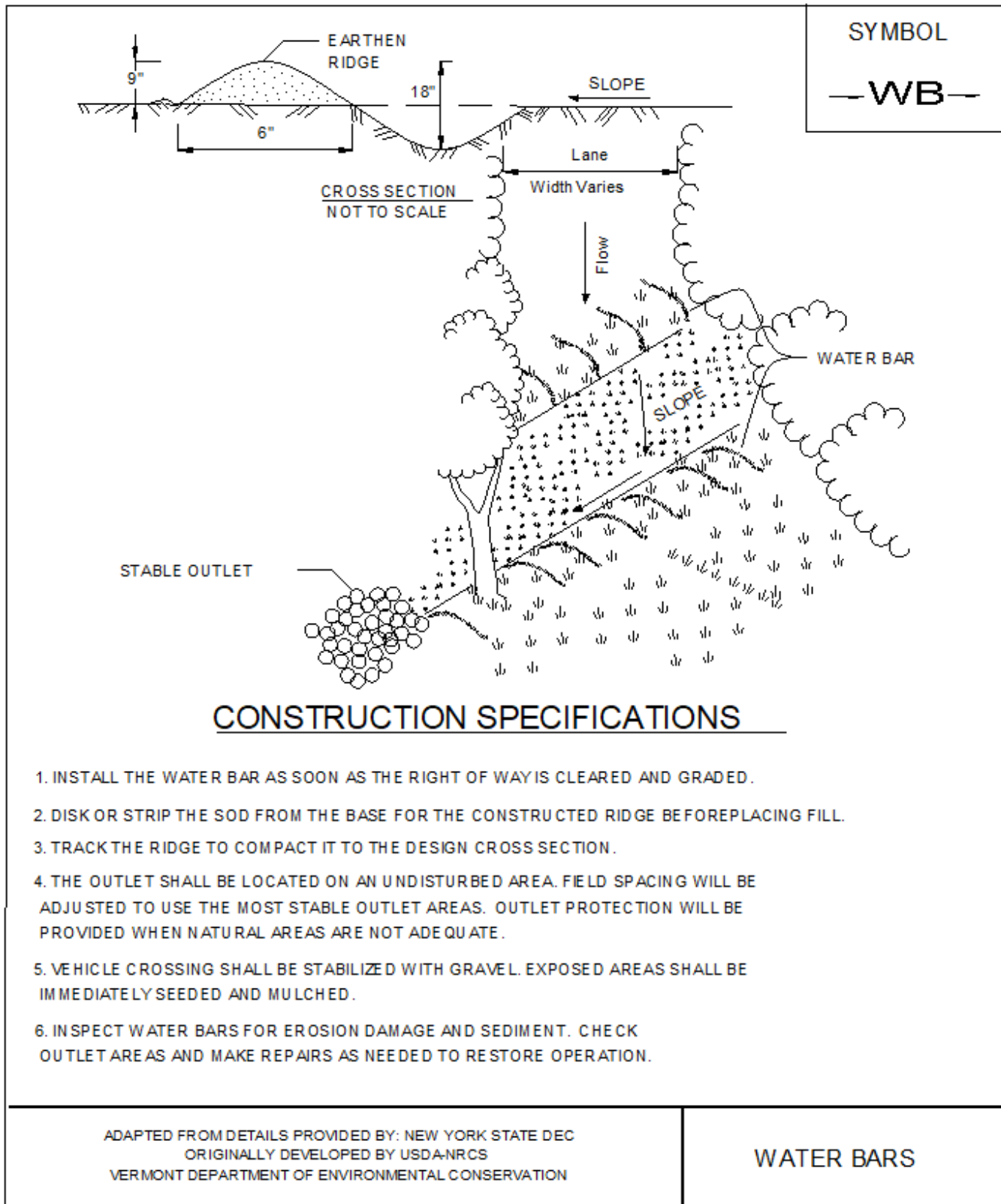


Figure 4.16 Water Bars

## Part 4 - Check Dam

### Definition

Small barriers or dams constructed of stone, or other durable material across a drainage way.

### Purpose

To reduce erosion in a drainage channel by creating pools that slow the velocity of flow in the channel and trap sediment.

### Conditions Where Practice Applies

This practice is used as a temporary measure to limit erosion by reducing velocities in small open channels that are degrading or subject to erosion.

### Design Criteria

Height: Not greater than 2'. Center shall be maintained 9" lower than abutments at natural ground elevation.

Side Slopes: Shall be 2:1 or flatter.

Spacing: The check dams shall be spaced as necessary in the channel so that the crest of the downstream dam is at the elevation of the toe of the upstream dam. This spacing is equal to the height of the check dam divided by the channel slope.

Therefore:

$$S = h / s$$

Where:

S = spacing interval (ft.)

h = height of check dam (ft.)

s = channel slope (ft./ft)

Example:

For a channel with a 4% slope and 2' high stone check dams, they are spaced as follows:

$$S = \frac{2 \text{ ft.}}{.04 \text{ ft./ft.}} = 50 \text{ ft.}$$

Stone Size: Use a well graded stone matrix 2-9" in size.

The overflow of the check dams will be stabilized to resist erosion that might be caused by the check dam.

Check dams may be anchored in the channel by a cutoff trench 18" wide and 6" deep and lined with filter fabric to prevent soil migration.

### Maintenance

The check dams should be inspected after each runoff event. Correct all damage immediately. If significant erosion has occurred between structures, a liner of stone or other suitable material should be installed in that portion of the channel.

Remove sediment accumulated behind the dam as needed to allow channel to drain through the stone check dam and prevent large flows from carrying sediment over the dam. Replace stones as needed to maintain the design cross section of the structures.

### Considerations

For added stability, the base of the check dam should be keyed into the soil to a depth of 6". Filter fabric may be used under the rock to provide a stable foundation and to facilitate removal of the rock. Check dams are effective in reducing flow velocity and thereby the potential for channel erosion. It is usually better to establish a protective vegetative lining before flow is confined or to install a structural channel lining than to install rock check dams. Field experience has shown rock check dams to perform much more effectively than silt fences or straw bales in the effort to stabilize "wet-weather" ditches. Accordingly, silt fences dams and hay bale check dams are not accepted practices in Vermont.

Rock check dams installed in grass-lined channels may kill the vegetative lining if submergence after rains is too long and/or siltation is excessive.

## Part 4 - Check Dam

If temporary rock check dams are used in grass-lined channels that will be mowed, care should be taken to remove all the rock when the rock check dam is removed. This should include any rocks that have washed downstream.

Field experience has shown that many rock check dams are not constructed with the center lower than the sides forming a weir. Stormwater flows are then forced to the rock-soil interface, thereby promoting scour at that point and subsequent failure of the structure to perform its intended function.

### Plans and Specifications

Plans and specifications for installing check dams shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the practice will be installed.
2. Dimensions, elevations, and spacing between the dams.
3. Rock gradation and quality.
4. Fabric specification if used.
5. Construction detail.

## Part 4 - Check Dam

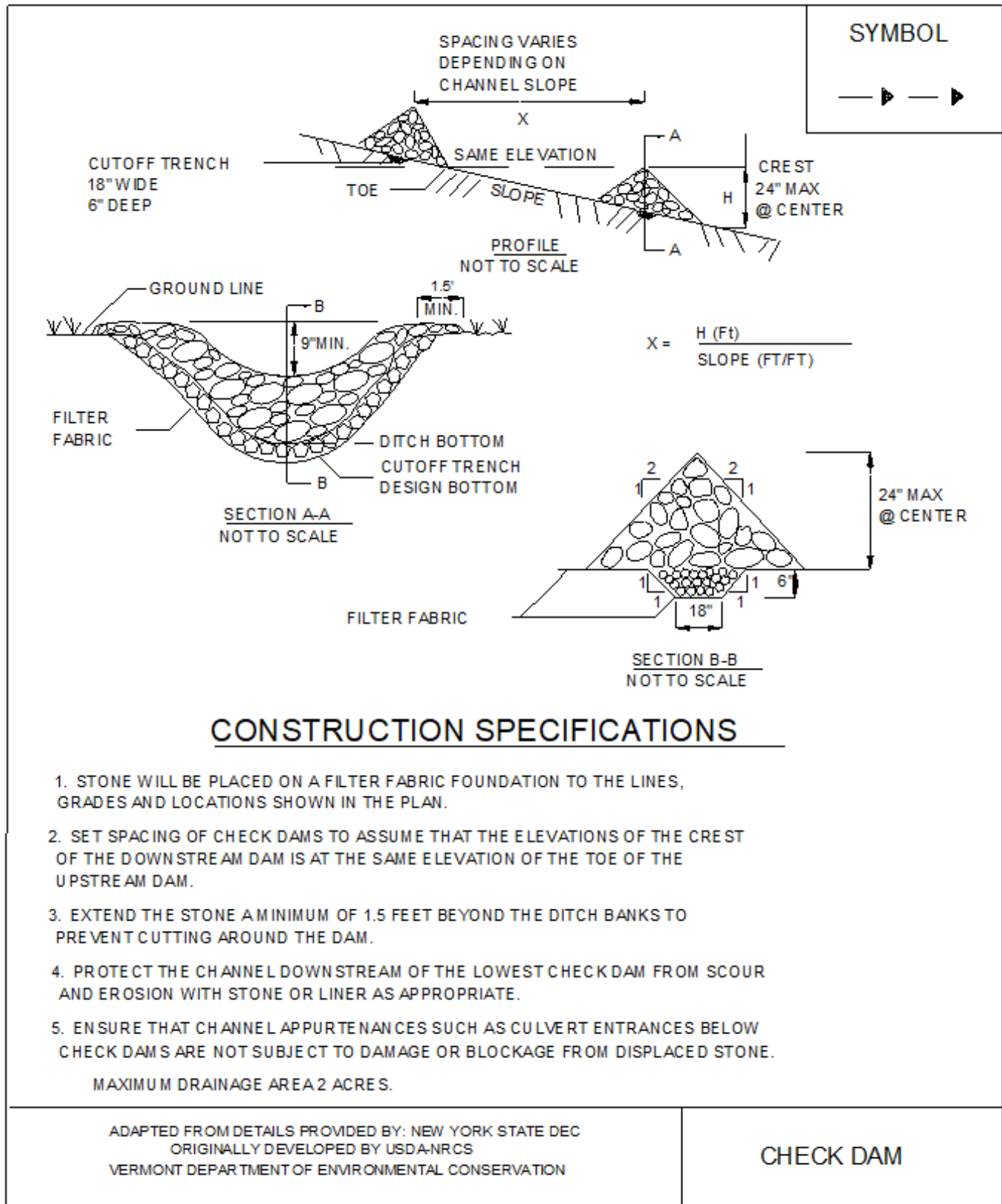


Figure 4.17 Check Dam

# Part 4 - Diversion

## Definition

A drainage way of parabolic or trapezoidal cross-section with a supporting ridge on the lower side that is constructed across the slope.

## Purpose

The purpose of a diversion is to intercept and convey runoff to stable outlets at non-erosive velocities.

## Conditions Where Practice Applies

Diversions are used where:

1. Runoff from higher areas has potential for damaging properties, causing erosion, or interfering with, or preventing the establishment of, vegetation on lower areas.
2. Surface and/or shallow subsurface flow is damaging sloping upland.
3. The length of slopes needs to be reduced so that soil loss will be kept to a minimum.

Diversions are only applicable below stabilized or protected areas. Avoid establishment on slopes greater than fifteen percent. Diversions should be used with caution on soils subject to slippage.

## Design Criteria

Location - Diversion location shall be determined by considering outlet conditions, topography, land use, soil type, length of slope, seep planes (when seepage is a problem), and the development layout.

Capacity - Peak rates of runoff values used in determining the capacity requirements shall be computed by TR-55, Urban Hydrology for Small Watersheds, or other appropriate methods.

Cross Section - The diversion channel shall be parabolic or trapezoidal in shape. Parabolic Diversion design charts are provided in Figures 4.19a-f. The

diversion shall be designed to have stable side slopes. The side slopes shall not be steeper than 2:1 and shall be flat enough to ensure ease of maintenance of the diversion and its protective vegetative cover.

The ridge shall have a minimum width of four feet at the design water elevation; a minimum of 4 inches freeboard and a reasonable settlement factor shall be provided.

Velocity and Grade - The permissible velocity for the specified method of stabilization will determine the maximum grade. Maximum permissible velocities of flow for the stated conditions of stabilization shall be considered.

Diversions are not usually applicable below high sediment producing areas unless land treatment practices or structural measures, designed to prevent damaging accumulations of sediment in the channels, are installed with, or before, the diversions.

Outlets - Each diversion must have an adequate outlet. The outlet may be a grassed waterway, vegetated or paved area, grade stabilization structure, stable watercourse, or subsurface drain outlet. In all cases, the outlet must convey runoff to a point where outflow will not cause damage. Vegetated outlets shall be installed before diversion construction, if needed, to ensure establishment of vegetative cover in the outlet channel.

The design elevation of the water surface in the diversion shall not be lower than the design elevation of the water surface in the outlet at their junction when both are operating at design flow.

Stabilization - Diversions shall be stabilized in accordance with the approved EPSC Plans.

## Considerations

Diversions should be planned as a part of initial site development. They are principally runoff control measures that subdivide the site into specific drainage

## Part 4 - Diversion

areas. Permanent diversions can be installed as temporary diversions until the site is stabilized, then completed as a permanent measure, or they can be installed in final form during the initial construction operation. The amount of sediment anticipated and the maintenance required as a result of construction operations will determine which approach should be used. Stabilize permanent diversions with vegetation or materials such as riprap, paving stone, or concrete as soon as possible after installation. Base the location, type of stabilization, and diversion configuration on final site conditions. Evaluate function, need, velocity control, outlet stability, and site aesthetics. When properly located, landforms such as landscape islands, swales or ridges can be used effectively as permanent diversions. Base the capacity of a diversion on the runoff characteristics of the site and the potential damage after development. Consider designing an emergency overflow section or bypass area to limit damage from storms that exceed the design storm. The overflow section may be designed as a weir with riprap protection.

### Plans and Specifications

Plans and specifications for installing diversions shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended function. At a minimum include the following items:

1. Diversion location.
2. Channel grade.
3. Diversion cross-sections.
4. Directions for stabilization.
5. Design calculations.
6. Construction detail.

## Part 4 - Diversion

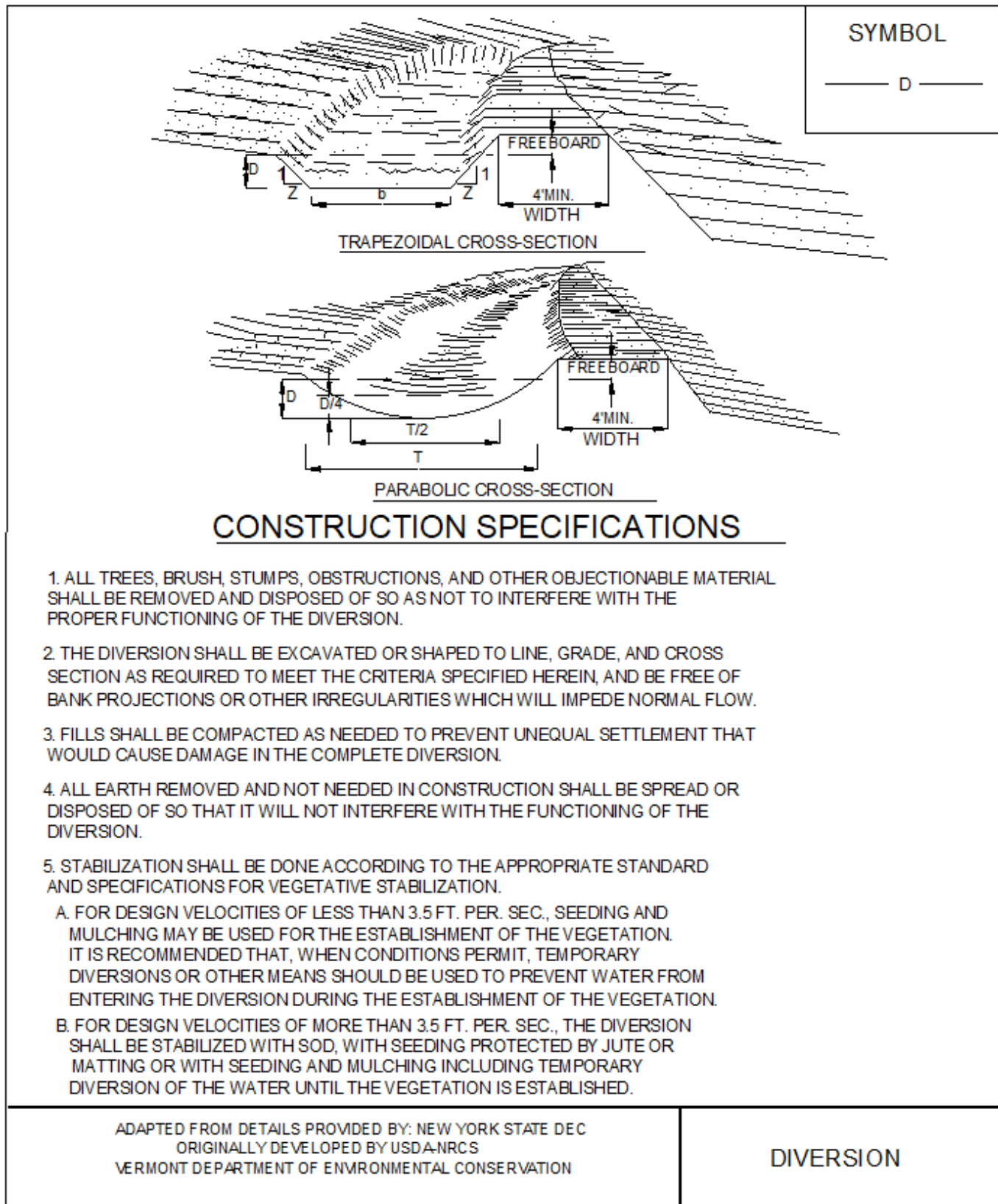


Figure 4.18 Diversion

# Part 4 - Diversion

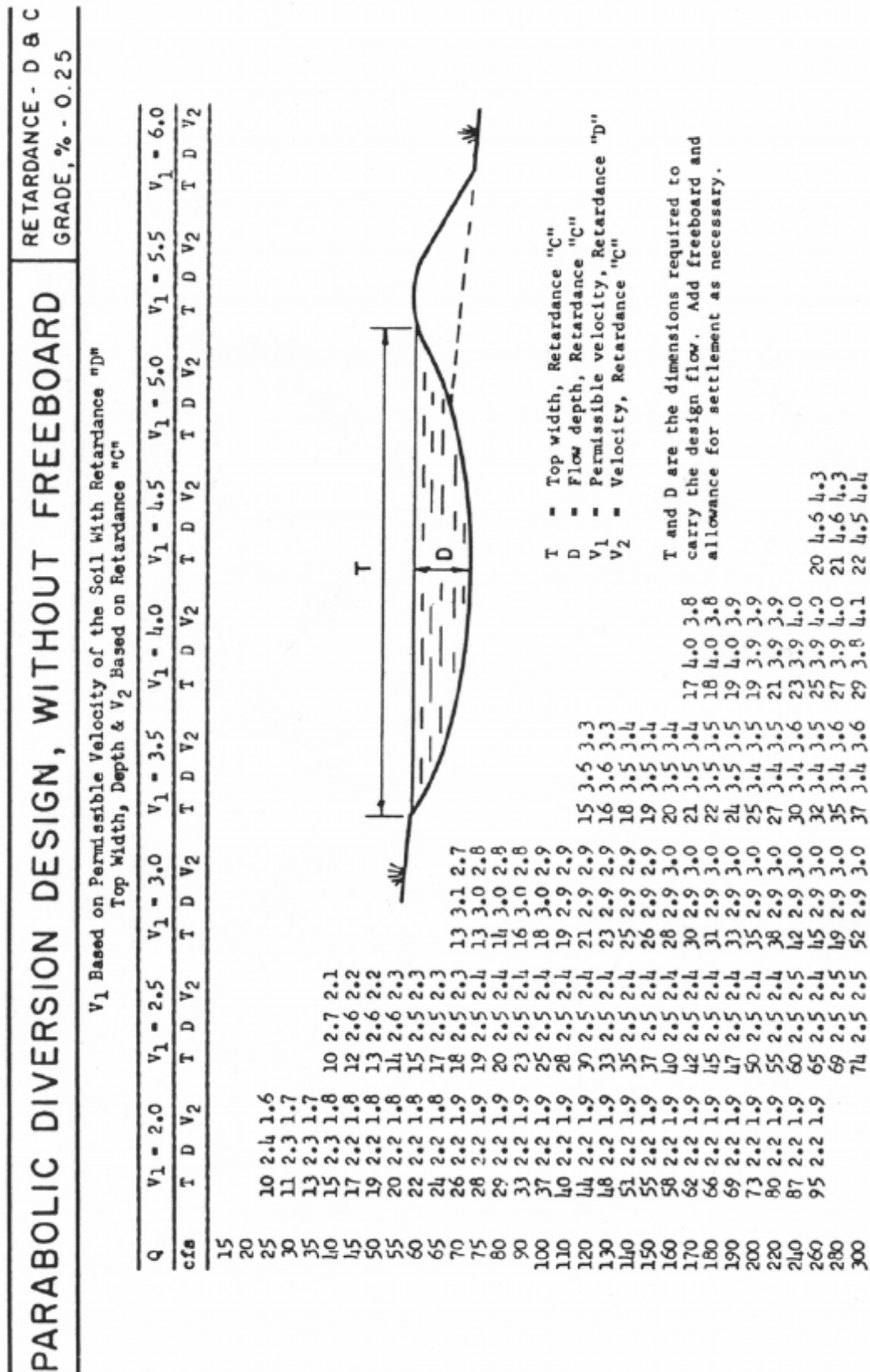


Figure 4.19a Parabolic Diversion Design, Without Freeboard 1 (USDA-NRCS)

# Part 4 - Diversion

PARABOLIC DIVERSION DESIGN, WITHOUT FREEBOARD															RETARDANCE - D & C GRADE, % - 0.50			
V <sub>1</sub> Based on Permissible Velocity of the Soil With Retardance "D" Top Width, Depth & V <sub>2</sub> Based on Retardance "C"																		
Q	V <sub>1</sub> = 2.0		V <sub>1</sub> = 2.5		V <sub>1</sub> = 3.0		V <sub>1</sub> = 3.5		V <sub>1</sub> = 4.0		V <sub>1</sub> = 4.5		V <sub>1</sub> = 5.0		V <sub>1</sub> = 5.5		V <sub>1</sub> = 6.0	
cfs	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	9	1.6	1.6															
20	11	1.6	1.7															
25	14	1.6	1.7	9	1.9	2.1												
30	17	1.6	1.7	11	1.9	2.2	8	2.2	2.5									
35	20	1.6	1.7	12	1.9	2.3	9	2.1	2.6									
40	22	1.6	1.7	14	1.8	2.3	11	2.1	2.7									
45	25	1.5	1.7	16	1.8	2.3	12	2.0	2.8									
50	28	1.5	1.7	18	1.8	2.4	13	2.0	2.8									
55	31	1.5	1.7	19	1.8	2.4	15	2.0	2.8									
60	33	1.5	1.7	21	1.8	2.4	16	2.0	2.8									
65	36	1.5	1.8	23	1.8	2.4	17	2.0	2.9									
70	39	1.5	1.7	24	1.8	2.4	18	2.0	2.9									
75	42	1.5	1.8	26	1.8	2.4	19	2.0	2.9									
80	44	1.5	1.8	28	1.8	2.4	21	2.0	2.9									
90	50	1.5	1.8	31	1.8	2.4	24	2.0	2.9									
100	55	1.5	1.8	35	1.8	2.4	26	2.0	2.9									
110	61	1.5	1.8	42	1.8	2.4	29	2.0	2.9									
120	66	1.5	1.8	48	1.8	2.4	31	2.0	2.9									
130	72	1.5	1.8	55	1.8	2.4	34	2.0	2.9									
140	77	1.5	1.8	62	1.8	2.4	36	2.0	2.9									
150	83	1.5	1.8	69	1.8	2.4	39	2.0	2.9									
160	88	1.5	1.8	76	1.8	2.4	41	2.0	2.9									
170	93	1.5	1.8	82	1.8	2.4	44	2.0	2.9									
180	99	1.5	1.8	89	1.8	2.4	47	2.0	2.9									
190				96	1.8	2.4	49	2.0	2.9									
200				69	1.8	2.4	52	2.0	2.9									
220				76	1.8	2.4	57	2.0	2.9									
240				82	1.8	2.5	62	2.0	2.9									
260				89	1.8	2.5	67	2.0	2.9									
280				96	1.8	2.5	72	2.0	3.0									
300							77	2.0	3.0									

Figure 4.19b Parabolic Diversion Design, Without Freeboard 2 (USDA-NRCS)

# Part 4 - Diversion

PARABOLIC DIVERSION DESIGN, WITHOUT FREEBOARD															RETARDANCE - D & C GRADE, % - 0.75			
V <sub>1</sub> Based on Permissible Velocity of the Soil With Retardance "D" Top Width, Depth & V <sub>2</sub> Based on Retardance "C"																		
Q	V <sub>1</sub> = 2.0		V <sub>1</sub> = 2.5		V <sub>1</sub> = 3.0		V <sub>1</sub> = 3.5		V <sub>1</sub> = 4.0		V <sub>1</sub> = 4.5		V <sub>1</sub> = 5.0		V <sub>1</sub> = 5.5		V <sub>1</sub> = 6.0	
cfs	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	12	1.3	1.5	7	1.6	2.0												
20	16	1.3	1.5	9	1.5	2.2												
25	19	1.3	1.5	11	1.5	2.2												
30	23	1.3	1.5	13	1.5	2.2												
35	27	1.3	1.5	15	1.5	2.3												
40	31	1.3	1.5	18	1.5	2.3												
45	35	1.3	1.6	20	1.5	2.3												
50	38	1.3	1.6	22	1.5	2.3												
55	42	1.3	1.6	24	1.5	2.3												
60	46	1.3	1.6	26	1.5	2.3												
65	50	1.3	1.6	28	1.5	2.3												
70	53	1.3	1.6	30	1.5	2.3												
75	57	1.3	1.6	33	1.5	2.3												
80	61	1.3	1.6	35	1.5	2.3												
90	68	1.3	1.6	39	1.5	2.3												
100	76	1.3	1.6	43	1.5	2.3												
110	83	1.3	1.6	48	1.5	2.3												
120	91	1.3	1.6	52	1.5	2.3												
130	98	1.3	1.6	56	1.5	2.4												
140				60	1.5	2.4												
150				65	1.5	2.4												
160				69	1.5	2.4												
170				73	1.5	2.4												
180				77	1.5	2.4												
190				82	1.5	2.4												
200				86	1.5	2.4												
220				94	1.5	2.4												
240																		
260																		
280																		
300																		

Figure 4.19c Parabolic Diversion Design, Without Freeboard 3 (USDA-NRCS)

# Part 4 - Diversion

PARABOLIC DIVERSION DESIGN, WITHOUT FREEBOARD															RETARDANCE - D & C GRADE, %- 1.0			
V <sub>1</sub> based on Permissible Velocity of the Soil With Retardance "D" Top Width, Depth & V <sub>2</sub> Based on Retardance "C"																		
Q	V <sub>1</sub> = 2.0		V <sub>1</sub> = 2.5		V <sub>1</sub> = 3.0		V <sub>1</sub> = 3.5		V <sub>1</sub> = 4.0		V <sub>1</sub> = 4.5		V <sub>1</sub> = 5.0		V <sub>1</sub> = 5.5		V <sub>1</sub> = 6.0	
cfs	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	13	1.1	1.5	8	1.3	2.0												
20	18	1.1	1.5	11	1.3	2.1	8	1.5	2.6									
25	22	1.1	1.5	14	1.3	2.1	9	1.5	2.6									
30	27	1.1	1.5	17	1.3	2.1	11	1.5	2.7									
35	31	1.1	1.5	19	1.3	2.2	13	1.5	2.8									
40	35	1.1	1.5	22	1.3	2.1	15	1.4	2.8	8	1.8	3.5						
45	40	1.1	1.5	25	1.3	2.2	17	1.5	2.8	9	1.8	3.7						
50	44	1.1	1.5	28	1.3	2.2	19	1.4	2.8	10	1.8	3.7						
55	48	1.1	1.5	30	1.3	2.2	20	1.4	2.8	11	1.8	3.7						
60	53	1.1	1.5	33	1.3	2.2	22	1.4	2.8	12	1.8	3.7						
65	57	1.1	1.5	36	1.3	2.2	24	1.4	2.8	13	1.7	3.8						
70	61	1.1	1.5	38	1.3	2.2	26	1.4	2.8	14	1.7	3.8						
75	66	1.1	1.5	41	1.3	2.2	28	1.4	2.9	15	1.7	3.8						
80	70	1.1	1.5	44	1.3	2.2	29	1.4	2.9	16	1.7	3.9	9	2.2	4.7			
90	79	1.1	1.5	49	1.3	2.2	33	1.4	2.9	17	1.7	3.9	10	2.2	4.7			
100	87	1.1	1.5	55	1.3	2.2	37	1.4	2.9	18	1.7	3.9	11	2.2	4.9			
110	96	1.1	1.5	60	1.3	2.2	40	1.4	2.9	20	1.7	3.9	13	2.4	5.0	11	2.6	5.7
120				65	1.3	2.2	44	1.4	2.9	22	1.7	4.0	15	2.1	5.0	12	2.6	5.7
130				71	1.3	2.2	47	1.4	2.9	24	1.7	4.0	17	2.1	5.0	14	2.6	5.7
140				76	1.3	2.2	51	1.4	2.9	26	1.7	4.0	18	2.1	5.0	15	2.6	5.8
150				81	1.3	2.2	55	1.4	2.9	28	1.7	4.0	20	2.1	5.0	16	2.6	5.8
160				87	1.3	2.2	58	1.4	2.9	31	1.7	4.0	21	2.1	5.1	17	2.6	5.8
170				92	1.3	2.2	62	1.4	2.9	33	1.7	4.0	22	2.1	5.1	19	2.3	5.9
180				97	1.3	2.2	65	1.4	2.9	35	1.7	4.0	24	2.1	5.1	20	2.3	5.9
190							69	1.4	2.9	36	1.7	4.0	25	2.1	5.1	21	2.3	5.9
200							72	1.4	2.9	40	1.7	4.0	27	2.1	5.1	22	2.3	5.9
220							79	1.4	2.9	42	1.7	4.0	28	2.1	5.1	23	2.3	6.0
240							80	1.4	2.9	34	1.7	4.0	31	2.1	5.1	25	2.3	6.0
260							87	1.4	2.9	37	1.7	4.0	33	2.1	5.1	26	2.3	6.1
280							94	1.4	2.9	40	1.7	4.0	35	2.1	5.1	28	2.3	6.1
300										53	1.7	4.0	37	2.1	5.1	30	2.3	6.1
										57	1.7	4.0	40	2.1	5.1	32	2.3	6.2
										61	1.7	4.0	44	2.1	5.1	34	2.3	6.2
										66	1.7	4.0	47	2.1	5.1	36	2.3	6.2
										81	1.7	4.0	50	2.1	5.1	38	2.3	6.2
										87	1.7	4.0	52	2.1	5.1	40	2.3	6.2

Figure 4.19d Parabolic Diversion Design, Without Freeboard 4 (USDA-NRCS)

## Part 4 - Diversion

RETARDANCE - D & C  
GRADE, % - 1.5

PARABOLIC DIVERSION DESIGN, WITHOUT FREEBOARD

V<sub>1</sub> Based on Permissible Velocity of the Soil With Retardance "D"  
Top Width, Depth & V<sub>2</sub> Based on Retardance "C"

Q	V <sub>1</sub> = 2.0		V <sub>1</sub> = 2.5		V <sub>1</sub> = 3.0		V <sub>1</sub> = 3.5		V <sub>1</sub> = 4.0		V <sub>1</sub> = 4.5		V <sub>1</sub> = 5.0		V <sub>1</sub> = 5.5		V <sub>1</sub> = 6.0	
cfs	T	D	V <sub>2</sub>	T	D	V <sub>2</sub>	T	D	V <sub>2</sub>	T	D	V <sub>2</sub>	T	D	V <sub>2</sub>	T	D	V <sub>2</sub>
15	17	0.9	1.4	11	1.1	1.9	8	1.2	2.4									
20	23	0.9	1.4	15	1.0	1.9	10	1.2	2.5									
25	28	0.9	1.4	19	1.0	1.9	12	1.2	2.6									
30	34	0.9	1.4	22	1.0	1.9	15	1.2	2.6									
35	40	0.9	1.4	26	1.0	2.0	17	1.1	2.6									
40	45	0.9	1.4	30	1.0	1.9	20	1.2	2.6									
45	51	0.9	1.4	33	1.0	2.0	22	1.1	2.6									
50	56	0.9	1.4	37	1.0	2.0	25	1.1	2.7									
55	62	0.9	1.5	41	1.0	2.0	27	1.1	2.6									
60	67	0.9	1.5	44	1.0	2.0	30	1.1	2.7									
65	73	0.9	1.5	48	1.0	2.0	32	1.1	2.7									
70	78	0.9	1.5	51	1.0	2.0	34	1.1	2.7									
75	83	0.9	1.5	55	1.0	2.0	37	1.1	2.7									
80	89	0.9	1.5	59	1.0	2.0	39	1.1	2.7									
90	100	0.9	1.5	66	1.0	2.0	44	1.1	2.7									
100				73	1.0	2.0	49	1.1	2.7									
110				80	1.0	2.0	54	1.1	2.7									
120				87	1.0	2.0	59	1.1	2.7									
130				95	1.0	2.0	63	1.1	2.7									
140				68	1.1	2.7	47	1.3	3.5									
150				73	1.1	2.7	50	1.3	3.5									
160				78	1.1	2.7	53	1.3	3.5									
170				82	1.1	2.7	56	1.3	3.5									
180				87	1.1	2.7	60	1.3	3.5									
190				92	1.1	2.7	63	1.3	3.5									
200				97	1.1	2.7	66	1.3	3.5									
220				73	1.3	3.5	59	1.4	4.0									
240				79	1.3	3.5	65	1.4	4.0									
260				86	1.3	3.5	70	1.4	4.0									
280				92	1.3	3.5	75	1.4	4.0									
300				99	1.3	3.5	81	1.4	4.0									

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**Figure 4.19e Parabolic Diversion Design, Without Freeboard 5 (USDA-NRCS)**

# Part 4 - Diversion

PARABOLIC DIVERSION DESIGN, WITHOUT FREEBOARD															RETARDANCE - D & C GRADE, % - 2.0			
V <sub>1</sub> Based on Permissible Velocity of the Soil With Retardance "D" Top Width, Depth & V <sub>2</sub> based on Retardance "C"																		
Q	V <sub>1</sub> = 2.0		V <sub>1</sub> = 2.5		V <sub>1</sub> = 3.0		V <sub>1</sub> = 3.5		V <sub>1</sub> = 4.0		V <sub>1</sub> = 4.5		V <sub>1</sub> = 5.0		V <sub>1</sub> = 5.5		V <sub>1</sub> = 6.0	
cfs	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	21	0.8	1.3	13	0.9	1.9	9	1.0	2.4	7	1.2	2.9	5	1.4	3.8			
20	28	0.8	1.3	17	0.9	1.9	12	1.0	2.4	9	1.1	3.0	8	1.3	3.7			
25	35	0.8	1.3	21	0.9	1.9	15	1.0	2.4	11	1.1	3.0	10	1.2	3.7			
30	41	0.8	1.3	26	0.9	1.9	18	1.0	2.5	13	1.1	3.0	13	1.2	3.7			
35	48	0.8	1.4	30	0.9	1.9	22	1.0	2.4	15	1.1	3.1	11	1.2	3.8			
40	55	0.8	1.3	34	0.9	1.9	25	1.0	2.5	18	1.1	3.1	13	1.2	3.8			
45	62	0.8	1.4	38	0.9	1.9	28	1.0	2.5	20	1.1	3.1	14	1.2	3.8			
50	68	0.8	1.4	42	0.9	1.9	31	1.0	2.5	22	1.1	3.1	15	1.2	3.9			
55	75	0.8	1.4	46	0.9	1.9	34	1.0	2.5	24	1.1	3.1	17	1.2	3.8			
60	82	0.8	1.4	51	0.9	1.9	37	1.0	2.5	26	1.1	3.1	19	1.2	3.9			
65	88	0.8	1.4	55	0.9	1.9	40	1.0	2.5	28	1.1	3.1	21	1.2	3.9			
70	95	0.8	1.4	59	0.9	1.9	43	1.0	2.5	30	1.1	3.1	22	1.2	3.9			
75	63	0.7	1.9	46	1.0	2.5	32	1.1	3.2	24	1.2	3.9	20	1.3	4.4			
80	67	0.9	2.0	48	1.0	2.5	35	1.1	3.1	25	1.2	3.9	21	1.3	4.4			
90	75	0.9	2.0	54	1.0	2.5	39	1.1	3.2	28	1.2	3.9	23	1.3	4.4			
100	83	0.9	2.0	60	1.0	2.5	43	1.1	3.2	31	1.2	3.9	26	1.3	4.4			
110	92	0.9	2.0	66	1.0	2.5	47	1.1	3.2	34	1.2	3.9	28	1.3	4.4			
120	100	0.9	2.0	72	1.0	2.5	52	1.1	3.2	38	1.2	3.9	31	1.3	4.4			
130				78	1.0	2.5	56	1.1	3.2	41	1.2	3.9	34	1.3	4.5			
140				84	1.0	2.5	60	1.1	3.2	44	1.2	4.0	36	1.3	4.5			
150				90	1.0	2.5	64	1.1	3.2	47	1.2	4.0	39	1.3	4.5			
160				96	1.0	2.5	69	1.1	3.2	50	1.2	4.0	41	1.3	4.5			
170							73	1.1	3.2	53	1.2	4.0	44	1.3	4.5			
180							77	1.1	3.2	56	1.2	4.0	46	1.3	4.5			
190							81	1.1	3.2	59	1.2	4.0	49	1.3	4.5			
200							85	1.1	3.2	62	1.2	4.0	51	1.3	4.5			
220							94	1.1	3.2	68	1.2	4.0	56	1.3	4.5			
240										74	1.2	4.0	61	1.3	4.5			
260										80	1.2	4.0	66	1.3	4.5			
280										86	1.2	4.0	71	1.3	4.5			
300										92	1.2	4.0	76	1.3	4.5			

Figure 4.19f Parabolic Diversion Design, Without Freeboard 6 (USDA-NRCS)

## Part 4 - Earth Dike

### Definition

A temporary berm or ridge of compacted soil, located in such a manner as to channel water to a desired location.

### Purpose

The purpose of an earth dike is to direct runoff to a sediment trapping device, thereby reducing the potential for erosion and off site sedimentation. Earth dikes can also be used for diverting clean water away from disturbed areas.

### Conditions Where Practice Applies

Earth dikes are often constructed across disturbed areas and around construction sites such as graded parking lots and subdivisions. The dikes shall remain in place until the disturbed areas are permanently stabilized.

### Design Criteria

	<b>Dike A</b>	<b>Dike B</b>
Drainage Area	<5 acres	5-10 acres
Dike Height	18 inches	36 inches
Dike Width	24 inches	36 inches
Flow Width	4 feet	6 feet
Flow Depth in Channel	8 inches	15 inches
Side Slopes	2:1 or flatter	2:1 or flatter
Grade	0.5% min. 20% max.	0.5% min. 20% max.

For drainage areas larger than 10 acres, refer to the standards and specifications for Diversion.

Outlet - Earth dikes shall have an outlet that functions with a minimum of erosion.

Runoff shall be conveyed to a sediment trapping device until the drainage area above the dike is adequately stabilized.

The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet.

Stabilization - Stabilization of the dike shall be completed within 48 hours of installation in accordance with the standard and specifications for seed and straw mulch or straw mulch only if not in seeding season and flow channel shall be stabilized as per the following criteria:

<b>Type of treatment</b>	<b>Channel Grade<sup>1</sup></b>	<b>Flow Channel A (&lt;5 acres)</b>	<b>Flow Channel B (5-10 acres)</b>
1	0.5-3.0%	Seed and Straw Mulch	Seed and Straw Mulch
2	3.1-5.0%	Seed and Straw Mulch	Seed and cover with RECP, Sod, or Line with Plastic or 2' Stone
3	5.1-8.0%	Seed and cover with RECP, Sod, or Line with Plastic or 2" Stone	Line with 4-8" Stone or Recycled Concrete Equivalent or Geotextile
4	8.1-20%	Line with 4-8" Stone or Recycled Concrete Equivalent <sup>2</sup> or Geotextile	Site Specific Engineering Design

<sup>1</sup> In highly erodible soils, as defined by the local approving agency, refer to the next higher slope grade for type of stabilization.

<sup>2</sup> Recycled Concrete Equivalent shall be concrete broken into the required size, and shall contain no steel reinforcement.

## Part 4 - Earth Dike

### Considerations

An earth dike is a special application of a temporary or permanent diversion. It differs from other diversions in that the location and grade are usually fixed, and the cross section and stabilization requirements are based on the existing grade of the work boundary. Hence, the design cross section may vary significantly throughout the length. Give special care to avoid erosive velocities in steep areas. Identify areas where sedimentation will occur since they are often subject to overtopping. Earth dikes should be protected from damage from ongoing construction activities.

Immediately vegetate diversion dikes after construction, but make sure channel flow area is stabilized during the initial phase of construction. Exercise caution in diverting flow to be certain that the diverted water is released through a stable outlet and that the flow will not cause flood damage. Sediment laden water should first be directed through an approved sediment-trapping device before entering receiving surface waters.

### Plans and Specifications

The plans and specifications for installing earth dikes shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Diversion dike location.
2. Minimum cross-sections.
3. Channel grade.
4. Seeding requirements.
5. Construction detail.

## Part 4 - Earth Dike

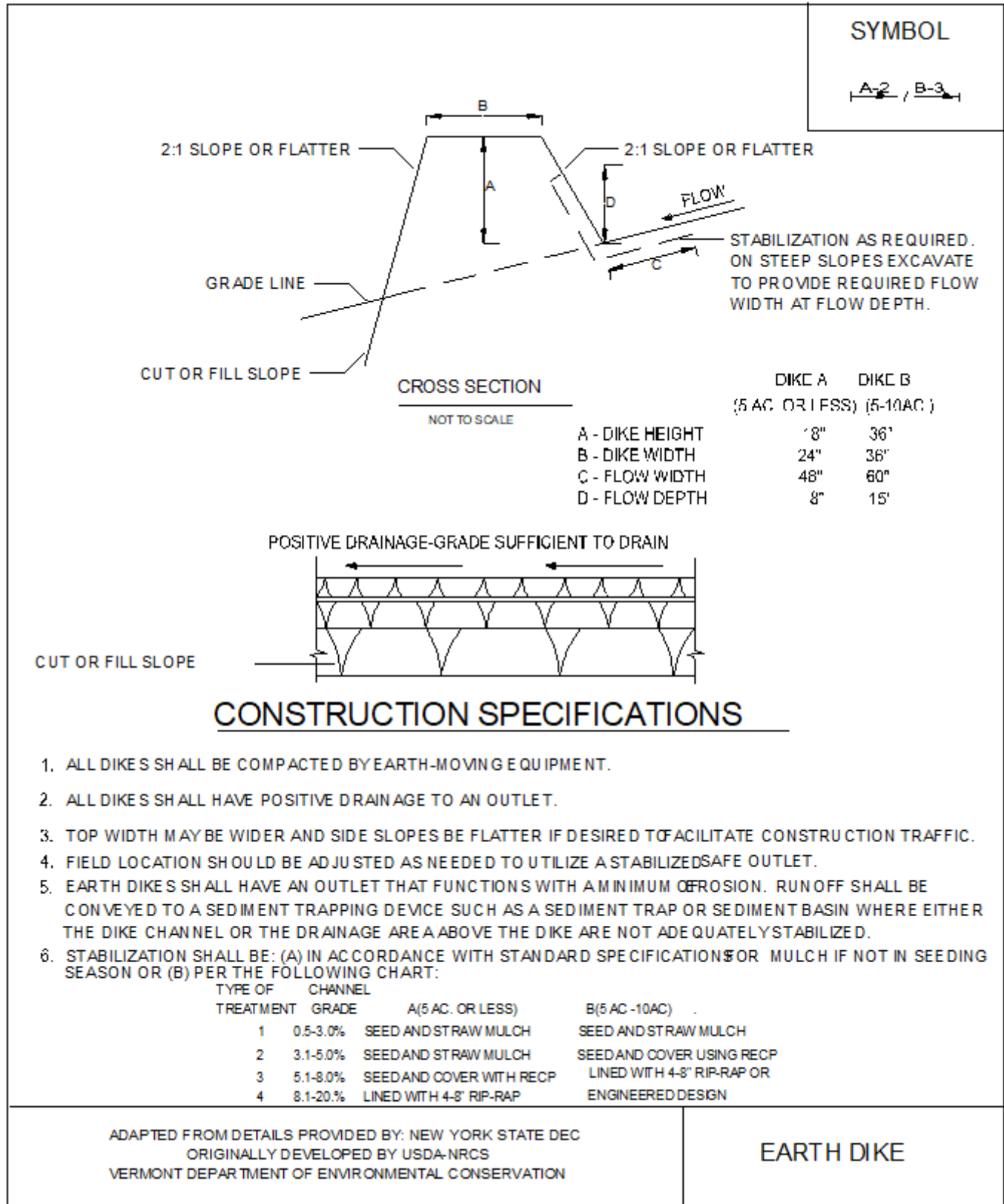


Figure 4.20 Earth Dike

## Part 4 - Temporary Swale

### Definition

A temporary excavated drainage way.

### Purpose

The purpose of a temporary swale is to prevent runoff from entering disturbed areas by intercepting and diverting it to a stabilized outlet or to intercept sediment laden water and divert it to a sediment trapping device.

### Conditions Where Practice Applies

Temporary swales are constructed:

1. To divert flows from entering a disturbed area.
2. Intermittently across disturbed areas to shorten overland flow distances.
3. To direct sediment laden water along the base of slopes to a trapping device.
4. To transport off-site flows across disturbed areas such as rights-of-way.

Swales collecting runoff from disturbed areas shall remain in place until the disturbed areas are permanently stabilized.

**Stabilization** - Stabilization of the swale shall be completed within 7 days of installation in accordance with the appropriate standard and specifications for vegetative stabilization or stabilization with mulch as determined by the time of year. The flow channel shall be stabilized as per the following criteria:

Type of Treatment	Channel Grade <sup>1</sup>	Flow Channel A (<5 acres)	Flow Channel B (5-10 acres)
1	0.5-3.0%	Seed and Straw Mulch	Seed and Straw Mulch
2	3.1-5.0%	Seed and Straw Mulch	Seed and cover with RECP, Sod, or Line with Plastic or 2' Stone
3	5.1-8.0%	Seed and cover with RECP, Sod, or Line with Plastic or 2" Stone	Line with 4-8" Stone or Recycled Concrete Equivalent or Geotextile
4	8.1-20%	Line with 4-8" Stone or Recycled Concrete Equivalent <sup>2</sup> or Geotextile	Site Specific Engineering Design

<sup>1</sup> In highly erodible soils, as defined by the local approving agency, refer to the next higher slope grade for type of stabilization.

<sup>2</sup> Recycled Concrete Equivalent shall be concrete broken into the required size, and shall contain no steel reinforcement.

**Outlet** - Swale shall have an outlet that functions with a minimum of erosion, and dissipates runoff velocity prior to discharge off the site.

Runoff shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin until the drainage area above the swale is adequately stabilized.

The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet condition.

If a swale is used to divert clean water flows from

## Part 4 - Temporary Swale

entering a disturbed area, a sediment trapping device may not be needed.

### Design Criteria

	Swale A	Swale B
Drainage Area	<5 acres	5-10 acres
Bottom Width of Flow Channel	4 feet	6 feet
Depth of Flow Channel	1 foot	1 foot
Side Slopes	2:1 or flatter	2:1 or flatter
Grade	0.5% min. 20% max.	0.5% min. 20% max.

### Considerations

It is important that temporary swales are properly designed, constructed and maintained since they concentrate water flow and increase erosion potential. Particular care must be taken in planning temporary swale grades. Too much slope can result in erosion in the channel or at the outlet. A change of slope from steeper grade to flatter may cause deposition to occur. The deposition reduces carrying capacity and may cause overtopping and failure. Frequent inspection and timely maintenance are essential to the proper functioning of temporary swales. Sufficient area must be available to construct and properly maintain temporary swales.

Temporary swales may serve as in-place sediment traps if over excavated 1 to 2' and placed on a nearly flat grade. The dike serves to divert water as the stage increases. Wherever feasible, build and stabilize temporary swales and outlets before initiating other land-disturbing activities.

### Plans and Specifications

Plans and specifications for installing temporary swales shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include

the following items:

1. Temporary swale location.
2. Channel grade.
3. Swale cross-sections.
4. Stabilization directions.
5. Appropriate outlet protection.
6. Construction detail.

## Part 4 - Temporary Swale

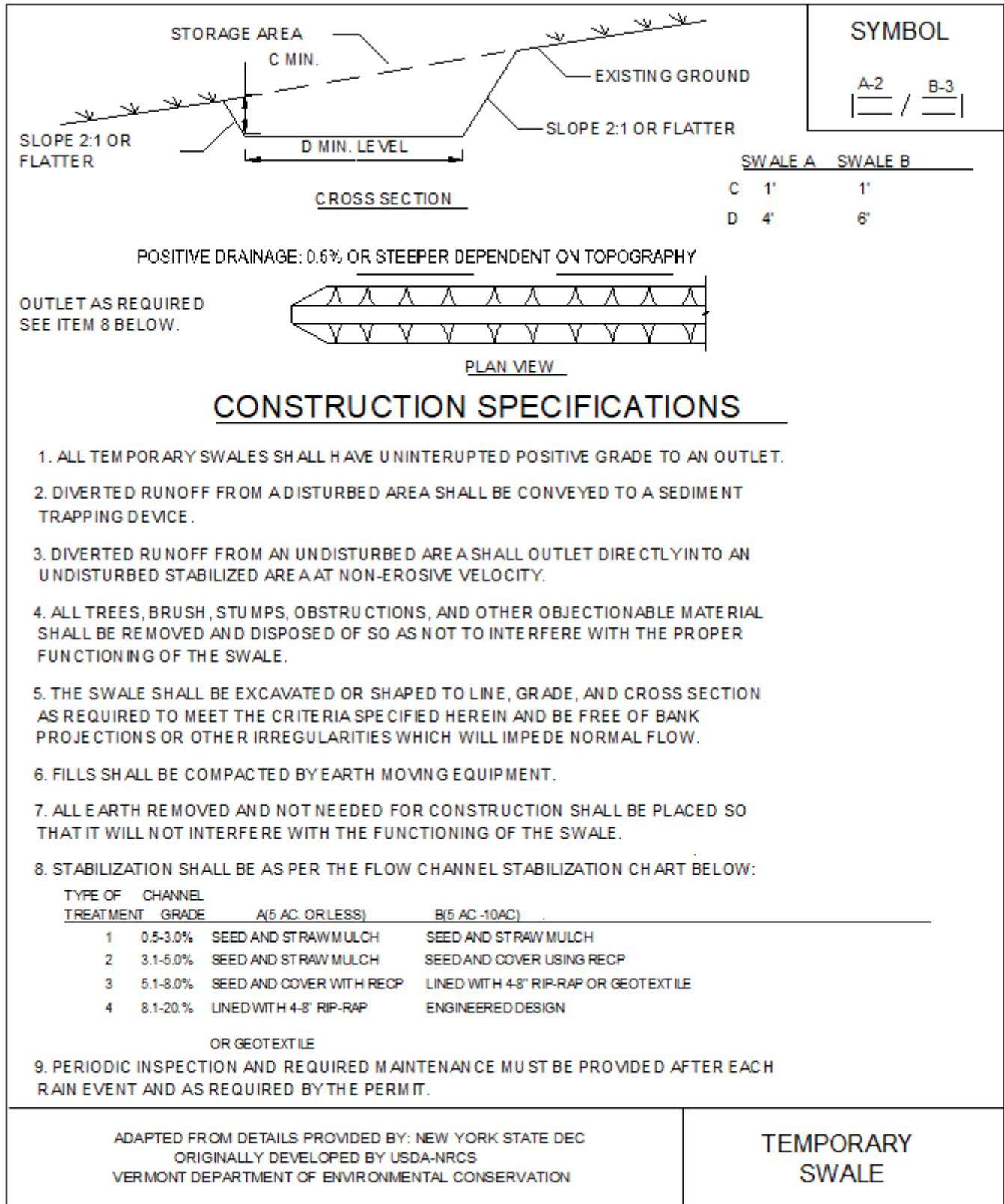


Figure 4.21 Temporary Swale

## Part 4 - Perimeter Dike/Swale

### Definition

A temporary ridge of soil excavated from an adjoining swale located along the perimeter of the site or disturbed area.

### Purpose

The purpose of a perimeter dike/swale is to prevent off site storm runoff from entering a disturbed area and to prevent sediment laden storm runoff from leaving the construction site or disturbed area.

### Conditions Where Practice Applies

Perimeter dike/swale is constructed to divert flows from entering a disturbed area, or along tops of slopes to prevent flows from eroding the slope, or along base of slopes to direct sediment laden flows to a trapping device.

The perimeter dike/swale shall remain in place until the disturbed areas are permanently stabilized.

### Design Criteria

A design is not required for perimeter dike/swale. The following criteria shall be used:

Drainage area – Less than 2 acres (for drainage areas larger than 2 acres but less than 10 acres, see earth dike or temporary swale; for drainage areas larger than 10 acres, see standard and specifications for diversion).

Height – 18 inches minimum from bottom of swale to top of dike evenly divided between dike height and swale depth.

Bottom Width of Dike– 24 inches minimum.

Width of Swale – 24 inches minimum.

Grade – Dependent upon topography, but shall have positive drainage (sufficient grade to drain) to an

adequate outlet. Maximum allowable grade not to exceed 8 percent.

Stabilization – The disturbed area of the dike and swale shall be stabilized within 7 days of installation, in accordance with the standard and specifications for temporary swales.

### Outlet

1. Perimeter dike/swale shall have a stabilized outlet.
2. Diverted runoff from a protected or stabilized upland area shall outlet directly onto an undisturbed stabilized area.
3. Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as a sediment trap, sediment basin, or to an area protected by any of these practices.
4. The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet.

### Considerations

It is important that perimeter dikes are properly designed, constructed and maintained since they concentrate water flow and increase erosion potential. Particular care must be taken in planning perimeter dike grades. Too much slope can result in erosion in the channel or at the outlet. A change of slope from steeper grade to flatter may cause deposition to occur. The deposition reduces carrying capacity and may cause overtopping and failure. Frequent inspection and timely maintenance are essential to the proper functioning of perimeter dikes.

Perimeter dikes may serve as in-place sediment traps if over excavated 1 to 2 feet and placed on a nearly flat grade. The dike serves to divert water as the stage increases. Wherever feasible, build and stabilize temporary swales and outlets before initiating other land-disturbing activities.

## Part 4 - Perimeter Dike/Swale

### Plans and Specifications

Plans and specifications for installing perimeter dikes shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Perimeter dike location.
2. Channel grade.
3. Dike/swale cross-sections.
4. Stabilization directions.
5. Appropriate outlet protection
6. Construction detail.

## Part 4 - Perimeter Dike/Swale

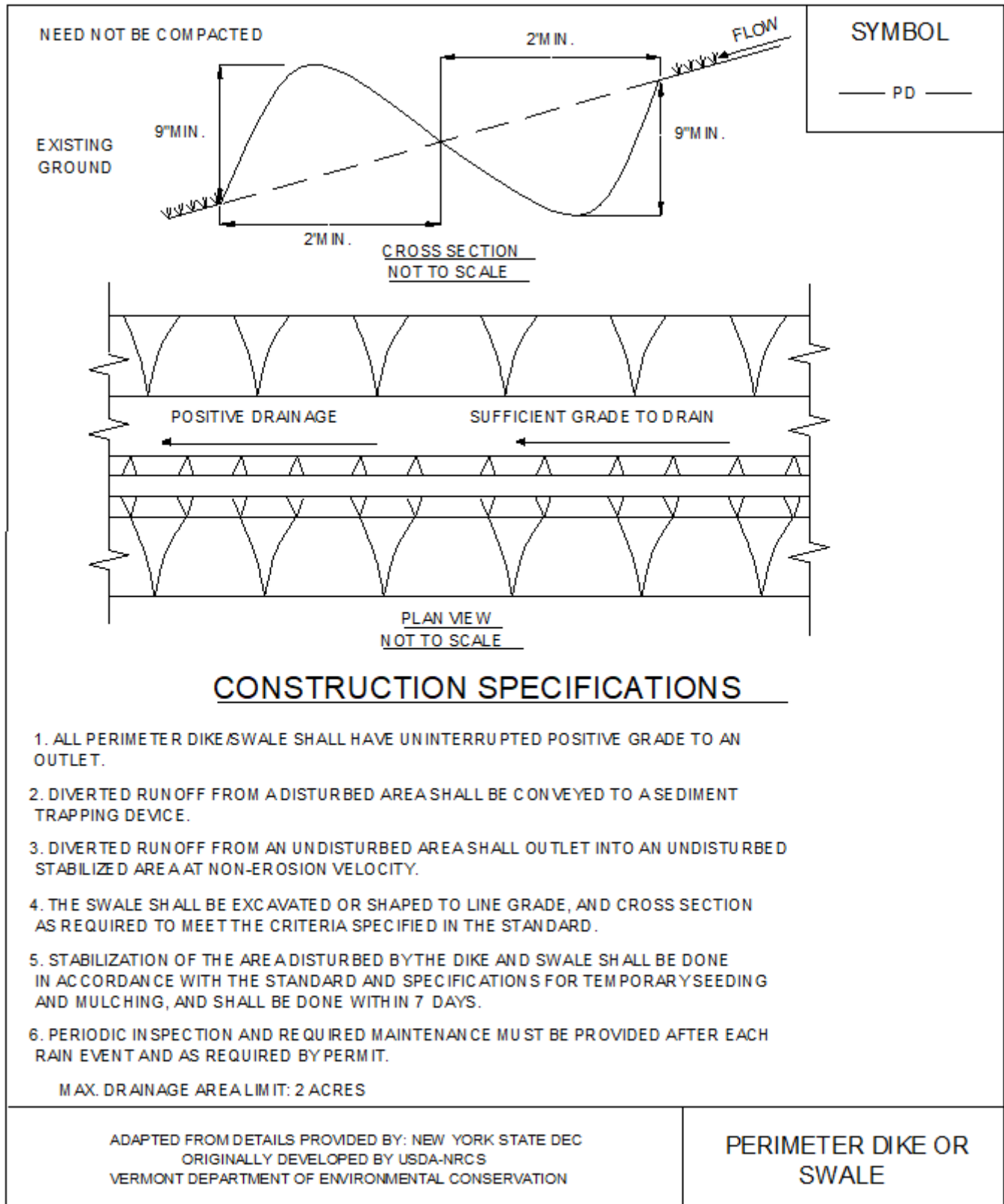


Figure 4.22 Perimeter Dike/Swale

## Part 4 - Pipe Slope Drain

### Definition

A temporary structure placed from the top of a slope to the bottom of a slope.

### Purpose

The purpose of the structure is to convey surface runoff down slopes without causing erosion.

### Conditions Where Practice Applies

Pipe slope drains are used where concentrated flow of surface runoff must be conveyed down a slope in order to prevent erosion. The maximum allowable drainage area shall be 3.5 acres.

### Design Criteria

#### General

Maximum Size	Pipe Diameter (in.)	Drainage Area (Ac)
PSD-12	12	0.5
PSD-18	18	1.5
PSD-21	21	2.5
PSD-24	24	3.5

#### Inlet

The minimum height of the earth dike at the entrance to the pipe slope drain shall be the diameter of the pipe (D) plus 12 inches.

#### Outlet

The pipe slope drain shall outlet into a sediment trapping device when the drainage area is disturbed. A riprap apron shall be installed below the pipe outlet where water is being discharged into a stabilized area.

### Construction Specifications

1. The pipe slope drain shall have a slope of 3 percent or steeper.
2. The top of the earth dike over the inlet pipe, and those dikes carrying water to the pipe, shall be at least one (1) foot higher at all points than the top of the inlet pipe.
3. Corrugated plastic pipe or equivalent shall be used with watertight connecting bands.
4. A flared end section shall be attached to the inlet end of pipe with a watertight connection.
5. The soil around and under the pipe and end section shall be hand tamped in 4 in. lifts to the top of the earth dike.
6. Where flexible tubing is used, it shall be the same diameter as the inlet pipe and shall be constructed of a durable material with hold down grommets spaced 10 ft. on centers.
7. The flexible tubing shall be securely fastened to the corrugated plastic pipe with metal strapping or watertight connecting collars.
8. The flexible tubing shall be securely anchored to the slope by staking at the grommets provided.
9. Where a pipe slope drain outlets into a sediment trapping device, it shall discharge at the riser crest or weir elevation.
10. A riprap apron shall be used below the pipe outlet where clean water is being discharged into a stabilized area.
11. Inspection and any needed maintenance shall be performed after each storm.

# Part 4 - Pipe Slope Drain

## Considerations

There is often a significant lag between the time a cut or fill is graded and the time it is permanently stabilized. During this period, the slope is very vulnerable to erosion, and temporary slope drains together with temporary diversions can provide valuable protection.

Slope drains must be sized, installed, and maintained properly, because failure will usually result in severe erosion of the slope. The entrance section to the drain should be well entrenched and stable so that surface water can enter freely. The drain should extend downslope beyond the toe of the slope to a stable area or outlet.

Other points of concern are failure from overtopping from inadequate pipe inlet capacity or blockage and lack of maintenance of diversion channel capacity and ridge height.

## Plans and Specifications

Plans and specifications for installing pipe slope drains shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Drain location.
2. Inlet type.
3. Conduit size and material.
4. Construction detail.

## Part 4 - Pipe Slope Drain

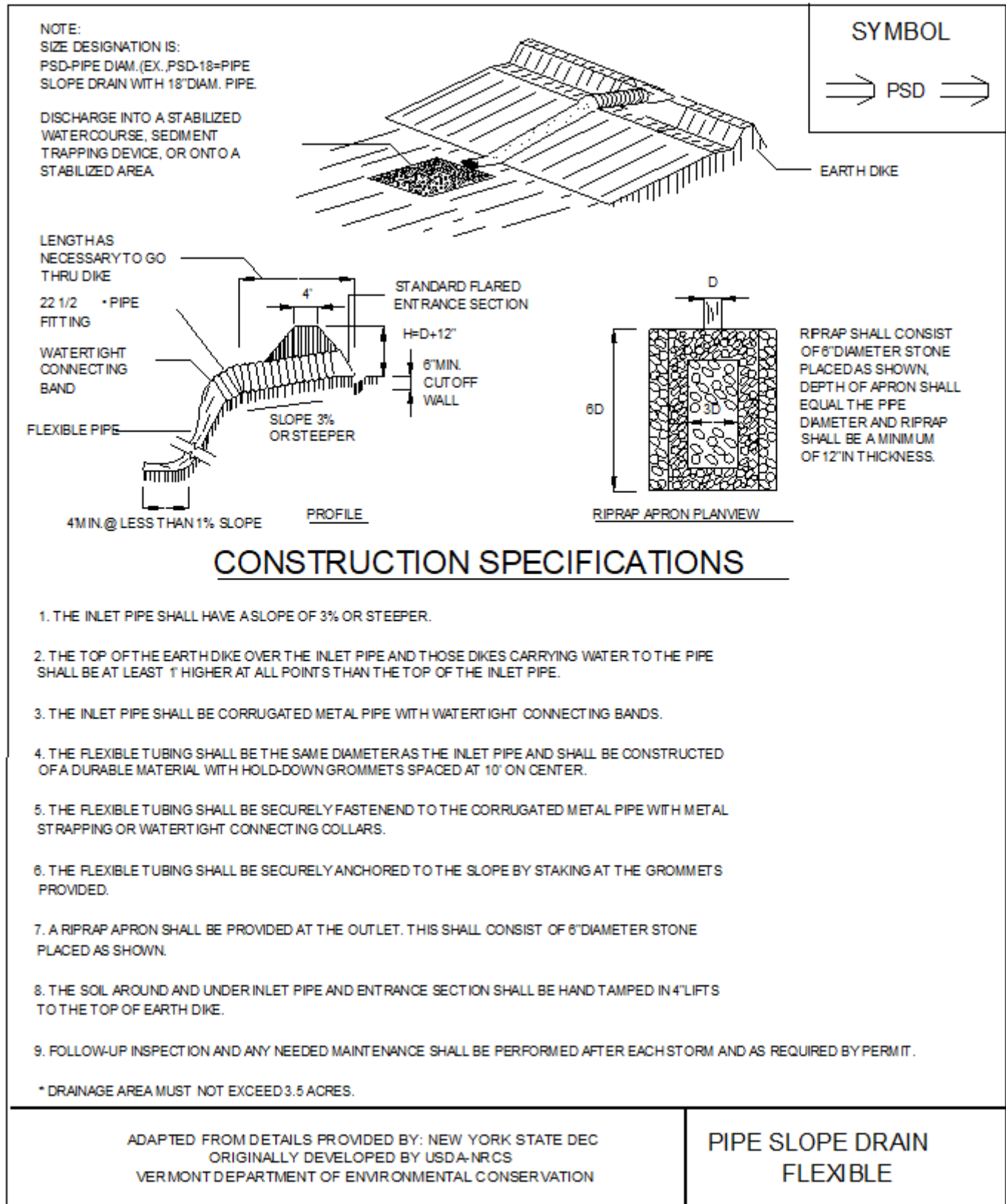


Figure 4.23 Pipe Slope Drain

## Part 4 - Grass Waterways

### Definition

Waterways are a natural or constructed outlet, shaped or graded. They are vegetated as needed for safe transport of runoff water.

### Purpose

To provide for the safe transport of excess surface water from construction sites and urban areas without damage from erosion.

### Conditions Where Practice Applies

This standard applies to vegetating waterways and similar water carrying structures.

Supplemental measures may be required with this practice. These may include: subsurface drainage to permit the growth of suitable vegetation and to eliminate wet spots; a section stabilized with asphalt, stone, or other suitable means; or additional storm drains to handle snowmelt or storm runoff.

Retardance factors for determining waterway dimensions are shown in Figure 4.26 and "Maximum Permissible Velocities for the selected seed mix and/or RECP for stabilization shall be considered.

### Design Criteria

Waterways or outlets shall be protected against erosion by vegetative means as soon after construction as practical. Vegetation must be well established before diversions or other channels are outletted into them. Consideration should be given to the use of synthetic products, jute or excelsior matting, other rolled erosion control products, or sodding of channels to provide erosion protection as soon after construction as possible. It is strongly recommended that the center line of the waterway be protected with one of the above materials to avoid center gullies.

### 1. Liming, fertilizing, and seedbed preparation.

- a. Lime to pH 6.5.
- b. The soil should be tested to determine the amounts of amendments needed. If the soil must be fertilized before results of a soil test can be obtained to determine fertilizer needs, apply commercial fertilizer at 1.0 lbs/1,000 sq. ft. of N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O.
- c. Lime and fertilizer shall be mixed thoroughly into the seedbed during preparation.
- d. Channels, except for paved section, shall have at least 4 inches of topsoil.
- e. Remove stones and other obstructions that will hinder maintenance.

### 2. Timing of Seeding.

- a. Early spring and late August are best.
- b. Temporary cover to protect from erosion is recommended during periods when seedings may fail.

## Part 4 - Grass Waterways

### 3. Seed Mixtures:

Mixtures	Rate per Acre (lbs)	Rate per 1,000 sq. ft. (lbs)
A. Birdsfoot trefoil or ladino clover <sup>1</sup>	8	0.20
Tall fescue or smooth brome grass	20	0.45
Redtop <sup>2</sup>	2	0.05
	30	0.70
OR		
B. Kentucky bluegrass <sup>3</sup>	25	0.60
Creeping red fescue	20	0.50
Perennial ryegrass	10	0.20
	55	1.30

<sup>1</sup> Inoculate with appropriate inoculum immediately prior to seeding. Ladino or common white clover may be substituted for birdsfoot trefoil and seeded at the same rate.

<sup>2</sup> Perennial ryegrass may be substituted for the redtop but increase seeding rate to 5 lbs/acre (0.1 lb/1,000 sq. ft.).

<sup>3</sup> Use this mixture in areas which are mowed frequently. Common white clover may be added if desired and seeded at 8 lbs/acre (0.2 lb/1,000 sq. ft.)

### 4. Seeding

Select the appropriate seed mixture and apply uniformly over the area. Rolling or cultipacking across the waterway is desirable.

Waterway centers or crucial areas may be sodded. Refer to the standard and specification for Stabilization with Sod. Be sure sod is securely anchored using staples or stakes.

### 5. Mulching.

All seeded areas will be mulched. Channels more than 300 feet long, and/or where the slope is 5 percent or more, must have the mulch securely anchored. Refer to the standard and specifications for Mulching for details.

### 6. Maintenance

Fertilize, lime, and mow as needed to maintain dense protective vegetative cover.

Waterways shall not be used for roadways.

If rills develop in the centerline of a waterway, prompt attention is required to avoid the formation of gullies. Either stone and/or compacted soil fill with excelsior or filter fabric as necessary may be used during the establishment phase. Spacing between rill maintenance barriers shall not exceed 100 feet.

### Considerations

Generally, grassed waterways should be located to conform with and use the natural drainage system. Waterways may also be needed along development boundaries, roadways, and back lot lines. In all situations channels should be located so that they do not make sharp, unnatural changes in direction or grade of flow. Avoid crossing watershed boundaries or ridges.

Major reconfiguration of the drainage system often entails increased maintenance and risk of failure. Establishment of a dense, erosion resistant vegetation is essential. Construct and vegetate grassed waterways early in the construction schedule before grading and paving increase the rate of runoff.

All grassed waterways should be designed to permit easy crossing of equipment during construction and maintenance.

## Part 4 - Grass Waterways

Geotextile fabrics or special mulch protection such as fiberglass roving or straw and netting provide stability until the vegetation is fully established. It may also be necessary to divert water from the waterway until vegetation is established or to line the channel with sod. Rock checks or filter fabric checks may also be needed to protect the channel before vegetation is established. Sediment traps may be needed at waterway inlets and outlets.

### Plans and Specifications

Plans and specifications for installing grass-lined channels shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Waterway location and alignment.
2. Grade, depth and width.
3. Channel cross section type.
4. Stabilization directions.
5. Construction detail.

## Part 4 - Grass Waterways

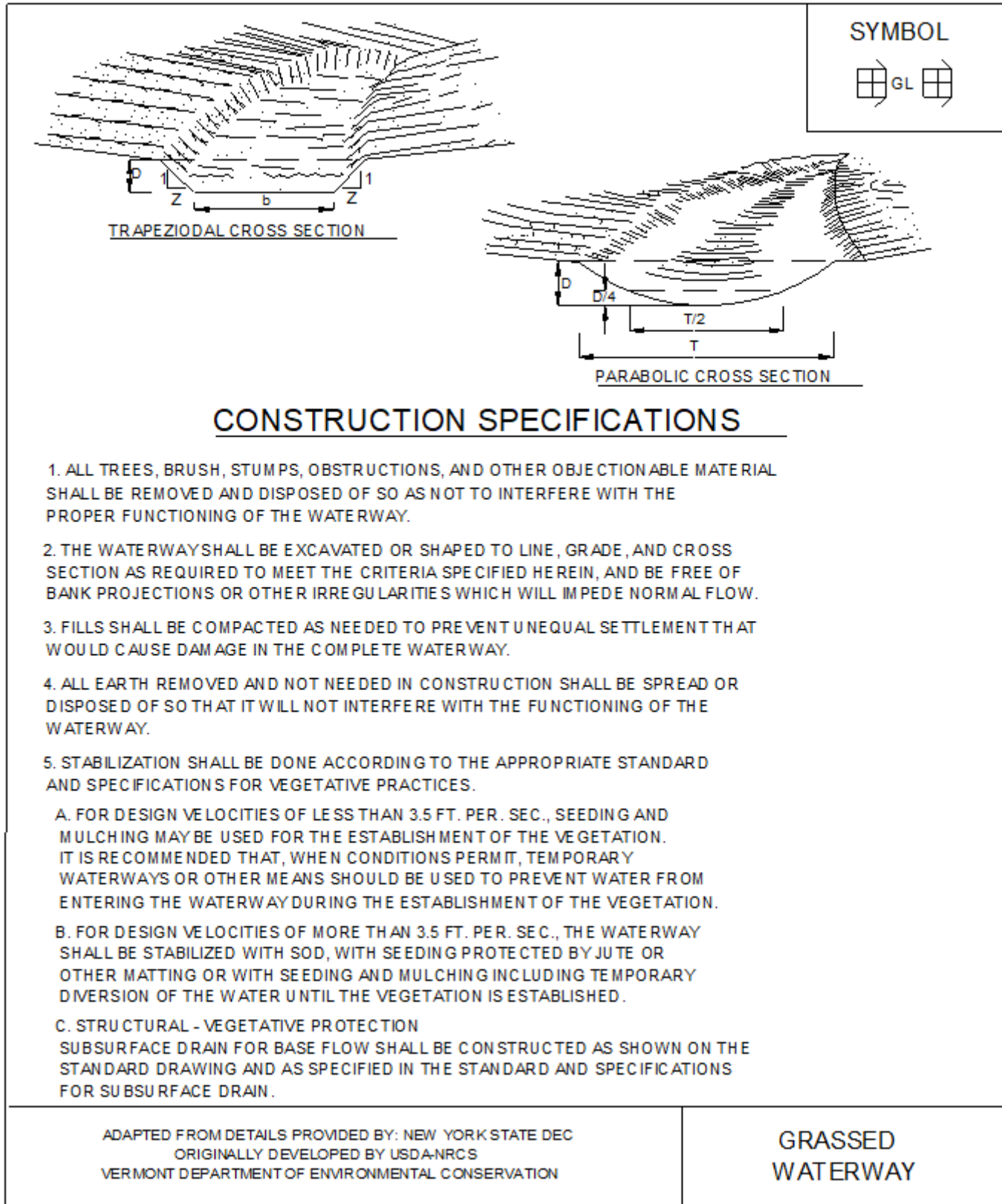
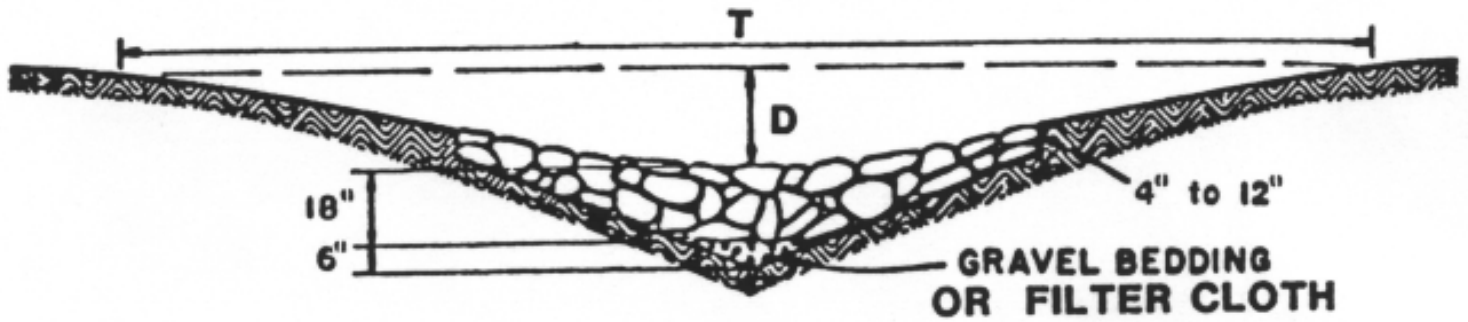


Figure 4.24 Grassed Waterways

## Part 4 - Grass Waterways



Waterway with stone center drain. "V" section shaped by motor grader.

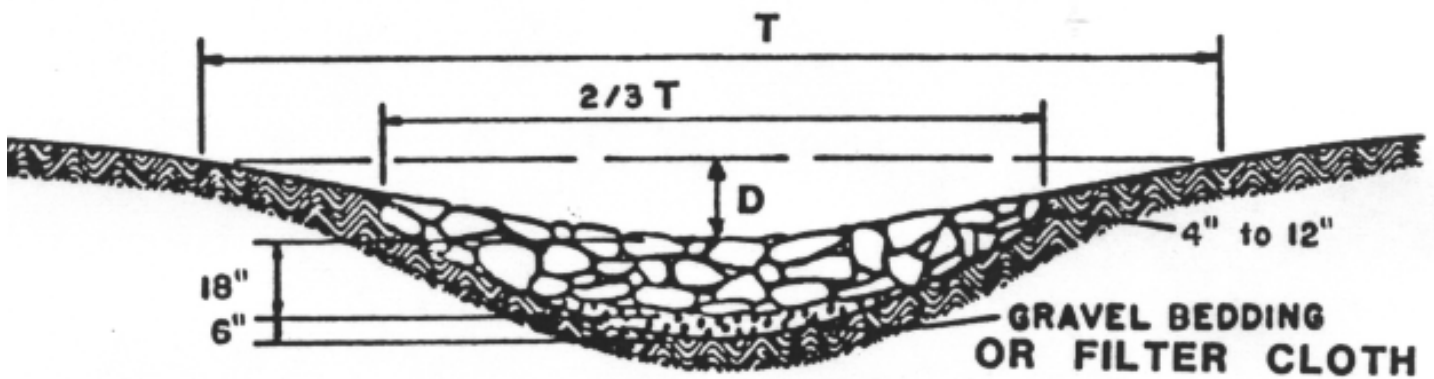


Figure 4.25 Typical Waterway Cross Section

## Part 4 - Grass Waterways

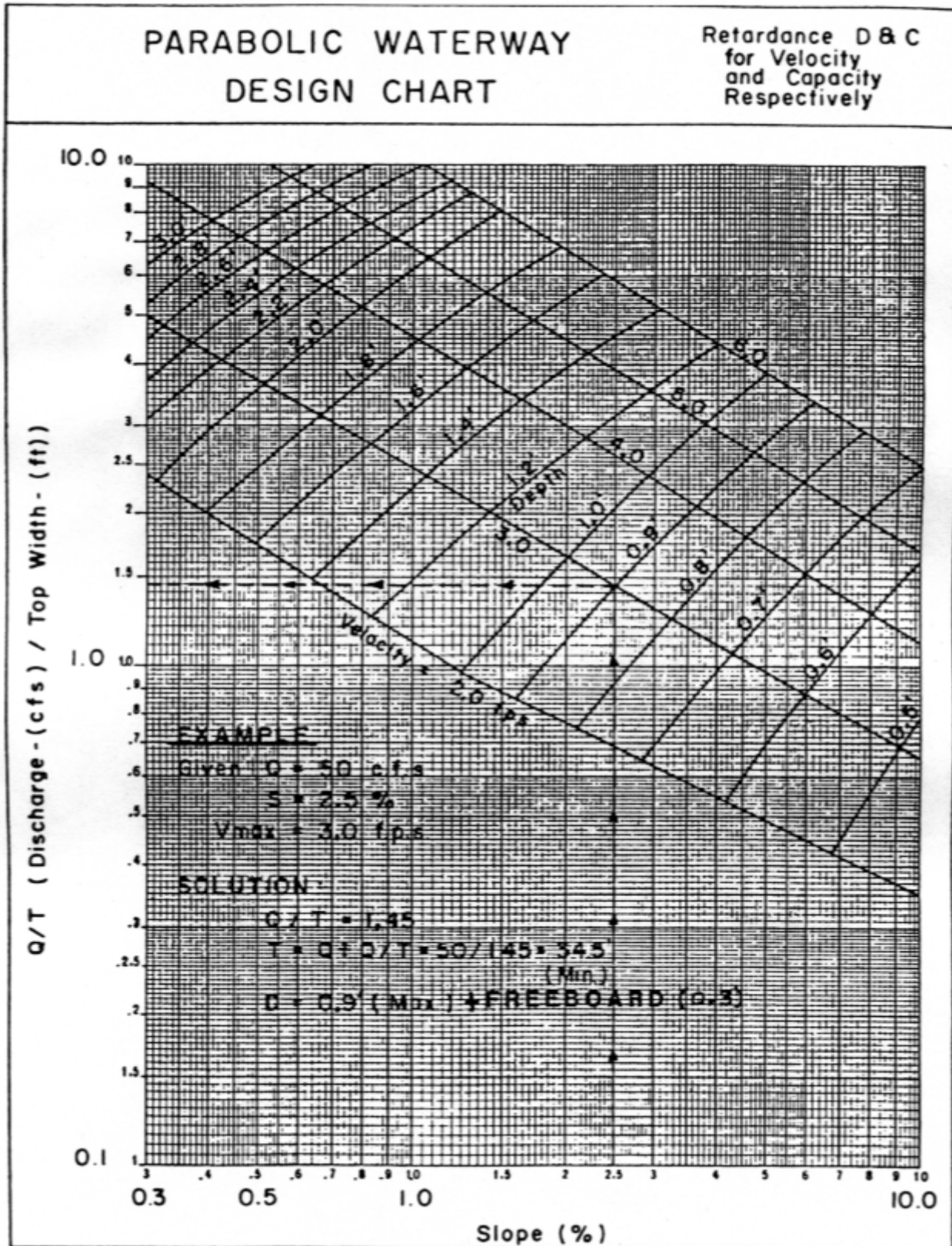


Figure 4.26 Parabolic Waterway Design Chart

# Part 4 - Lined Waterway or Outlet

## Definition

A waterway or outlet with a lining of concrete, stone, or other permanent material. The lined section extends up the side slopes to the designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

## Purpose

To provide for the disposal of concentrated runoff without damage from erosion or flooding, where grassed waterways would be inadequate due to high velocities.

## Scope

This standard applies to waterways or outlets with linings of cast-in-place concrete, flagstone mortared in place, rock riprap, gabions, or similar permanent linings. It does not apply to irrigation ditch or canal linings, grassed waterways with stone centers or small lined sections that carry prolonged low flows, or to reinforced concrete channels. The maximum capacity of the waterway flowing at design depth shall not exceed 100 cubic feet per second.

## Conditions Where Practice Applies

This practice applies where the following or similar conditions exist:

1. Concentrated runoff is such that a lining is required to control erosion.
2. Steep grades, wetness, prolonged base flow, seepage, or piping that would cause erosion.
3. The location is such that damage from use by people or animals precludes use of vegetated waterways or outlets.
4. Soils are highly erosive or other soil and climate conditions preclude using vegetation.
5. High value property or adjacent facilities warrant the extra cost to contain design runoff in a limited space.

## Design Criteria

### Capacity

1. The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year, 24-hour storm. Velocity shall be computed using Manning's equation with a coefficient of roughness "n" as follows:

<u>Lined Material</u>	<u>"n"</u>
Concrete (Type):	
Trowel Finish	0.015
Float Finish	0.019
Gunite	0.019
Flagstone	0.022
Riprap	Determine from Figure 4.27
Gabion	0.030

2. Riprap gradation and filter (bedding) are generally designed in accordance with criteria set forth in the National Cooperative Highway Research Program Report 108, available from the University Microfilm International, 300 N. Zeeb Road, Ann Arbor, Michigan 48106, Publication No. PB-00839; or the Hydraulic Engineering Circular No. 11, prepared by the U.S. Bureau of Public Roads, available from Federal Highway Administration, 400 7th Street, S.W., Washington, D.C. 20590, HNG-31, or the procedure in the USDA-NRCS's Engineering Field Manual, Chapter 16.

### Velocity

1. Maximum design velocity shall be as shown below. Except for short transition sections, flow with a channel gradient within the range of 0.7 to 1.3 of this flow's critical slope must be avoided unless the channel is straight. Velocities exceeding critical will be restricted to straight reaches.

## Part 4 - Lined Waterway or Outlet

Design Flow Depth (ft.)	Maximum Velocity (ft./sec.)
0.0 – 0.5	25
0.5 – 1.0	15
Greater than 1.0	10

2. Waterways or outlets with velocities exceeding critical shall discharge into an energy dissipater to reduce velocity to less than critical, or to a velocity the downstream soil and vegetative conditions will allow.

### Cross Section

The cross section shall be triangular, parabolic, or trapezoidal. Monolithic concrete or gabions may be rectangular.

### Freeboard

The minimum freeboard for lined waterways or outlets shall be 0.25 feet above design high water in areas where erosion resistant vegetation cannot be grown adjacent to the paved side slopes. No freeboard is required where good vegetation can be grown and is maintained.

### Side Slope

Steepest permissible side slopes, horizontal to vertical will be as follows:

1. Non-Reinforced Concrete
  - a. Hand-placed, formed concrete:
 

Height of lining, 18 inches or less.... Vertical
  - b. Hand placed screened concrete or mortared in-place flagstone:
 

Height of lining, less than 2 ft..... 1:1

Height of lining, more than 2 ft.....2:1

2. Slip form concrete:
 

Height of lining, less than 3 ft.....1:1
3. Rock Riprap..... 2:1
4. Gabions..... Vertical
5. Pre-cast Concrete Sections..... Vertical

### Lining Thickness

Minimum lining thickness shall be as follows:

1. Concrete.....4 in.
 

(In most problem areas, shall be 5 in. with welded wire fabric reinforcing.)
2. Rock Riprap.....1.5 x maximum stone size plus thickness of filter or bedding.
3. Flagstone.....4 in. including mortar bed.

### Related Structures

Side inlets, drop structures, and energy dissipaters shall meet the hydraulic and structural requirements of the site.

### Filters or Bedding

Filters or bedding to prevent piping, reduce uplift pressure, and collect water will be used as required and will be designed in accordance with sound engineering principles. Weep holes and drains should be provided as needed.

### Concrete

Concrete used for lining shall be so proportioned that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense product will be required. A mix that can be certified as suitable to produce a minimum strength of at least 3,000 pounds per square inch will be required. Cement used shall be Portland Cement, Type I, II, IV, or V. Aggregate used shall have a maximum diameter

## Part 4 - Lined Waterway or Outlet

of 1 ½ inches.

Weep holes should be provided in concrete footings and retaining walls to allow free drainage of water. Pipe used for weep holes shall be non-corrosive.

### Mortar

Mortar used for mortared in-place flagstone shall consist of a mix of cement, sand, and water. Follow directions on the bag of mortar for proper mixing of mortar and water.

### Contraction Joints

Contraction joints in concrete linings, where required, shall be formed transversely to a depth of about one third the thickness of the lining at a uniform spacing in the range of 10 to 15 feet.

### Rock Riprap or Flagstone

Stone used for riprap or gabions shall be dense and hard enough to withstand exposure to air, water, freezing, and thawing. Flagstone shall be flat for ease of placement and have the strength to resist exposure and breaking. Rock riprap maximum size shall be as follows:

Velocity, f.p.s.	dmax, inches
5.0	6
8.5	12
10	18
12	24
15	36

### Cutoff Walls

Cutoff walls shall be used at the beginning and ending of concrete lining. For rock riprap lining, cutoff walls shall be keyed into the channel bottom and at both ends of the lining.

### Construction Specifications

1. The foundation area shall be cleared of trees, stumps, roots, sod, loose rock, or other objectionable material.
2. The cross-section shall be excavated to the neat lines and grades as shown on the plans. Over-excavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.
3. No abrupt deviations from design grade or horizontal alignment shall be permitted.
4. Concrete linings shall be placed to the thickness shown on the plans and finished in a workmanlike manner. Adequate precautions shall be taken to protect freshly placed concrete from extreme (hot or cold) temperatures, to ensure proper curing.
5. Filter bedding and rock riprap shall be placed to line and grade in the manner specified.
6. Construction operation shall be done in such a manner that erosion, air pollution, and water pollution will be minimized and held within legal limits. The completed job shall present a workmanlike appearance. All disturbed areas shall be vegetated or otherwise protected against soil erosion.

### Maintenance

Pavement or lining should be maintained as built to prevent undermining and deterioration. Existing trees next to pavements should be removed, as roots can cause uplift damage.

Vegetation next to pavement should be maintained in good condition to prevent scouring if the pavement is overtopped. See Standard and Specifications for Permanent Critical Area Seeding.

## Part 4 - Lined Waterway or Outlet

### Considerations

The outlets of channels, conduits and other structures are points of high erosion potential, because they frequently carry flows at velocities that exceed the allowable limit for the area downstream. To prevent scour and undermining, an outlet stabilization structure is needed to absorb the impact of the flow and reduce the velocity to non-erosive levels. A riprap-lined apron is the most commonly used practice for this purpose because of its relatively low cost and ease of installation. The riprap apron should be extended downstream until stable conditions are reached even though this may exceed the length calculated for design velocity control.

Riprap-stilling basins or plunge pools reduce flow velocity rapidly. They should be considered in lieu of aprons where overfalls exit at the ends of pipes or where high flows would require excessive apron length. Consider other energy dissipaters such as concrete impact basins or paved outlet structures when conduits are flowing more than 10 fps.

### Plans and Specifications

Plans and specification for installing a lined waterway or outlet shall be in keeping with this standard and will describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the practice will be installed.
2. Dimensions of the practice.
3. Construction detail.
4. Design calculations.

## Part 4 - Lined Waterway or Outlet

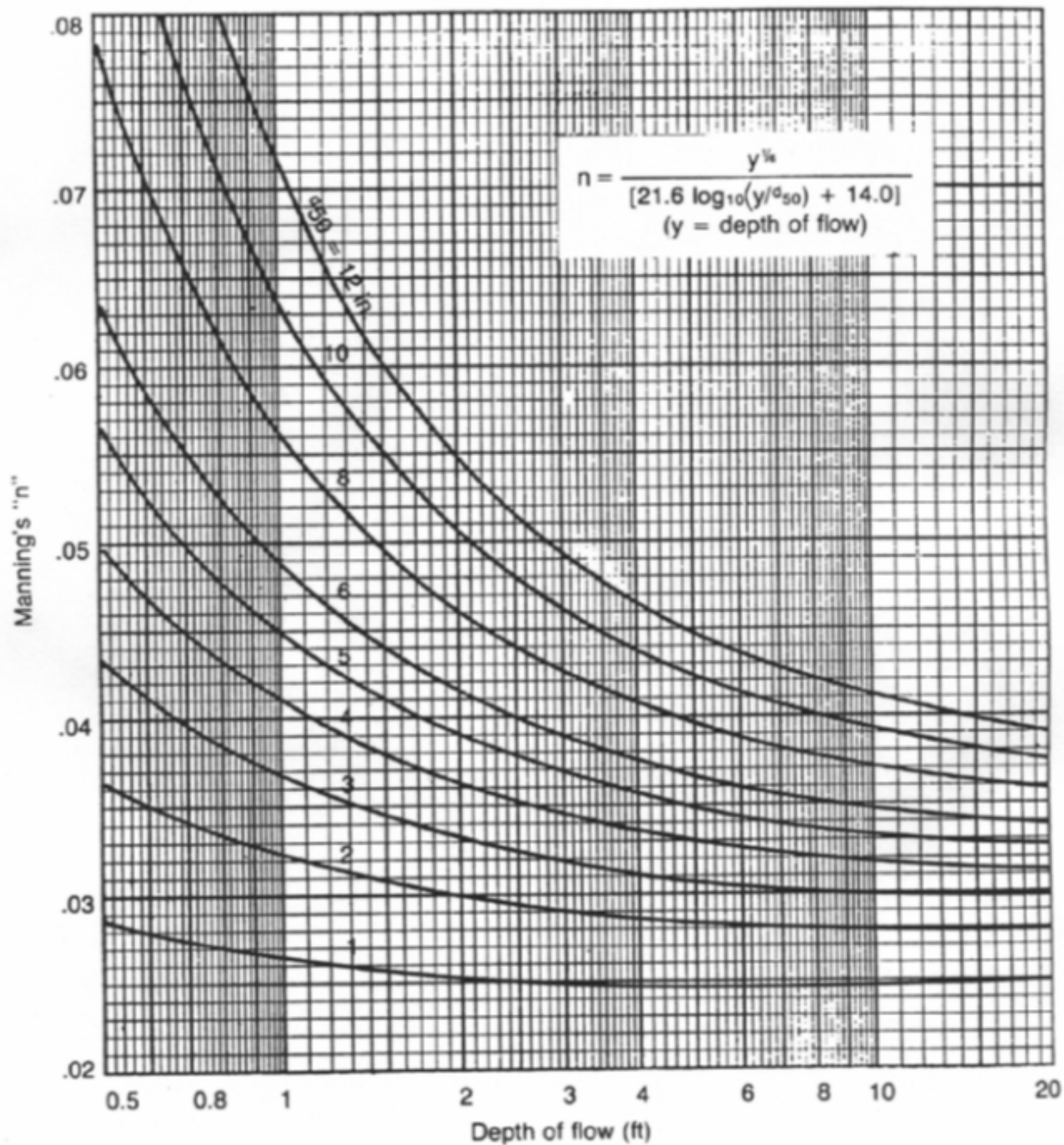


Figure 4.27 Determining "n" for Riprap Lined Channel using Depth of Flow (UDSA-NRCS)

# Part 4 - Rock Outlet Protection

## Definition

A section of rock protection placed at the outlet end of the culverts, conduits, or channels.

## Purpose

The purpose of the rock outlet protection is to reduce the depth, velocity, and energy of water, such that the flow will not erode the receiving downstream reach.

## Scope

This standard applies to the planning, design, and construction of rock riprap and gabions for protection of downstream areas. It does not apply to rock lining of channels or streams.

## Conditions Where Practice Applies

This practice applies where discharge velocities and energies at the outlets of culverts, conduits, or channels are sufficient to erode the next downstream reach. This applies to:

1. Culvert outlets of all types.
2. Pipe conduits from all sediment basins, dry storm water ponds, and permanent type ponds.
3. New channels constructed as outlets for culverts and conduits.

## Design Criteria

The design of rock outlet protection depends entirely on the location. Pipe outlet at the top of cuts or on slopes steeper than 10 percent cannot be protected by rock aprons or riprap sections due to re-concentration of flows and high velocities encountered after the flow leaves the apron.

## Tailwater Depth

The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of

the pipe. If the tailwater depth is less than half the diameter of the outlet pipe, and the receiving stream is wide enough to accept divergence of the flow, it shall be classified as a Minimum Tailwater Condition. If the tailwater depth is greater than half the pipe diameter and the receiving stream will continue to confine the flow, it shall be classified as a Maximum Tailwater Condition. Pipes which outlet onto flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition.

## Apron Size

The apron length and width shall be determined from the curves according to the tailwater conditions:

Minimum Tailwater – Use Figure 4.28

Maximum Tailwater – Use Figure 4.29

If the pipe discharges directly into a well defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank, whichever is less.

The upstream end of the apron, adjacent to the pipe, shall have a width two (2) times the diameter of the outlet pipe, or conform to pipe end section if used.

## Bottom Grade

The outlet protection apron shall be constructed with no slope along its length. There shall be no overfall at the end of the apron. The elevation of the downstream end of the apron shall be equal to the elevation of the receiving channel or adjacent ground.

## Alignment

The outlet protection apron shall be located so that there are no bends in the horizontal alignment.

## Part 4 - Rock Outlet Protection

### Materials

The outlet protection may be done using rock riprap, grouted riprap, or gabions.

Riprap shall be composed of a well-graded mixture of stone size so that 50 percent of the pieces, by weight, shall be larger than the  $d_{50}$  size determined by using the charts. A well-graded mixture, as used herein, is defined as a mixture composed primarily of larger stone sizes, but with a sufficient mixture of other sizes to fill the smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the  $d_{50}$  size.

### Thickness

The minimum thickness of the riprap layer shall be 1.5 times the maximum stone diameter for  $d_{50}$  of 15 inches or less; and 1.2 times the maximum stone size for  $d_{50}$  greater than 15 inches. The following chart lists some examples:

### Stone Quality

Stone for riprap shall consist of field stone or rough unhewn quarry stone. The stone shall be hard and angular and of a quality that will not disintegrate on exposure to water or weathering. The specific gravity of the individual stones shall be at least 2.5.

$D_{50}$ (inches)	$d_{max}$ (inches)	Minimum Blanket Thickness (inches)
4	6	9
6	9	14
9	14	20
12	18	27
15	22	32
18	27	32
21	32	38
24	36	43

Recycled concrete equivalent may be used provided it has a density of at least 150 pounds per cubic foot,

and does not have any exposed steel or reinforcing bars.

### Filter

A filter is a layer of material placed between the riprap and the underlying soil surface to prevent soil movement into and through the riprap. Riprap shall have a filter placed under it in all cases.

A filter can be of two general forms: a gravel layer or a plastic filter cloth. The plastic filter cloth can be woven or non-woven monofilament yarns, and shall meet these base requirements: thickness 20-60 mils, grab strength 90-120 lbs; and shall conform to ASTM D-1777 and ASTM D-1682.

Gravel filter blanket, when used, shall be designed by comparing particle sizes of the overlying material and the base material. Design criteria are available in Standard and Specification for Riprap Slope Protection.

### Gabions

Gabions shall be made of hexagonal triple twist mesh with heavily galvanized steel wire. The maximum linear dimension of the mesh opening shall not exceed 4 ½ inches and the area of the mesh opening shall not exceed 10 square inches.

Gabions shall be fabricated in such a manner that the sides, ends, and lid can be assembled at the construction site into a rectangular basket of the specified sizes. Gabions shall be of single unit construction and shall be installed according to manufacturers recommendations.

The area on which the gabion is to be installed shall be graded as shown on the drawings. Foundation conditions shall be the same as for placing rock riprap, and filter cloth shall be placed under all gabions. Where necessary, key, or tie, the structure into the bank to prevent undermining of the main gabion structure.

## Part 4 - Rock Outlet Protection

### Maintenance

Once a riprap outlet has been installed, the maintenance needs are very low. It should be inspected after high flows for evidence of scour beneath the riprap or for dislodged stones. Repairs should be made immediately.

### Design Procedure

1. Investigate the downstream channel to assure that nonerosive velocities can be maintained.
2. Determine the tailwater condition at the outlet to establish which curve to use.
3. Enter the appropriate chart with the design discharge to determine the riprap size and apron length required. Note that references to pipe diameters in the charts are based on full flow. For other than full pipe flow, the parameters of depth of flow and velocity must be used to adjust the design discharges.
4. Calculate apron width at the downstream end if a flare section is to be employed.

### Examples

Example 1: Pipe Flow (full) with discharge to unconfined section.

Given: A circular conduit flowing full.

$Q = 280$  cfs, diam. = 66 in., tailwater (surface) is 2 ft. above pipe invert (minimum tailwater condition).

Find: Read  $d_{50} = 1.2$  and apron length ( $L_a$ ) = 38 ft.  
Apron width = diam. +  $L_a = 5.5 + 38 = 43.5$  ft.

$$D_{\max} = 1.5(d_{50}) = 1.5 (15'') = 22.5''$$

Use:  $d_{50} = 15''$ ,  $d_{\max} = 22''$

$$\begin{aligned} D_{50} &\leq 15'', \text{ blanket thickness} = 1.5 (\text{max } d) \\ &= 1.5 (22'') \\ &= 33'' \end{aligned}$$

Use blanket thickness = 32''.

Example 2: Box Flow (partial) with high tailwater

Given: A box conduit discharging under partial flow conditions. A concrete box 5.5 ft. x 10 ft. flowing 5.0 ft. deep,

$Q = 600$  cfs and tailwater surface is 5 ft. above invert (max. tailwater condition).

Since this is not full pipe and does not directly fit the nomograph assumptions of Figure 4.24 substitute depth as the diameter, to find a discharge equal to full pipe flow for that diameter, in this case 60 inches.

$$\text{Since, } Q = AV \text{ and } A = \frac{\pi D^2}{4}$$

First, compute velocity:

$$V = (Q/A) = (600/(5) (10)) = 12 \text{ fps}$$

Then substituting:

$$Q = \frac{\pi D^2}{4} \times V = \frac{3.14 (5 \text{ ft})^2}{4} \times 12 \text{ fps} = 236 \text{ cfs}$$

At the intersection of the curve  $d = 60$  in. and  $Q = 236$  cfs, read  $d_{50} = 0.4$  ft.

Then reading the  $d = 60$  in. curve, read apron length ( $L_a$ ) = 40 ft.

$$\text{Apron width, } W = \text{conduit width} + (6.4)(L_a) = 10 + (0.4)(40) = 26 \text{ ft.}$$

## Part 4 - Rock Outlet Protection

Example 3: Open Channel Flow with Discharge to unconfined section

Given: A trapezoidal concrete channel 5 ft. wide with 2:1 side slopes is flowing 2 ft. deep,  $Q = 180$  cfs (velocity = 10 fps) and the tailwater surface downstream is 0.8 ft. (minimum tailwater condition).

Find: Using similar principles as Example 2, compute equivalent discharge for a 2 foot, using depth as a diameter, circular pipe flowing full at 10 feet per second.

Velocity:

$$Q = \frac{\pi (2\text{ft})^2}{4} \times 10 \text{ fps} = 31.4 \text{ cfs}$$

At intersection of the curve,  $d = 24$  in. and  $Q = 31.4$  cfs, read  $d_{50} = 0.6$  ft.

Then reading the  $d = 24$  in. curve, read apron length ( $L_a$ ) = 20 ft.

Apron width,  $W = \text{bottom width of channel} + L_a = 5 + 20 = 25$  ft.

Example 4: Pipe flow (partial) with discharge to a confined section

Given: A 48 in. pipe is discharging with a depth of 3 ft.  $Q = 100$  cfs, and discharge velocity of 10 fps (established from partial flow analysis) to a confined trapezoidal channel with a 2 ft. bottom, 2:1 side slopes,  $n = 0.04$ , and grade of 0.6%.

Calculation of the downstream channel (by Manning's Equation) indicates a normal depth of 3.1 ft. and normal velocity of 3.9 fps.

Since the receiving channel is confined, the maximum tailwater condition controls.

Find: discharge using previous principles:

$$Q = \frac{\pi (3\text{ft})^2}{4} \times 10 \text{ fps} = 71 \text{ cfs}$$

At the intersection of  $d = 36$  in. and  $Q = 71$  cfs, read  $d_{50} = 0.3$  ft.

Reading the  $d = 36$ " curve, read apron length ( $L_a$ ) = 30 ft.

Since the maximum flow depth in this reach is 3.1 ft., that is the minimum depth of riprap to be maintained for the entire length.

### Construction Specifications

1. The subgrade for the filter, riprap, or gabion shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density of approximately that of the surrounding undisturbed material.
2. The rock or gravel shall conform to the specified grading limits when installed respectively in the riprap or filter.
3. Filter cloth shall be protected from punching, cutting, or tearing. Any damage other than an occasional small hole shall be repaired by placing another piece of cloth over the damaged part or by completely replacing the cloth. All overlaps, whether for repairs or for joining two pieces of cloth, shall be a minimum of one foot.

Stone for the riprap or gabion outlets may be placed by equipment. Both shall each be constructed to the full course thickness in one operation and in such a manner as to avoid displacement of underlying materials. The stone for riprap or gabion outlets shall be delivered and placed in a manner that will ensure that it is reasonably homogenous with the smaller stones filling the voids between the larger stones. Riprap shall be placed in a manner to prevent damage to the filter blanket or filter cloth. Hand placement will be required to the extent necessary to prevent damage to the permanent works.

## Part 4 - Rock Outlet Protection

### Plans and Specifications

Plans and specifications for installing rock outlet protection shall be in keeping with this standard and will describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the practice will be installed.
2. Dimensions of the practice.
3. Construction detail.
4. Design calculations.

## Part 4 - Rock Outlet Protection

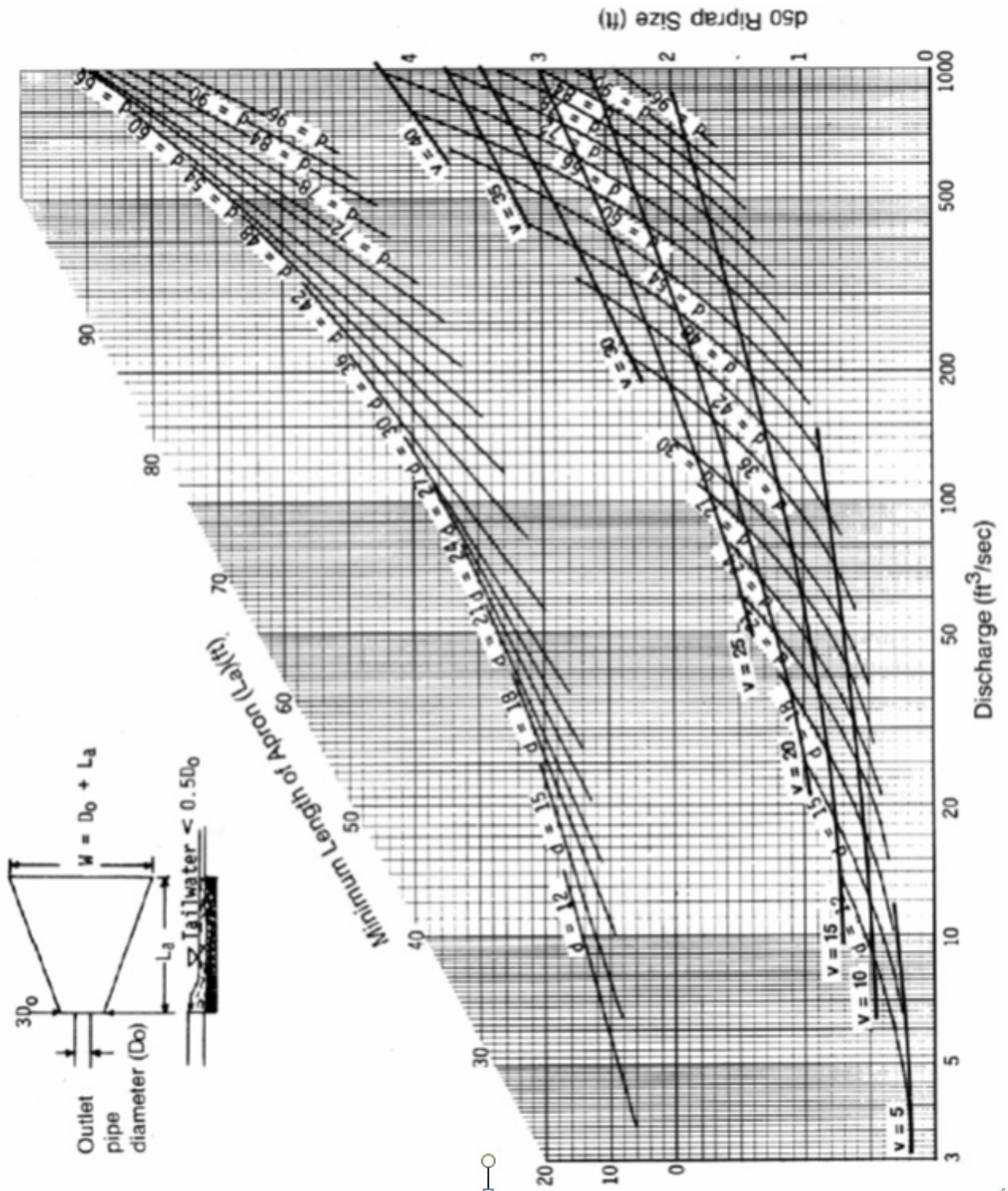


Figure 4.28 Outlet Protection Design—Minimum Tailwater Condition (Design of Outlet Protection from a Round Pipe Flowing Full, Minimum Tailwater Condition:  $T_w < 0.5 D_0$ ) (USDA-NRCS)

## Part 4 - Rock Outlet Protection

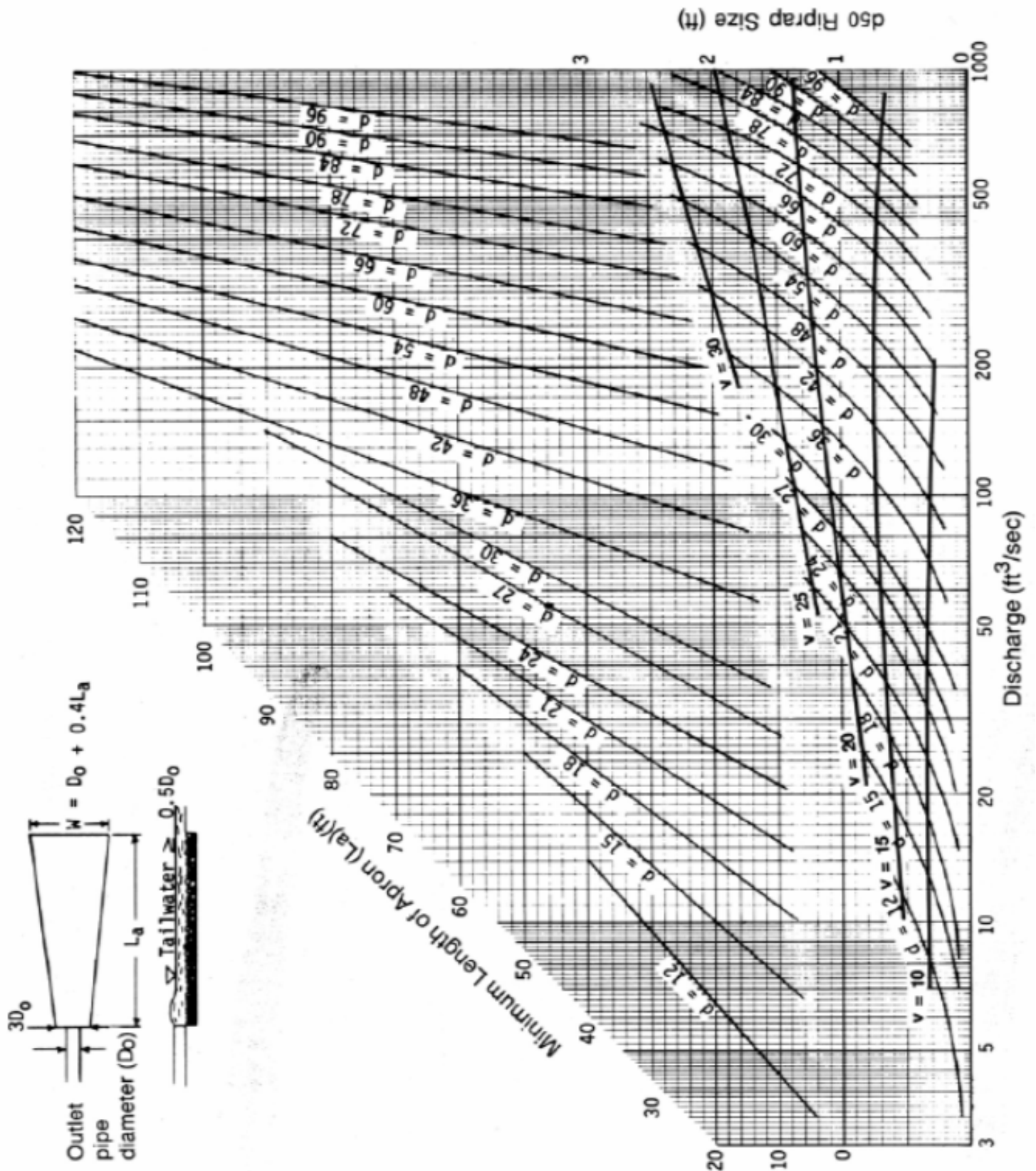


Figure 4.29 Outlet Protection Design—Maximum Tailwater Condition (Design of Outlet Protection from a Round Pipe Flowing Full, Maximum Tailwater Condition:  $T_w > 0.5 D_o$ ) (USDA-NRCS)

## Part 4 - Rock Outlet Protection

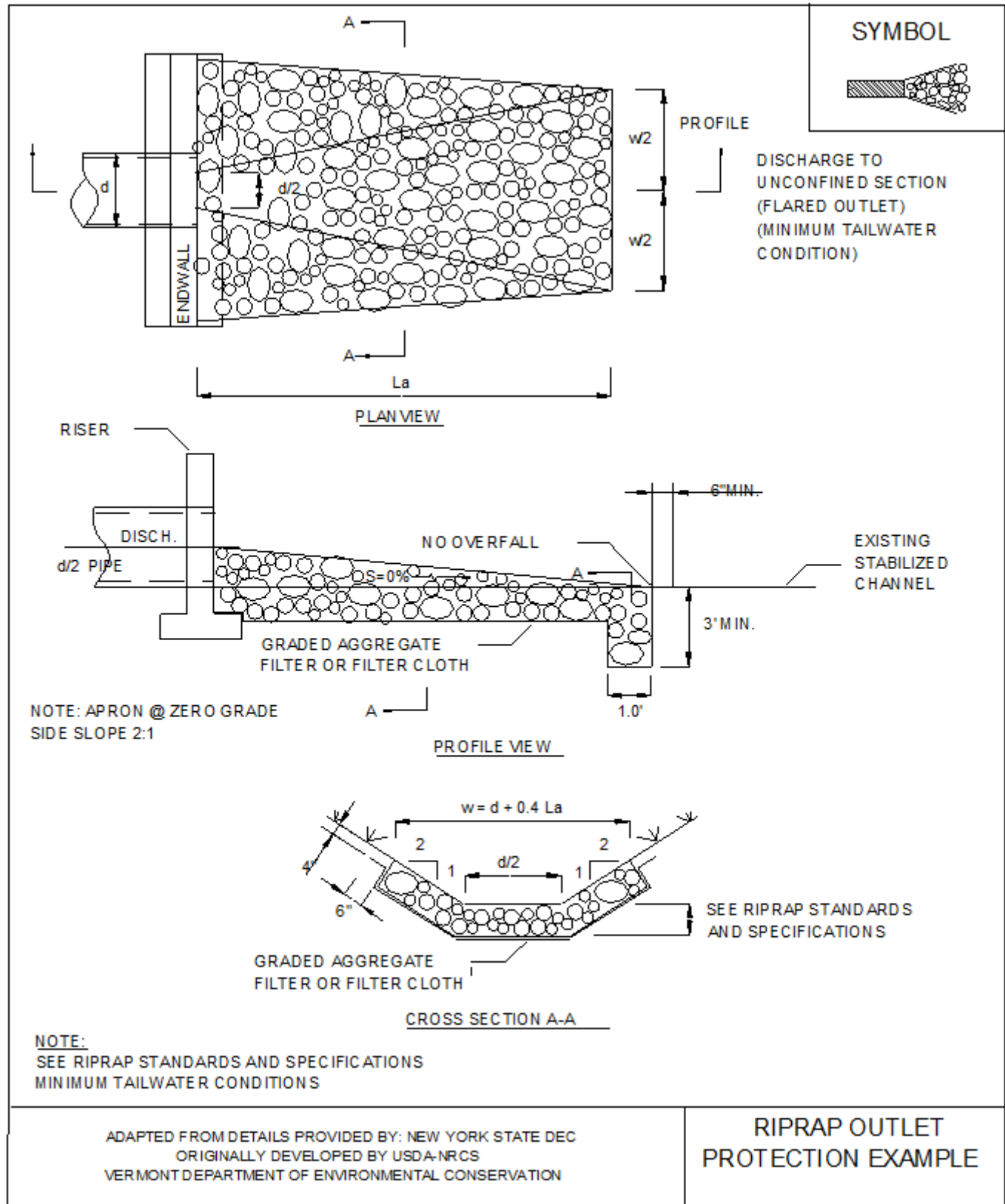


Figure 4.30 Riprap Outlet Protection Detail (1)

## Part 4 - Rock Outlet Protection

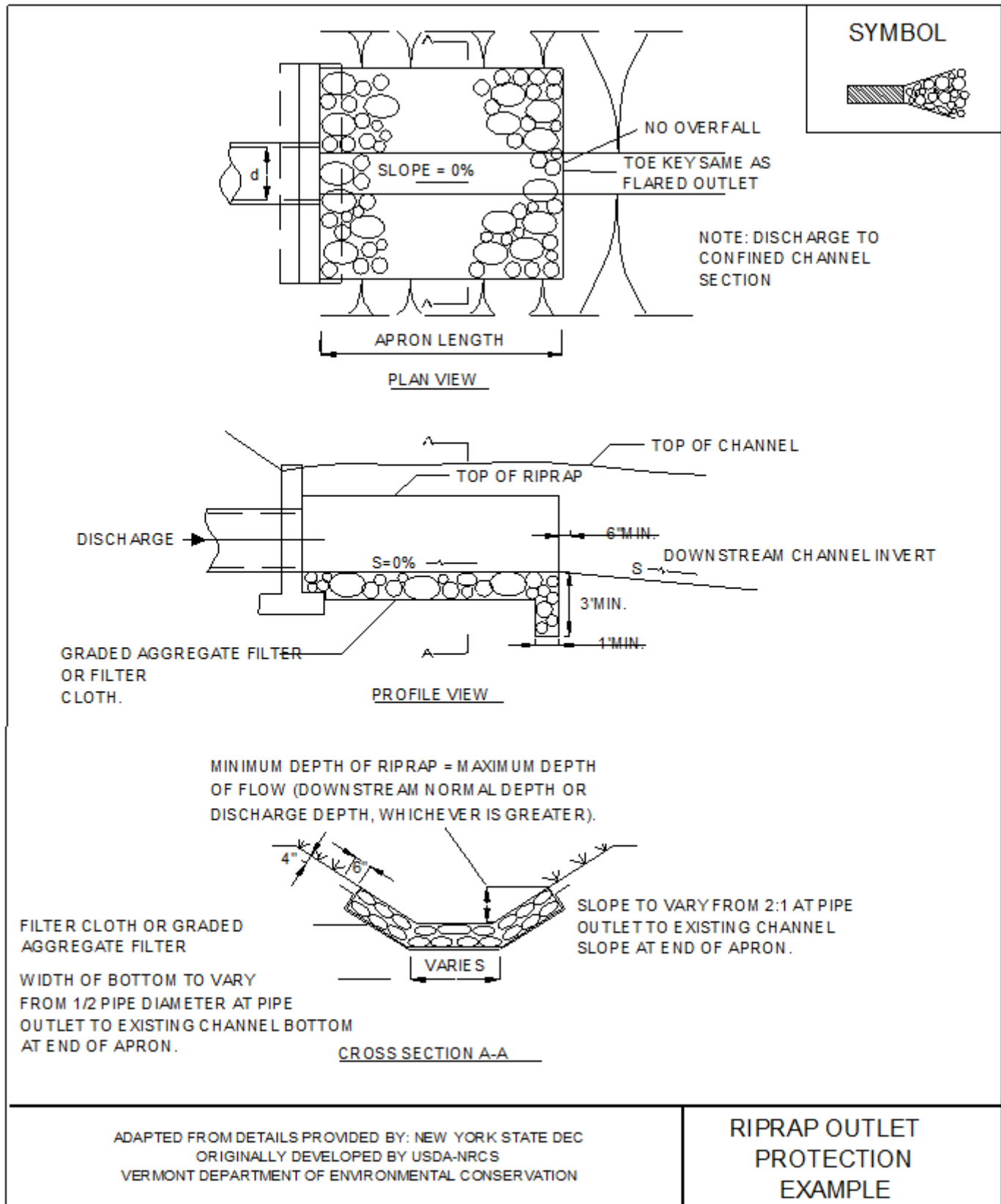


Figure 4.31 Riprap Outlet Protection

## Part 4 - Rock Outlet Protection

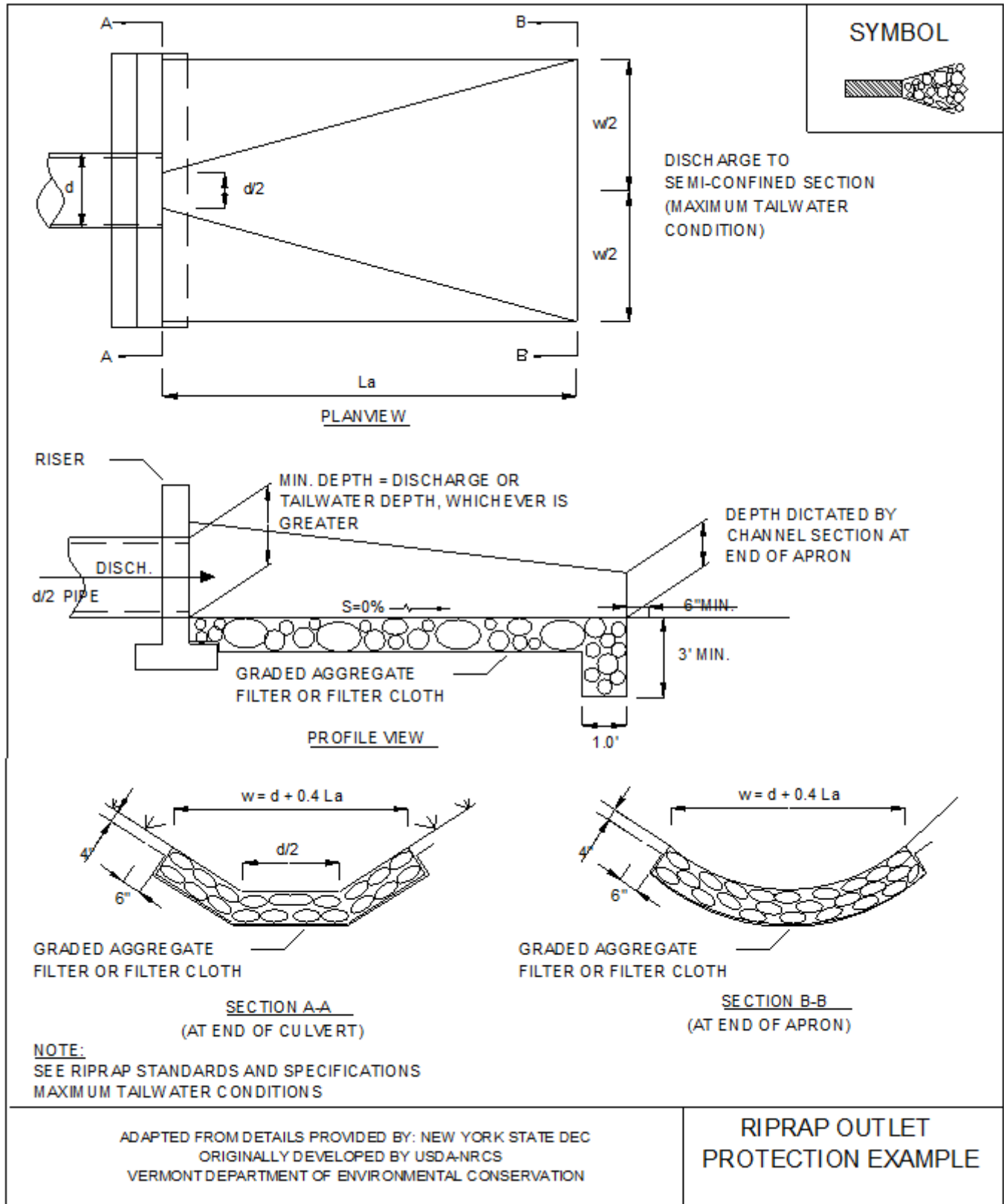


Figure 4.32a Riprap Outlet Protection

## Part 4 - Rock Outlet Protection

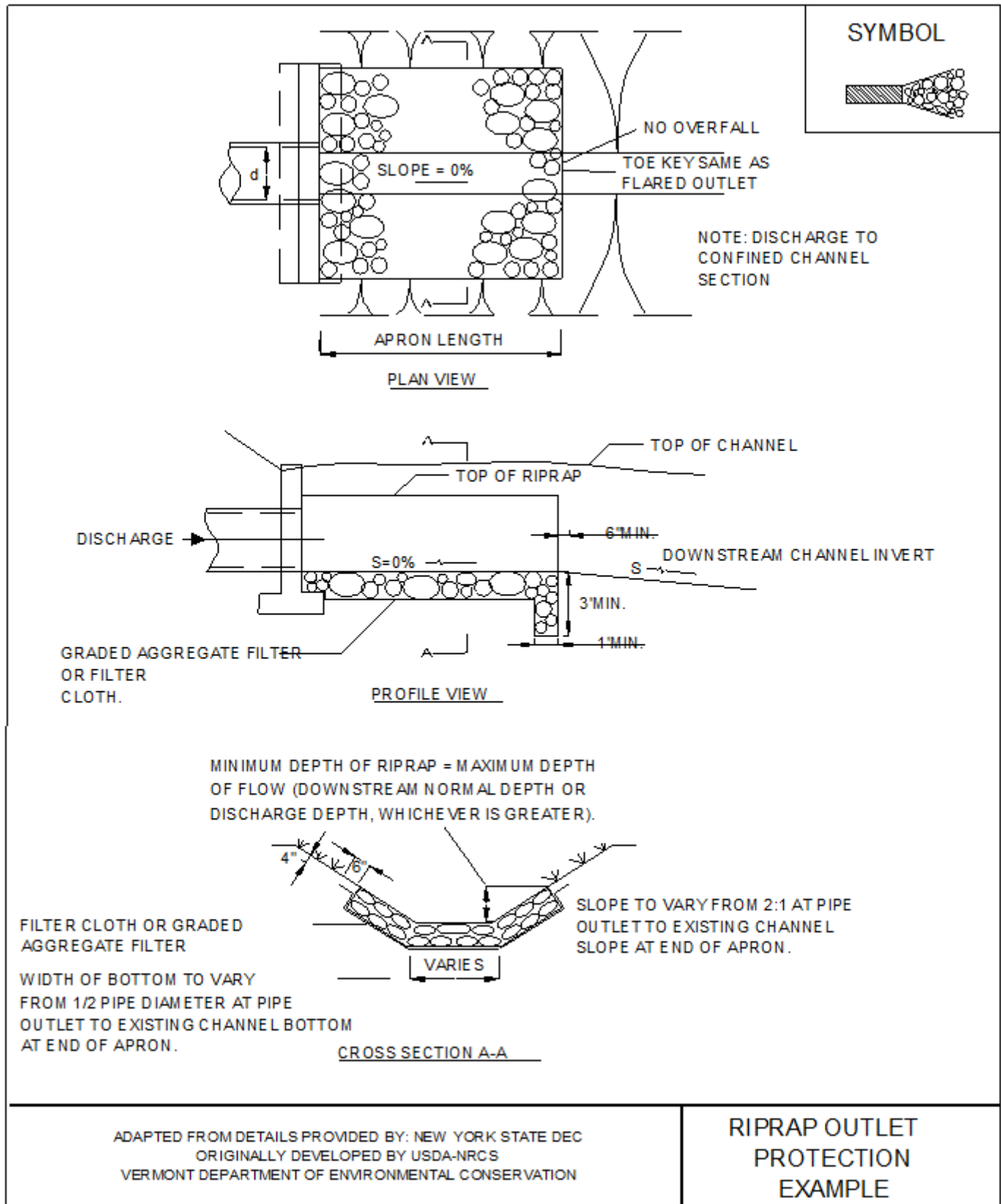


Figure 4.32b Riprap Outlet Protection

## Part 4 - Rock Outlet Protection

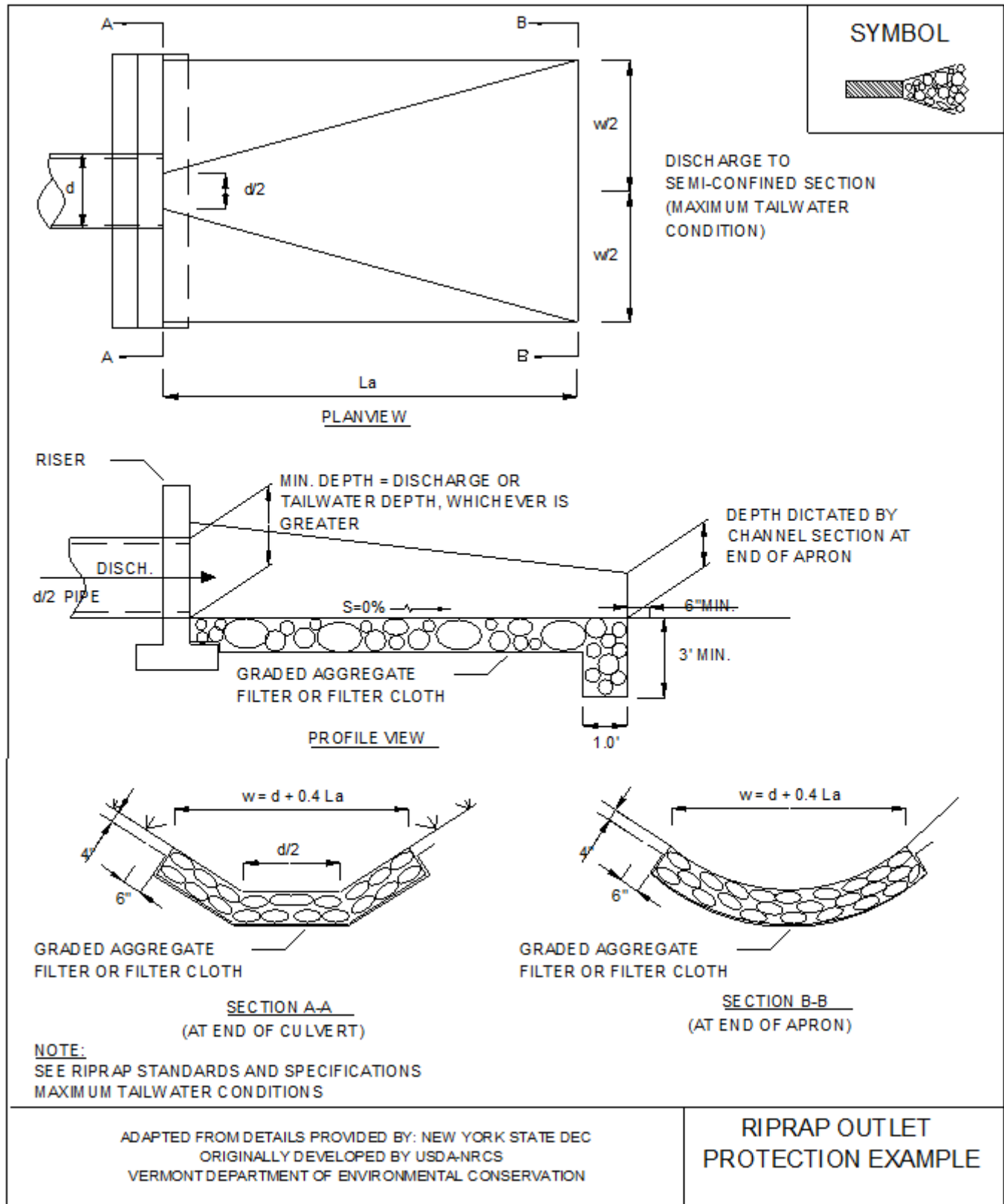


Figure 4.32c

# Part 4 - Grade Stabilization Structure

## Definition

A structure to stabilize the grade or to control head cutting in natural or artificial channels.

## Purpose

Grade stabilization structures are used to reduce or prevent excessive erosion by reduction of velocities and grade in the watercourse or by providing channel linings or structures that can withstand the higher velocities.

## Scope

This standard applies to all types of grade stabilization structures. It does not apply to storm sewers or their component parts.

## Conditions Where Practice Applies

This practice applies to sites where the capability of earth and vegetative measures is exceeded in the safe handling of water at permissible velocities, where excessive grades or overfall conditions are encountered, or where water is to be lowered structurally from one elevation to another. These structures should generally be planned and installed along with, or as a part of, other conservation practices in an overall surface water disposal system.

## Design Criteria

### General

Designs and specifications shall be prepared for each structure on an individual job basis depending on its purpose, site conditions, and the basic criteria of the conservation practice with which the structure is planned. Typical structures are as follows:

1. Channel linings of concrete, asphalt, half round metal pipe or other suitable lining materials. These linings should generally be used where channel velocities exceed safe velocities for vegetated

channels due to increased grade or a change in channel cross section or where durability of vegetative lining is adversely affected by seasonal changes. Adequate protection will be provided to prevent erosion or scour of both ends of the channel lining.

2. Overfall structures of concrete, metal, rock riprap, or other suitable material are used to lower water from one elevation to another. These structures are applicable where it is desirable to drop the watercourse elevation over a very short horizontal distance. Adequate protection will be provided to prevent erosion or scour upstream, downstream and along sides of overfall structures. Structures should be located on straight sections of channel with a minimum of 100 feet of straight channel each way.
3. Pipe drops of metal pipe with suitable inlet and outlet structures. The inlet structure may consist of a vertical section of pipe or similar material, an embankment, or a combination of both. The outlet structure will provide adequate protection against erosion or scour at the pipe outlet.

### Capacity

Structures that are designed to operate in conjunction with other erosion control practices shall have, at a minimum, a capacity equal to the bankfull capacity of the channel delivering water to the structures. The minimum design capacity for structures that are not designed to perform in conjunction with other practices shall be that required to handle the peak rate of flow from a 10-year, 24-hour frequency storm or bankfull, whichever is greater. Peak rates of runoff used in determining the capacity requirements shall be determined by TR-55, Urban Hydrology for Small Watersheds, or other appropriate method.

Set the rest of the structure at an elevation that will stabilize the grade of the upstream channel. The outlet should be set at an elevation to assure stability. Outlet velocities should be kept within the allowable

## Part 4 - Grade Stabilization Structure

limits for the receiving stream. Structural drop spillways need to include a foundation drainage system to reduce hydrostatic loads.

### Construction Specifications

Structures shall be installed according to lines and grades shown on the plan. The foundation for structures shall be cleared of all undesirable materials prior to the installation of the structure. Materials used in construction shall be in conformance with the design frequency and life expectancy of the practice.

Earth fill, when used as a part of the structure, shall be placed in 4-inch lifts and hand compacted within 2 feet of the structure.

Locate emergency bypass areas so that floods in excess of structural capacity enter the channel far enough downstream so as not to cause damage to the structure.

### Maintenance

Once properly installed, the maintenance for the grade stabilization structure should be minimal. Inspect the structure periodically and after major storm events. Check fill for piping or extreme settlement. Ensure a good vegetative cover. Check the channel for scour or debris and loss of rock from aprons. Repair or replace failing structures immediately.

### Plans and Specifications

Plans and specification for installing grade stabilization structures shall be in keeping with this standard and will describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the practice will be installed.
2. Dimensions of the practice.
3. Design calculations.

## Part 4 - Paved Flume

### Definition

A small concrete-lined channel to convey water on a relatively steep slope.

### Purpose

To convey concentrated runoff safely down the face of a cut or fill slope without causing erosion.

### Conditions Where Practice Applies

Where concentrated storm runoff must be conveyed down a cut or fill slope as part of a permanent erosion control system. Paved flumes serve as stable outlets for diversions, drainage channels, or natural drainageways, that are located above relatively steep slopes. Paved flumes should be used on slopes of 1.5:1 or flatter.

### Design Criteria

Capacity – Minimum capacity should be the 10-year frequency storm. Freeboard or enough bypass capacity should be provided to safeguard the structure from peak flows expected for the life of the structure.

Slope – The slope should not be steeper than 1.5:1 (67%).

Cutoff Walls – Install cutoff walls at the beginning and end of paved flumes. The cutoff should extend a minimum of 18 inches into the soil and across the full width of the flume and be 6 inches thick. Cutoff walls should be reinforced with #3 reinforcing bars (3/8") placed on a 6-inch grid in the center of the wall.

Anchor Lugs – Space anchor lugs a minimum of 10 feet on center for the length of the flume. They will extend the width of the flume, extend 1 foot into subsoil, be a minimum of 6 inches thick, and be reinforced with #3 reinforcing bars placed on a 6-inch grid.

Concrete – Minimum strength of design mix shall be 3000 psi. Concrete thickness shall be a minimum

of 6 inches reinforced with #3 reinforcing bars. Mix shall be dense, durable, stiff enough to stay in place on steep slopes, and sufficiently plastic for consolidation. Concrete mix should include an air-entraining admixture to resist freeze-thaw cycles.

Cross Section – Flumes shall have minimum depth of 1 foot with 1.5:1 side slopes. Bottom widths shall be based on maximum flow capacity. Chutes will be maintained in a straight alignment because of supercritical flow velocities.

Drainage filters – Use a drainage filter with all paved flumes to prevent piping and reduce uplift pressures. Size of the filter material will be dependent on the soil material the flume is located in.

Inlet Section – Design the inlet to the following minimum dimensions: side walls 2 feet high, length 6 feet, width equal to the flume channel bottom, and side slopes the same as the flume channel side slopes.

Outlet Section – Outlets must be protected from erosion. Usually an energy dissipater is used to reduce the high chute velocities to lower non-erosive velocities. Rock riprap should be placed at the end of the dissipater to spread flow evenly to the receiving channel.

Invert – Precast concrete sections may be used in lieu of cast in place concrete. The sections should be designed at the joint to be overlapped to prevent displacement between sections. Joint sealing compound should be used to prevent migration of soil through a joint. Cutoff walls and anchor lugs should be cast in the appropriate sections to accommodate the design criteria.

Small Flumes – Where the drainage area is 10 acres or less, the design dimensions for concrete flumes may be selected from those shown in the following table:

## Part 4 - Paved Flume

### Maintenance

Inspect flumes after each rainfall until all areas adjoining the flume are permanently stabilized. Repair all damage immediately. Inspect outlet and rock riprap to assure presence and stability. Any missing components should be immediately replaced.

### Plans and Specifications

Plans and specification for installing a paved flume shall be in keeping with this standard and will describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the practice will be installed.
2. Dimensions of the practice.
3. Construction detail.
4. Design calculations

	<u>5</u>	<u>10</u>
Min Bottom Width	4	8
Min Inlet Depth (ft)	2	2
Min Channel Depth (ft)	1.3	1.3
Max Channel Slope	1.5:1	1.5:1
Max Side Slope	1.5:1	1.5:1

### Construction Specifications

1. The subgrade shall be constructed to the lines and grades shown on the plans. Remove all unsuitable material and replace them if necessary with compacted stable fill materials. Shape subgrade to uniform surface. Where concrete is poured directly on subsoil, maintain it in a moist condition.
2. On fill slopes, the soil adjacent to the chute must be well compacted for a minimum of 5 feet.
3. Where drainage filters are placed under the structure, the concrete will not be poured on the filter. A plastic liner, a minimum of 4 mils thick, shall be placed to prevent contamination of filter layer.
4. Place concrete for the flume to the thickness shown on the plans and finish according to details. Protect freshly poured concrete from extreme temperatures (hot or cold) and ensure proper curing.
5. Form, reinforce, and pour together cutoff walls, anchor lugs and channel linings. Provide traverse joints to control cracking at 20-foot intervals. Joints can be formed by using a 1/8 inch thick removable template or by sawing to a minimum depth of 1 inch. Flumes longer than 50 feet shall have preformed expansion joints installed.
6. Immediately after construction, all disturbed areas shall be final graded and seeded.

## Part 4 - Paved Flume

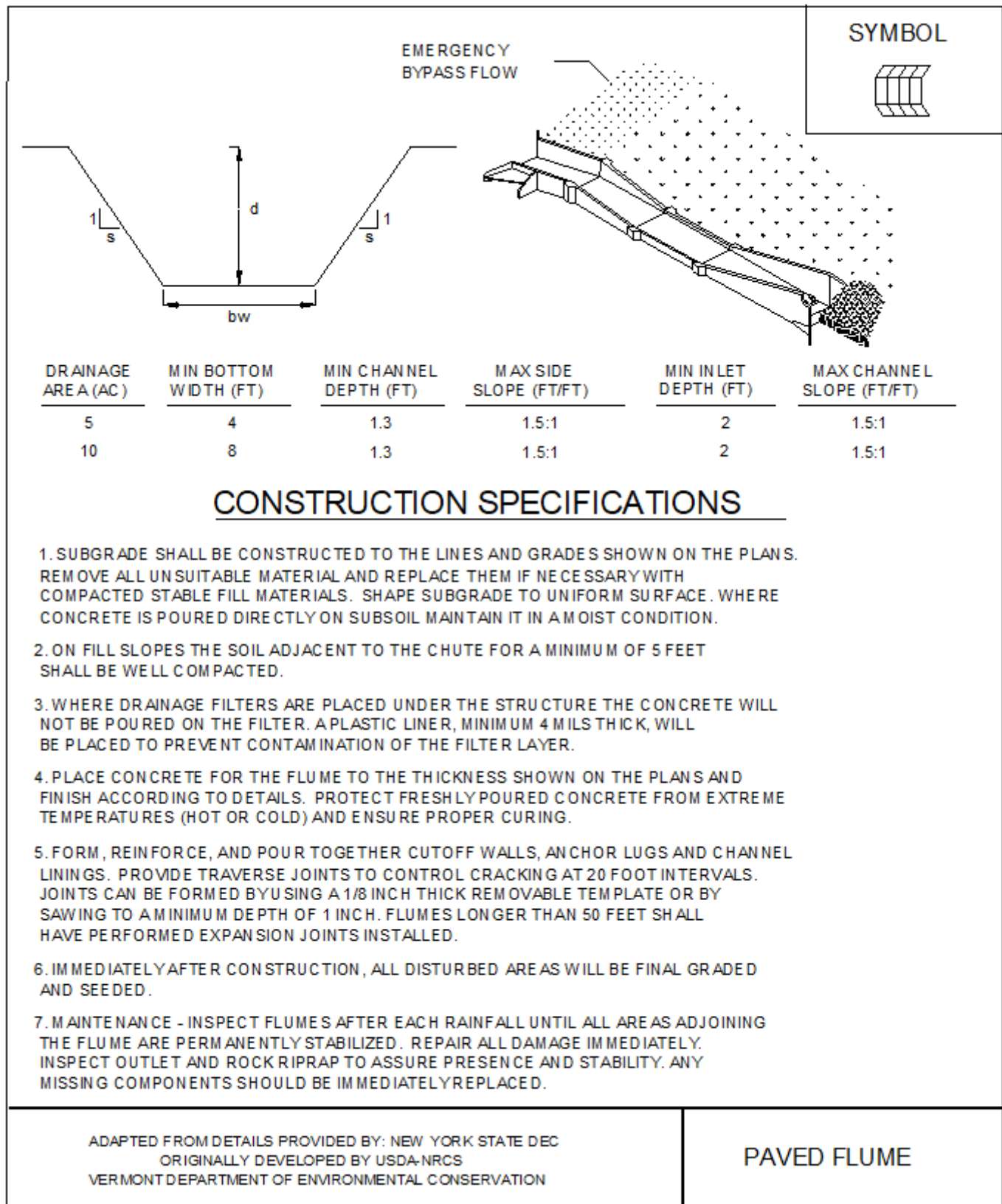


Figure 4.33 Paved Flume

## Part 4 - Paved Flume

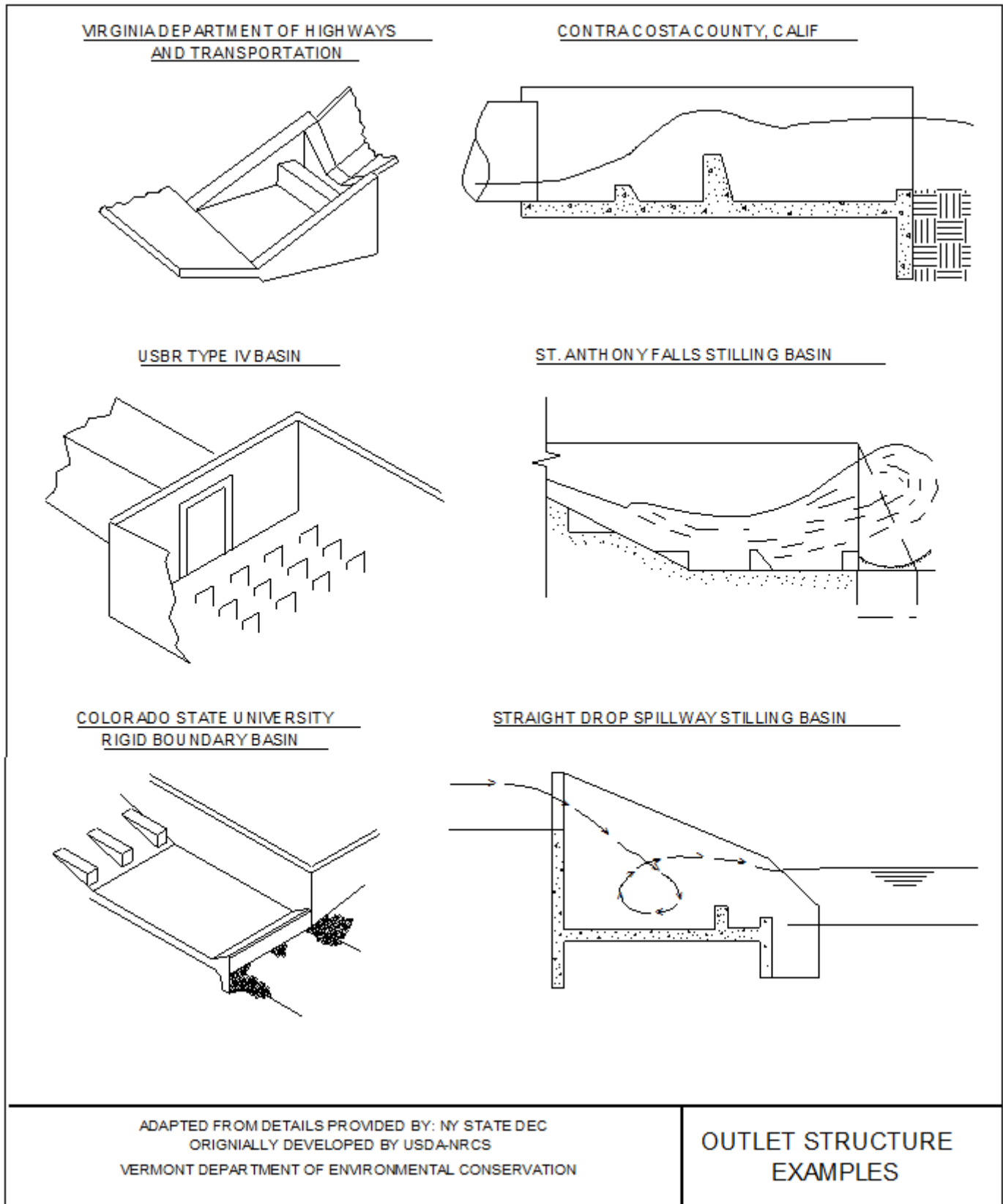


Figure 4.34 Paved Flume Outlet Structures Example

## Part 5 - Silt Fence

### Definition

A temporary barrier of geotextile fabric installed on the contours across a slope used to intercept sediment laden runoff from small drainage areas of disturbed soil and to provide perimeter control to the site.

### Purpose

The purpose of a silt fence is to reduce runoff velocity in order to promote deposition of transported sediment load. Limits imposed by ultraviolet stability of the fabric will dictate the maximum period the silt fence may be used (approximately one year).

### Conditions Where Practice Applies

Downslope of areas of earth disturbance.

A silt fence may be used subject to the following conditions:

1. Maximum allowable slope lengths contributing runoff to a silt fence placed on a slope are:

<u>Slope Steepness</u>	<u>Maximum Length (ft.)</u>
2:1	25
3:1	50
4:1	75
5:1 or flatter	100

2. Maximum drainage area for overland flow to a silt fence shall not exceed ¼ acre per 100 feet of fence, with maximum ponding depth of 1.5 feet behind the fence; and
3. Erosion would occur in the form of sheet or rill erosion; and
4. There is no concentration of water flowing to the barrier (i.e. silt fence is not to be used in areas of concentrated water flow).

### Design Criteria

All silt fence shall be placed as close to the disturbed areas as possible, but at least 10 feet from the toe of a slope to allow for maintenance and energy dissipation. The area beyond the fence must be undisturbed or stabilized. Silt fence is required to be reinforced during the winter construction period (October 15-April 15) by using heavy wire fencing for added support or pairing with an additional practice, such as filter socks. See Part 3 for EPSC Plan Requirements for Winter Construction. Where ends of filter cloth come together, they shall be overlapped, and rolled together to prevent sediment bypass. A detail of the silt fence shall be shown on the plan.

### Criteria for Silt Fence Materials

1. Silt Fence Fabric: The fabric shall meet the following specifications unless otherwise approved by the VT DEC.

<u>Fabric Properties</u>	<u>Minimum Acceptable Value</u>	<u>Test Method</u>
Grab Tensile Strength (lbs)	90	ASTM D1682
Elongation at Failure (%)	50	ASTM D1682
Mullen Burst Strength (PSI)	190	ASTM D3786
Puncture Strength (lbs)	40	ASTM D751 (modified)
Slurry Flow Rate (gal/min/sf)	0.3	
Equivalent Opening Size	40-80	US Std Sieve CW-02215
Ultraviolet Radiation Stability (%)	90	ASTM G-26

## Part 5 - Silt Fence

2. Fence Posts (for fabricated units): The length shall be a minimum of 36 inches long. Wood posts will be of sound quality hardwood with a minimum cross sectional area of 3.0 square inches. Steel posts will be standard T and U section weighing not less than 1.00 pound per linear foot.
3. Wire Fence (for fabricated units): Wire fencing shall be a minimum 14 gage with a maximum 6 in. mesh opening, or as approved.

### Considerations

Silt fences should be considered for trapping sediment where sheet and rill erosion may be expected to occur in small drainage areas. Silt fences should not be placed in areas of concentrated flows.

### Plans and Specifications

Plans and specifications for installing silt fences shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the silt fence is to be installed.
2. The type, size, and spacing of fence posts.
3. The type and size of wire or other approved support mesh backing, if used.
4. The type of filter fabric used.
5. The method of anchoring the filter fabric.
6. The method of fastening the filter fabric to the fencing support.
7. Construction detail.

## Part 5 - Silt Fence

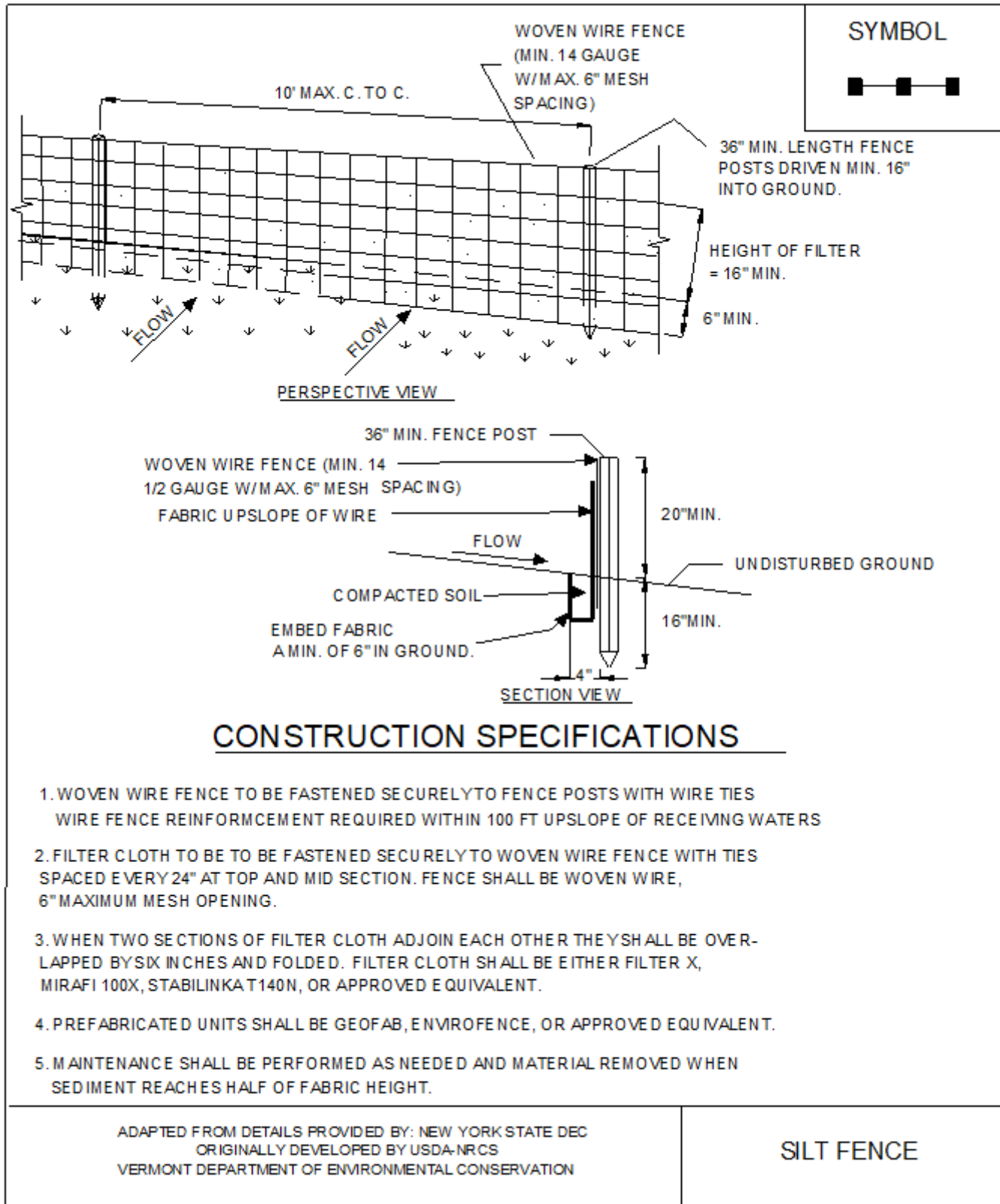


Figure 5.1 Silt Fence

# Part 5 - Erosion Control Berm

## Definition

A berm comprised of a dense, processed mixture of intertwining wood fragments and grit that form a stable, long lasting mulch used to reduce flow velocity and filter construction site runoff. Common sources include stump grindings and aged wood waste and may also contain shredded bark as part of the mix.

## Purpose

Erosion control berms are a perimeter control that act to slow and filter overland flow from construction sites before leaving the site.

## Conditions Where Practice Applies

Erosion control berms are an appropriate perimeter control on most construction sites and can be applied on ledge, frozen ground, and wooded areas where root damage is a concern. They are to be installed downslope of earth disturbance between the disturbed area and the construction site boundary.

Light vegetative clearing may be required in the area of berm placement to insure direct contact with the ground.

The maximum drainage area for overland flow to an erosion control berm shall not exceed 1/4 acre per 100' of berm,.

Maximum allowable slope lengths contributing runoff to an erosion control berm placed on a slope are:

Slope Steepness	Maximum Length (ft.)
2:1	25
3:1	50
4:1	75
5:1 or flatter	100

## Design Criteria

1. Erosion Control Berms shall be placed along the contour and constructed of stump grindings and may also contain partially aged wood material and shredded bark.
2. At a minimum the berm should be 1' tall and 2' at the base. Larger berms may be needed in steeper drainage areas with higher velocity flows.
3. Erosion control berms should be made of a mix that is 50-100% organic material, with the mineral component coming from the root ball the mineral component should not include rocks >4" or large amounts of silts and clays.
4. The mix should contain no unsuitable material including refuse, construction debris or reprocessed wood products.
5. The intertwining matrix of shredded wood and grit is essential to this practice working properly and therefore use of wood chips as the primary component will not meet the specifications and is not an acceptable primary source material.
6. Erosion control berms should not be used in areas of concentrated flows (i.e. these should only receive runoff as sheet flow).

## Considerations

This practice is best implemented on sites where clearing is required, and source material is readily available.

## Maintenance

Erosion control berms can be reshaped as needed. Sediment build-up should be removed and placed in a stable upslope location once it reaches halfway up the berm or before if needed.

## **Part 5 - Erosion Control Berm**

### Plans and Specifications

Plans and specifications for installing erosion control berms shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the erosion control berm is going to be installed.
2. Source material and approximate composition of the berm.
3. Construction detail.

## Part 5 - Erosion Control Berm

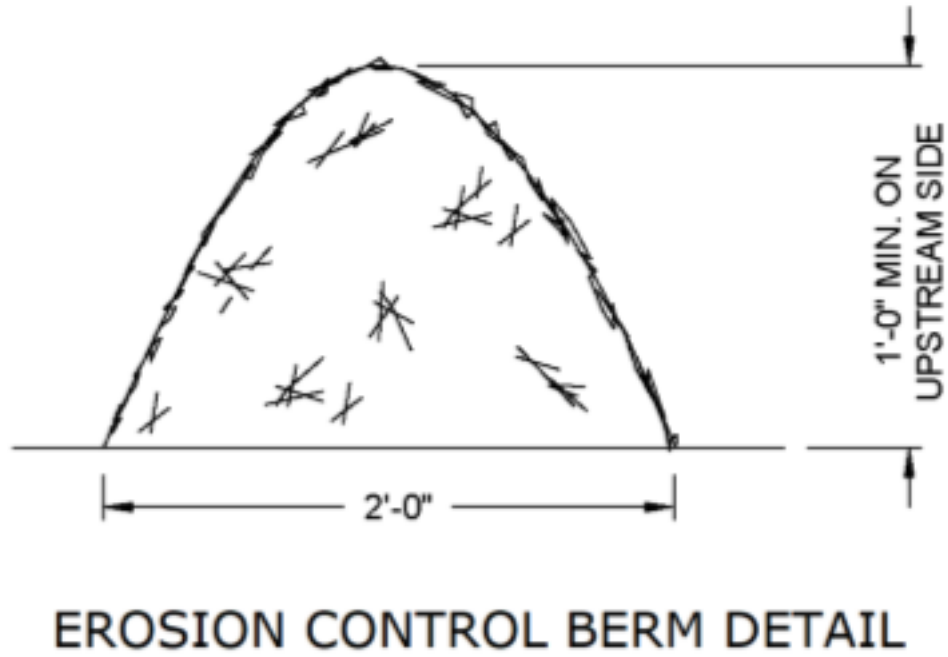


Figure 5.2 Erosion Control Berm

# Part 5 - Filter Socks

## Definition

An organic filter media encased in a mesh tube used as a temporary perimeter control that filters stormwater before discharging from the construction site.

## Purpose

Filter socks are a perimeter control that act to slow and filter overland flow from construction sites before leaving the site.

## Conditions Where Practice Applies

Filter socks are an appropriate perimeter control on most construction sites and can be applied on ledge, frozen ground, concrete, asphalt, and other impervious surfaces, as well as on pervious surfaces. They are to be installed downslope of earth disturbance between the disturbed area and the construction site boundary.

Filter sock performance is dictated by contributing slope, slope length, and filter sock diameter. Typical filter sock lifespan is one year.

## Design Criteria

1. Filter socks shall be placed on the contour, with the ends of socks turned uphill at a 45 degree angle to prevent bypass of flow.
2. Anchoring shall be in the form of driven wooden stakes spaced at 10' intervals on pervious ground applications and by sandbags or other anchors placed over the filter sock at 10' intervals on impervious ground applications, including ledge, frozen ground, asphalt, concrete, and gravel to ensure continuous contact with the ground surface.
3. No vehicle traffic shall be directed over the filter sock.
4. Maintenance shall be performed when sediment accumulation reaches half of the effective height of the filter sock and shall include removal of

accumulated sediment.

5. Removal of filter sock upon final stabilization shall include removal of the stakes and mesh and spreading of the contents of the filter sock in a stabilized location. Plastic mesh may not be left in place, even if considered to be photo- or biodegradable.

## Media Specifications

Filter media shall be composed of well-decomposed organic media that meets the conditions below:

1. pH between 6-8.
2. Particle size: 100% passing a 2 in (50mm) sieve and a maximum of 40% passing a 3/8 in (9.5mm) sieve.
3. Moisture content of less than 60%. Material shall be relatively free (<1% by dry weight) of inert or foreign man made materials.
4. Free of weeds.

## Mesh Specifications

1. Mesh opening shall not exceed 3/8"
2. Mesh shall be comprised of knitted cotton or polypropylene

## Criteria for Filter Sock Spacing

1. The maximum area contributing to filter socks shall not exceed 1/4 per 100 ft. of filter sock.
2. The maximum slope length contributing to any one filter sock is as follows:

## Part 5 - Filter Socks

Maximum slope length (in feet) above a filter sock:

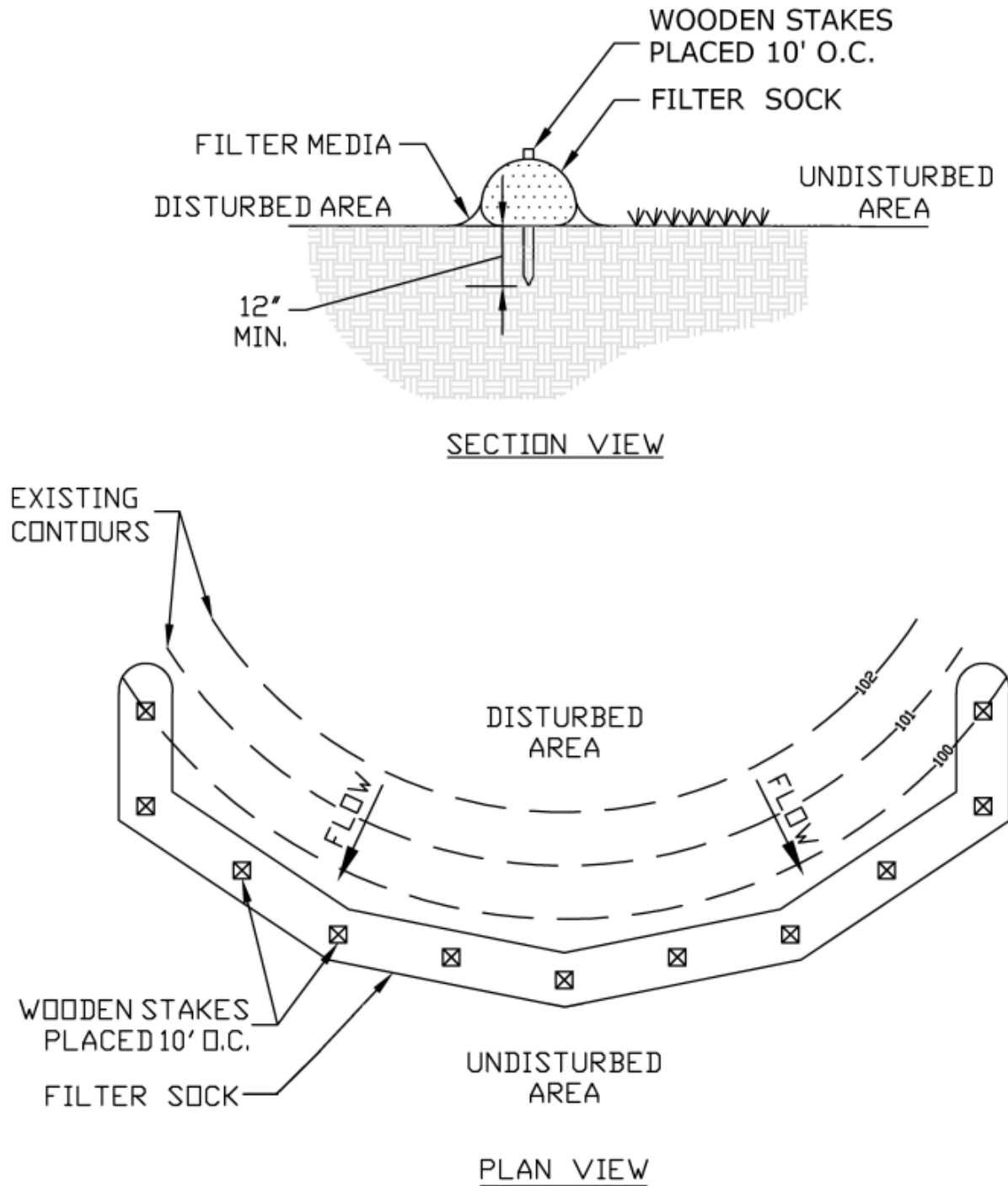
Slope (%)	Sock Diameter (in)			
	12"	18"	24"	32"
<5	225	250	275	325
5-10	125	150	200	275
10-20	65	70	130	150
20-25	50	55	100	120
25-33	40	45	60	75
>33	25	30	35	50

### Plans and Specifications

Plans and specifications for installing filter socks shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following:

1. Location where the filter sock is going to be installed.
2. Media specification.
3. Construction detail.

## Part 5 - Filter Socks



### FILTER SOCK DETAIL

Adapted from Detail  
Provided By NYS DEC

Figure 5.3 Filter Sock

## Part 5 - Stabilized Construction Access

### Definition

A stabilized pad of aggregate underlain with geotextile located at any point where traffic will be entering or leaving a construction site to or from a public right-of-way, street, alley, sidewalk, or parking area.

### Purpose

The purpose of stabilized construction access is to reduce or eliminate the tracking of sediment onto public rights-of-way or streets.

### Conditions Where Practice Applies

A stabilized construction access shall be used at all points of construction ingress and egress.

### Design Criteria

Aggregate Size: Use a matrix of 1-4 inch stone, or reclaimed or recycled concrete equivalent.

Thickness: Not less than eight (8) inches.

Width: 12-feet minimum but not less than the full width of points where ingress or egress occurs. Access shall be flared at road for vehicle turning.

Length: 40 feet minimum (or length of driveway for residential projects, if shorter).

Geotextile: To be placed over the entire area to be covered with aggregate. Piping for stormwater under construction access shall be provided as required.

### Criteria for Geotextile

The geotextile shall be woven or non-woven fabric consisting only of continuous chain polymeric filaments or yarns of polyester. The fabric shall be inert to commonly encountered chemicals, hydrocarbons, mildew, rot resistant, and conform to the fabric properties as shown:

Fabric Properties <sup>3</sup>	Light Duty <sup>1</sup> Roads	Heavy Duty <sup>2</sup> Haul Roads	Test Method
	Grade Subgrade	Rough Graded	
Grab Tensile Strength (lbs)	200	220	ASTM D1682
Elongation at Failure (%)	50	60	ASTM D1682
Mullen Brust Strength (lbs)	190	430	ASTM D3786
Puncture Strength (lbs)	40	125	ASTM D751 modified
Equivalent	40-80	40-80	US Std Sieve
Opening Size			CW-02215
Aggregate Depth	6	10	--

<sup>1</sup>Light Duty Road: Area sites that have been graded to subgrade and where most travel would be single axle vehicles and an occasional multi-axle truck. Acceptable materials are Trevira Spunbond 1115, Mirafi 100X, Typar 3401, or equivalent.

<sup>2</sup>Heavy Duty Road: Area sites with only rough grading, and where most travel would be multi-axle vehicles. Acceptable materials are Trevira Spunbond 1135, Mirafi 600X, or equivalent.

<sup>3</sup>Fabrics not meeting these specifications may be used only when design procedure and supporting documentation are supplied to determine aggregate depth and fabric strength.

### Maintenance

1. The access shall be maintained in a condition which will prevent tracking of sediment onto public rights-of-way or streets. Redress with clean stone or scarify to open voids as required to keep sediment from tracking onto street.

## Part 5 - Stabilized Construction Access

2. Where sediment has been tracked-out from the construction site onto paved roads, sidewalks, or other paved areas outside of the site, remove the deposited sediment by the end of the same day in which the track-out occurs. When necessary, wheels must be cleaned to remove sediment prior to entrance onto public rights-of-way.
3. Remove the track-out by sweeping, shoveling, or vacuuming these surfaces, or by using other similarly effective means of sediment removal.
4. Hosing or sweeping tracked-out sediment into any stormwater conveyance, storm drain inlet, or water of the State is prohibited.

applying the practice to achieve its intended purpose. At a minimum include the following items:

1. Location of stabilized construction accesses.
2. Construction detail.

### Considerations

Improperly planned and maintained construction accesses can become a continual erosion problem. The tracking of mud from active construction sites onto roads by construction vehicles can be greatly reduced, and in some cases eliminated, by the use of a stabilized construction access. These accesses provide an area where mud can be removed from construction vehicle tires before they enter a public road.

If the action of the vehicle tires traveling over the stone is not sufficient to remove the majority of the mud, then the tires must be washed before the vehicle enters a public road. When washing is required it shall be done on an area stabilized with aggregate, or using a wash rack underlain with gravel. Provisions shall be made to intercept the wash water and trap the sediment before it is carried off-site. Construction accesses should be used in conjunction with the stabilization of construction roads, and other exposed areas, to reduce the amount of mud picked up by construction vehicles and equipment.

### Plans and Specifications

Plans and specifications for installing stabilized construction accesses shall be in keeping with this standard and shall describe the requirements for

## Part 5 - Stabilized Construction Access

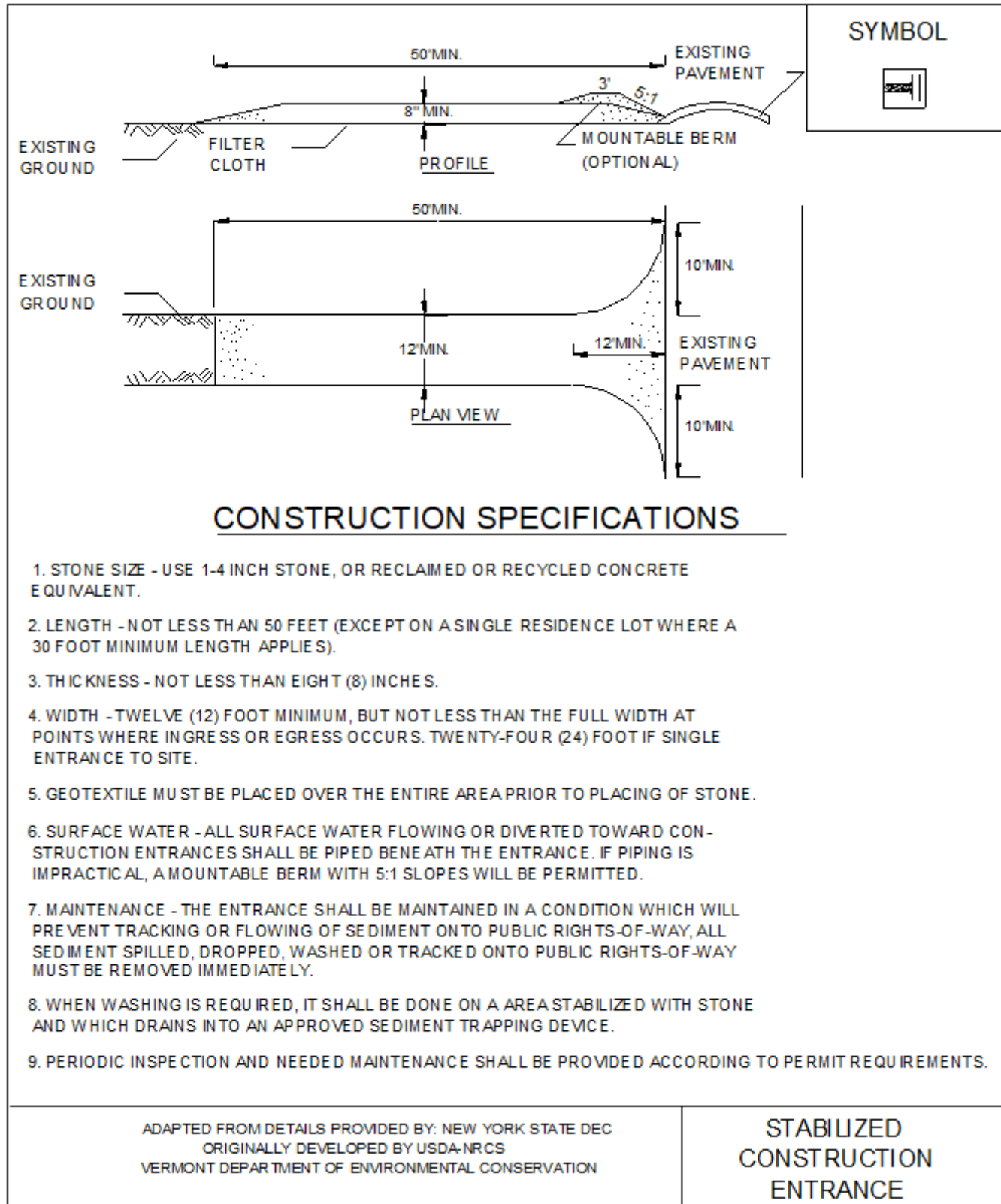


Figure 5.4 Stabilized Construction Access

# Part 5 - Storm Drain Inlet Protection

## Definition

A temporary, somewhat permeable barrier, installed around inlets in the form of a fence, berm or excavation around an opening, trapping water and thereby reducing the sediment content of stormwater by settling.

## Purpose

To prevent heavily sediment laden water from entering a storm drain system through inlets.

## Conditions Where Practice Applies

This practice shall be used where the drainage area to an inlet is disturbed, but where it is not possible to temporarily divert the storm drain outfall into a trapping device, and watertight blocking of inlets is not advisable. It is not to be used in place of sediment trapping devices. This may be used in conjunction with storm drain diversion to help prevent siltation of pipes installed with low slope angles.

## Types of Storm Drain Inlet Practices

There are five (5) specific types of storm drain inlet protection practices that vary according to their function, location, drainage area, and availability of materials:

- I. Excavated Drop Inlet Protection
- II. Fabric Drop Inlet Protection
- III. Stone & Block Drop Inlet Protection
- IV. Curb Drop Inlet Protection
- V. Proprietary Inlet Protection

## Design Criteria

**Drainage Area** – The drainage area for storm drain inlets shall not exceed one acre. The crest elevations of these practices shall provide storage and minimize bypass flow.

### Type I – Excavated Drop Inlet Protection

Limit the drainage area to the inlet device to 1 acre. Excavated side slopes shall be no steeper than 2:1. The minimum depth shall be 1 foot and the maximum depth 2 feet as measured from the crest of the inlet structure. Shape the excavated basin to fit conditions with the longest dimension oriented toward the longest inflow area to provide maximum trap efficiency. The capacity of the excavated basin should be established to contain 900 cubic feet per acre of disturbed area. Weep holes, protected by fabric and stone, should be provided for draining the temporary pool.

Inspect and clean the excavated basin after every storm. Sediment should be removed when 50 percent of the storage volume is achieved. This material should be incorporated into the site in a stabilized manner.

### Type II – Fabric Drop Inlet Protection

Limit the drainage area to 1 acre per inlet device. Land area slope immediately surrounding this device should not exceed 1 percent. The maximum height of the fabric above the inlet crest shall not exceed 1.5 feet unless reinforced.

The top of the barrier should be maintained to allow overflow to drop into the drop inlet and not bypass the inlet to unprotected lower areas. Support stakes for fabric shall be a minimum of 3 feet long, spaced a maximum 3 feet apart. They should be driven close to the inlet so any overflow drops into the inlet and not on the unprotected soil. Improved performance and sediment storage volume can be obtained by excavating the area.

Inspect the fabric barrier after each rain event and make repairs as needed. Remove sediment from the pool area as necessary with care not to undercut or damage the filter fabric. Upon stabilization of the drainage area, remove all materials and unstable sediment and dispose of properly. Bring the adjacent area of the drop inlet to grade, smooth and compact and stabilize in the appropriate manner to the site.

## Part 5 - Storm Drain Inlet Protection

### Type III – Stone and Block Drop Inlet Protection

Limit the drainage area to 1 acre at the drop inlet. The stone barrier should have a minimum height of 1 foot and a maximum height of 2 feet. Do not use mortar. The height should be limited to prevent excess ponding and bypass flow.

Recess the first course of blocks at least 2 inches below the crest opening of the storm drain for lateral support. Subsequent courses can be supported laterally if needed by placing a 2x4 inch wood stud through the block openings perpendicular to the course. The bottom row should have a few blocks oriented so flow can drain through the block to dewater the basin area.

The stone should be placed just below the top of the blocks on slopes of 2:1 or flatter. Place hardware cloth of wire mesh with ½ inch openings over all block openings to hold stone in place.

As an optional design, the concrete blocks may be omitted and the entire structure constructed of stone, ringing the outlet (“doughnut”). The stone should be kept at a 3:1 slope toward the inlet to keep it from being washed into the inlet. A level area 1-foot wide and four inches below the crest will further prevent wash. Stone on the slope toward the inlet should be at least 3 inches in size for stability and 1 inch or smaller away from the inlet to control flow rate.

The elevation of the top of the stone crest must be maintained 6 inches lower than the ground elevation down slope from the inlet to ensure that all storm flows pass over the stone into the storm drain and not past the structure. Temporary diking should be used as necessary to prevent bypass flow.

The barrier should be inspected after each rain event and repairs made where needed. Remove sediment as necessary to provide for accurate storage volume for subsequent rains. Upon stabilization of contributing drainage area, remove all materials and any unstable soil and dispose of properly.

Bring the disturbed area to proper grade, smooth, compact and stabilized in a manner appropriate to the site.

### Type IV – Curb Drop Inlet Protection

The drainage area should be limited to 1 acre at the drop inlet. The wire mesh must be of sufficient strength to support the filter fabric and stone with the water fully impounded against it. Stone is to be 2 inches in size and clean. The filter fabric must be of a type approved for this purpose with an equivalent opening size (EOS) of 40-85. The protective structure will be constructed to extend beyond the inlet 2 feet in both directions. Assure that storm flow does not bypass the inlet by installing temporary dikes (such as sand bags) directing flow into the inlet. Make sure that the overflow weir is stable. Traffic safety shall be integrated with the use of this practice. The structure should be inspected after every storm event. Any sediment should be removed and disposed of on the site. Any stone missing should be replaced. Check materials for proper anchorage and secure as necessary.

### Type V - Proprietary Inlet Protection

Proprietary storm drain inlet protection practices are acceptable for protecting inlets from sediment laden runoff when selected in consideration of the specific design and site conditions.

Proprietary inlet protection shall provide for storage and removal of sediment and shall be sized appropriately for the drainage area, while allowing stormwater to filter through. These may be used when installed and maintained in accordance with the manufacturer's specifications.

### Considerations

In developing areas, installation of streets and storm sewer networks usually occur before the construction of homes, businesses or other developments. During this and subsequent phases of construction,

## Part 5 - Storm Drain Inlet Protection

unprotected soil is susceptible to erosion. Storm sewers that are operational before their drainage areas are stabilized often carry large amounts of sediment to lakes, detention ponds, streams, or other natural or constructed drainageways. As a result, the water quality of the receiving body of water is detrimentally affected. In cases of extreme sediment loading, the storm sewer may clog completely or lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the system at the inlets.

Storm drain inlet protection consists of several types of inlet filters and traps. Each type differs in application dependant upon site conditions and type of inlet. Not all designs are appropriate in all cases. The user must carefully select a design suitable for the needs and site conditions. Field experience has shown that inlet protection that causes excessive ponding in an area of high construction activity may become so inconvenient that it is removed or bypassed, thus transmitting sediment-laden flows unchecked. In such situations, a structure with an adequate overflow mechanism must be utilized.

Stone is utilized as the chief ponding/filtering agent in many types of inlet protection. The various types of "coarse aggregates" which are shown are able to filter out sediment mainly through slowing down flows directed to the inlet by creating an increased flow path for the stormwater (through void space in the respective stone). The stone filtering medium by no means slows stormwater flow rate as does filter cloth and therefore cannot provide the same degree of filter efficiency when smaller silt and clay particles are introduced into stormwater flows. However, as mentioned earlier, excessive ponding in busy areas adjacent to stormwater inlets is in many cases unacceptable.

In most instances, inlet protection utilizing stone should not be the sole control measure. At the time that storm sewer inlet and associated appurtenances become operational, areas adjacent to the structures are most likely at final grade or will not be altered for

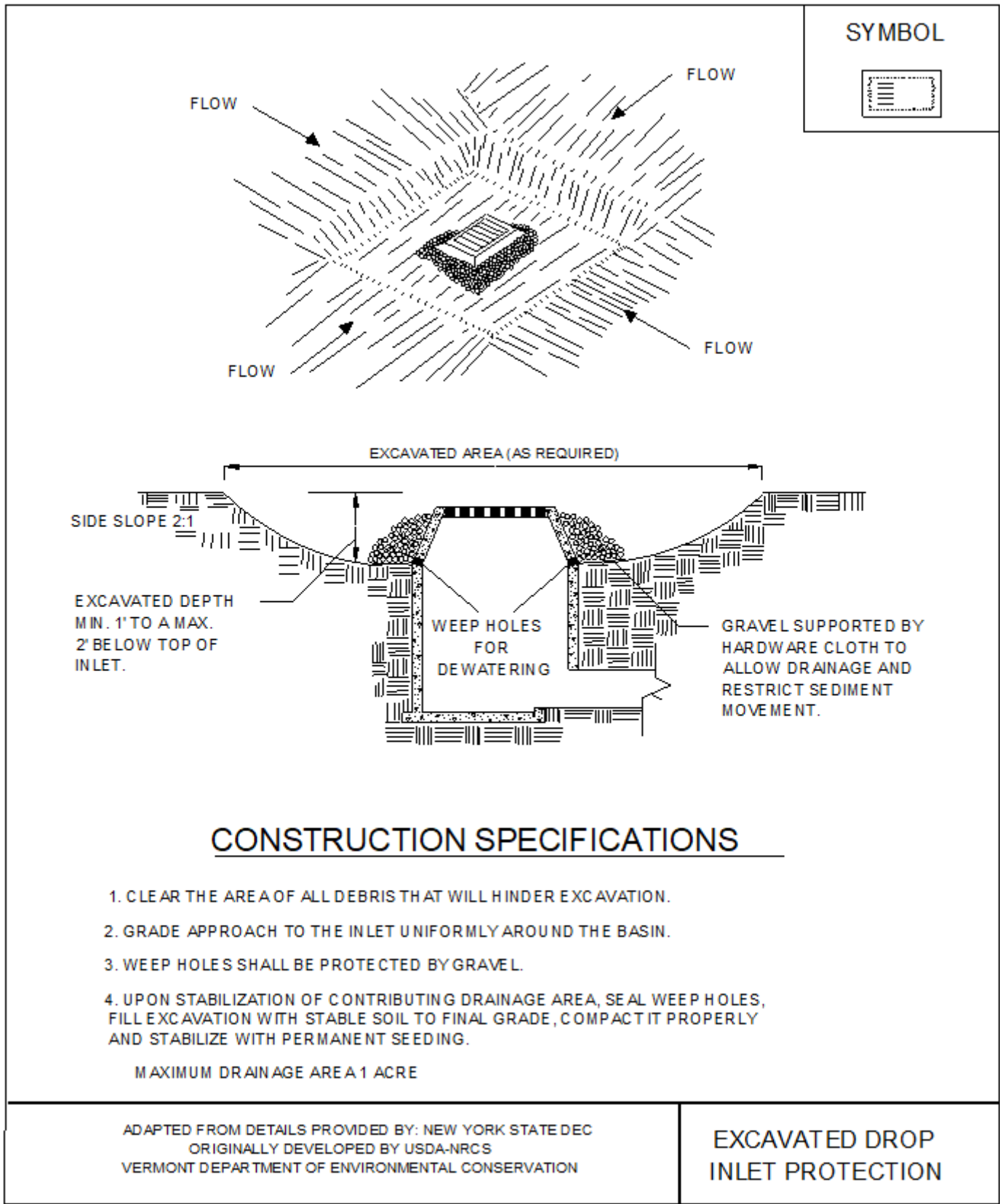
extended periods. This is the time when temporary or final stabilization should be in place and other appropriate controls should be implemented to enhance sediment-loss reductions. In addition, by varying stone sizes used in the construction of inlet protection, a greater degree of sediment removal can be obtained. As an option, filter cloth can be used with the stone in these devices to further enhance sediment removal. Notably, the potential inconvenience of excessive ponding must be examined with these choices, especially the latter. In all designs that utilize stone with a wire-mesh support as a filtering mechanism, the stone can be completely wrapped with the wire mesh to improve stability and provide easier cleaning.

### Plans and Specifications

Plans and specifications for installing storm drain inlet protection shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum include the following items:

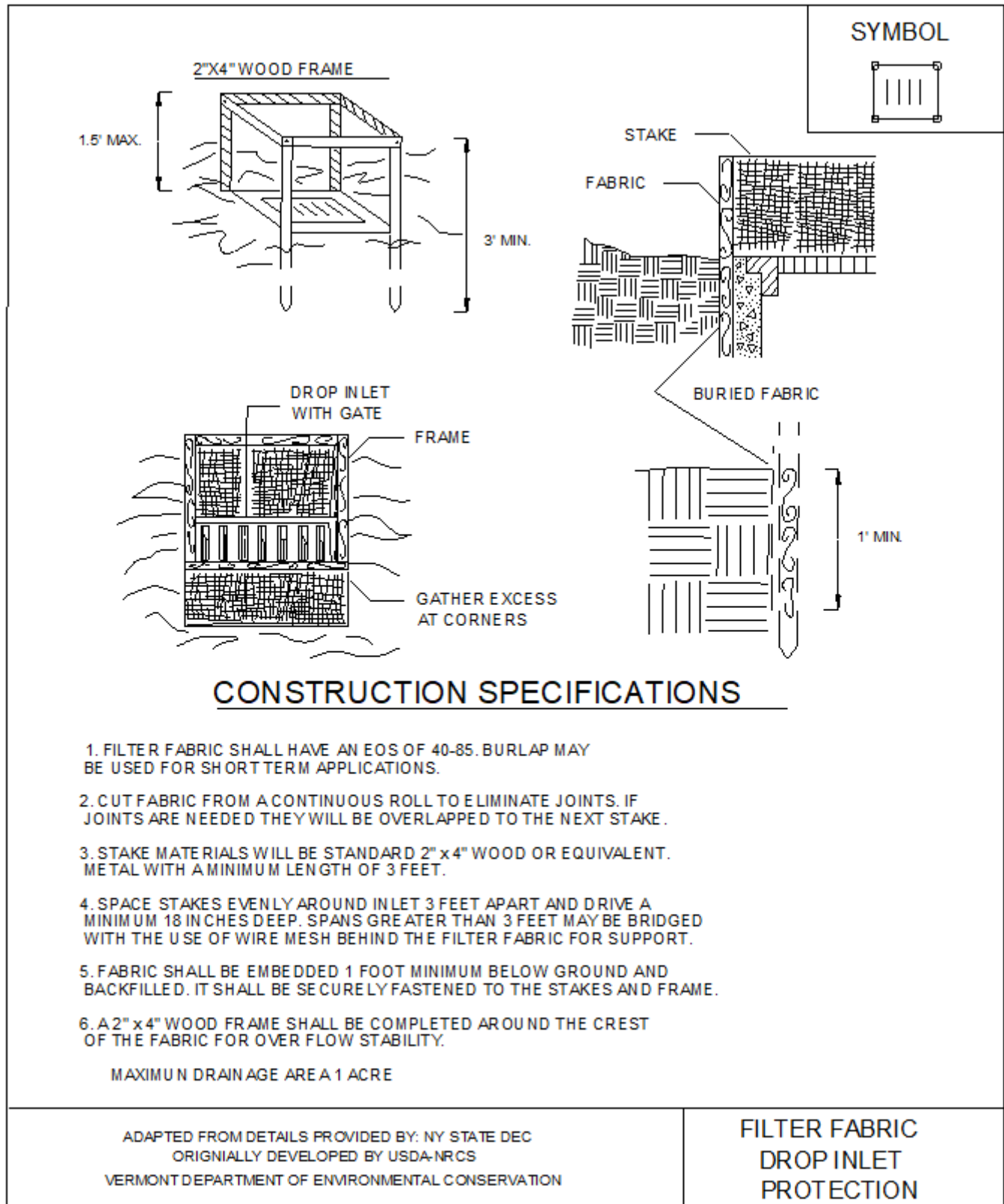
1. All locations where inlet protection is designated.
2. Type of inlet protection for each location.
3. Construction detail for each type of inlet protection designated.

## Part 5 - Storm Drain Inlet Protection



**Figure 5.5a Storm Drain Inlet Protection: Excavated**

## Part 5 - Storm Drain Inlet Protection



**Figure 5.5b Storm Drain Inlet Protection: Filter Fabric**

## Part 5 - Storm Drain Inlet Protection

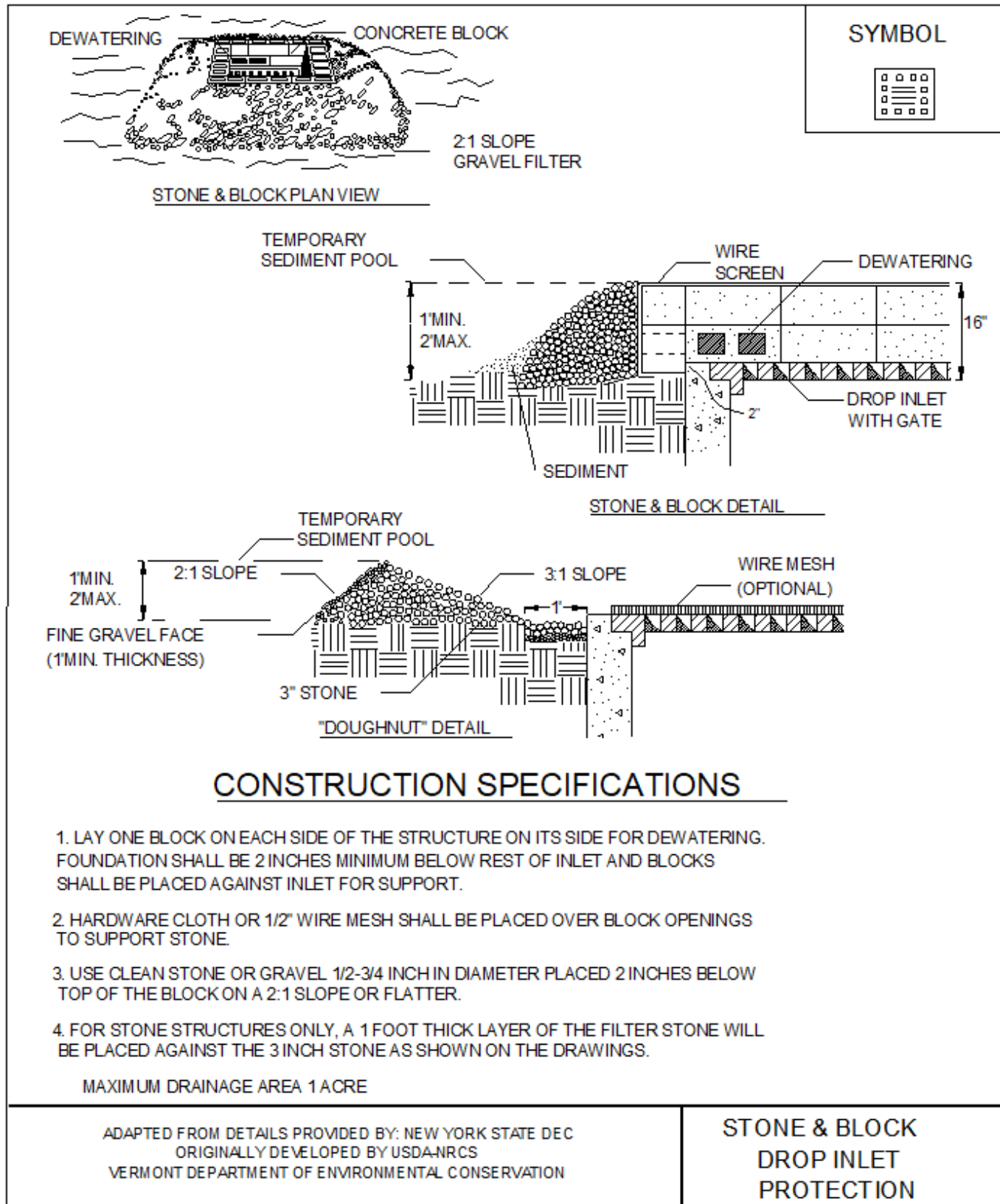


Figure 5.5c Storm Drain Inlet Protection: Stone & Block

## Part 5 - Storm Drain Inlet Protection

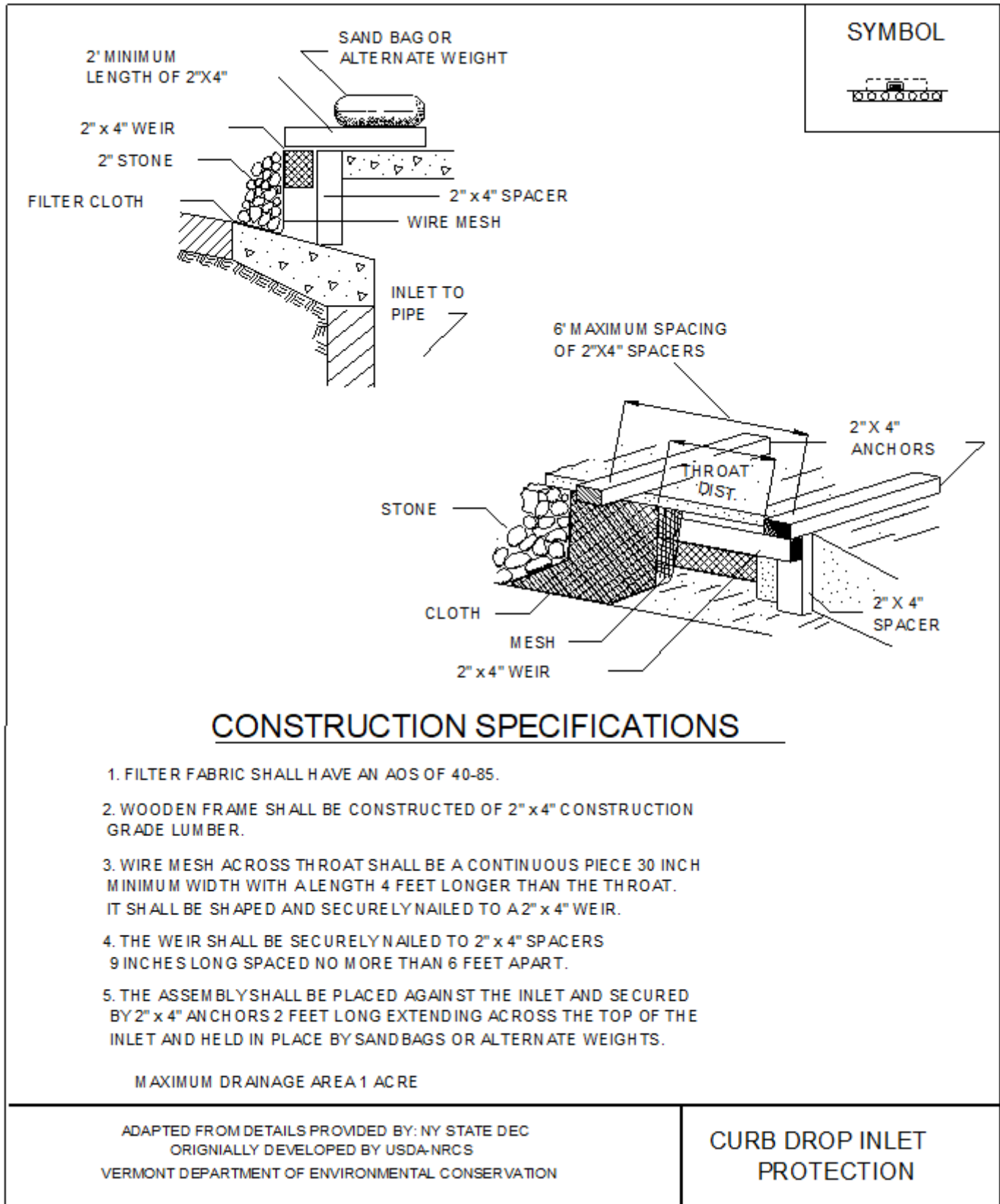


Figure 5.5d Storm Drain Inlet Protection: Curb Drop Inlet

# Part 5 - Sediment Trap

## Definition

A temporary sediment control device formed by excavation and/or embankment to intercept sediment laden runoff and retain the sediment.

## Purpose

The purpose of the structure is to intercept sediment-laden runoff and trap the sediment in order to protect drainage ways, properties, and rights-of-way below the sediment trap from sedimentation.

## Conditions Where Practice Applies

A sediment trap is usually installed in a drainage way, at a storm drain inlet, or other points of collection from a disturbed area. Sediment traps should be used to artificially break up the natural drainage area into smaller sections where a larger device (sediment basin) would be less effective.

## Design Criteria

If any of the design criteria presented here cannot be met, see the Standard and Specification for Sediment Basin.

## Drainage Area

The drainage area for sediment traps shall be in accordance with the specific type of sediment trap used (Type I through V).

## Location

Sediment traps shall be located so that they can be installed prior to grading or filling in the drainage area they are to protect. Traps must not be located any closer than 20 feet from a proposed building foundation if the trap is to function during building construction. Locate traps to obtain maximum storage benefit from the terrain and for ease of cleanout and disposal of the trapped sediment.

## Trap Size

The volume of a sediment trap as measured at the elevation of the crest of the outlet shall be at least 3,600 cubic feet per acre of drainage area. The volume of a constructed trap shall be calculated using standard mathematical procedures. The volume of a natural sediment trap may be approximated by the equation:

Volume (cu.ft.) = 0.4 x surface area (sq.ft.) x maximum depth (ft.).

## Trap Cleanout

Sediment shall be removed and the trap restored to the original dimensions when the sediment has accumulated to ½ of the design depth of the trap. Sediment removed from the trap shall be deposited in a protected area and in such a manner that it will not erode.

## Embankment

All embankments for sediment traps shall not exceed five (5) feet in height as measured at the low point of the original ground along the centerline of the embankment. Embankments shall have a minimum four (4) foot wide top and side slopes of 2:1 or flatter. The embankment shall be compacted by traversing with equipment while it is being constructed. The embankment shall be stabilized with seed and mulch as soon as it is completed.

The elevation of the top of any dike directing water to any sediment trap will equal or exceed the maximum height of the outlet structure along the entire length of the trap.

## Excavation

All excavation operations shall be carried out in such a manner that erosion and water pollution shall be minimal. Excavated portions of sediment traps shall have 1:1 or flatter slopes.

## Part 5 - Sediment Trap

### Outlet

The outlet shall be designed, constructed, and maintained in such a manner that sediment does not leave the trap and that erosion at or below the outlet does not occur.

Sediment traps must outlet onto stabilized (preferable undisturbed) ground, into a watercourse, stabilized channel, or into a storm drain system. Distance between inlet and outlet should be maximized to the longest length practicable.

### Type of Sediment Traps

There are five (5) specific types of sediment traps which vary according to their function, location, or drainage area.

- I. Pipe Outlet Sediment Trap
- II. Grass Outlet Sediment Trap
- III. Catch Basin Sediment Trap
- IV. Stone Outlet Sediment Trap
- V. Riprap Outlet Sediment Trap

#### I. Pipe Outlet Sediment Trap

A Pipe Outlet Sediment Trap consists of a trap formed by embankment or excavation. The outlet for the trap is through a perforated riser and a pipe through the embankment. The outlet pipe and riser shall be made of steel, corrugated metal or other suitable material. The top of the embankment shall be at least 1 ½ feet above the crest of the riser. The top 2/3 of the riser shall be perforated with one (1) inch nominal diameter holes or slits spaced six (6) inches vertically and horizontally placed in the concave portion of the corrugated pipe.

No holes or slits will be allowed within six (6) inches of the top of the horizontal barrel. All pipe connections shall be watertight. The riser shall be wrapped with ½ to ¾ inch hardware cloth wire then wrapped with filter cloth with a sieve size between #40-80 and secured with strapping or connecting

band at the top and bottom of the cloth. The cloth shall cover an area at least six (6) inches above the highest hole and six (6) inches below the lowest hole. The top of the riser pipe shall not be covered with filter cloth. The riser shall have a base with sufficient weight to prevent flotation of the riser. Two approved bases are:

1. A concrete base 12 in. thick with the riser embedded 9 in. into the concrete base, or
2. One quarter inch, minimum, thick steel plate attached to the riser by a continuous weld around the circumference of the riser to form a watertight connection. The plate shall have 2.5 feet of stone, gravel, or earth placed on it to prevent flotation. In either case, each side of the square base measurement shall be the riser diameter plus 24 inches.

Select minimum pipe diameter size from the following table:

Barrel Diameter <sup>1</sup> (in.)	Riser Diameter <sup>1</sup> (in.)	Maximum Drainage Area (ac.)
12	15	1
15	18	2
18	21	3
21	24	4
21 <sup>1E</sup>	27	5

Pipe outlet sediment traps shall be limited to a five (5) acre maximum drainage area with a required storage of 3600 cubic feet per acre of drainage area.

Pipe outlet sediment traps may be interchangeable in the field with stone outlet or riprap sediment traps provided that these sediment traps are constructed in accordance with the detail and specifications for that trap.

## Part 5 - Sediment Trap

### II. Grass Outlet Sediment Trap

A Grass Outlet Sediment Trap consists of a trap formed by excavating the earth to create a holding area. The trap has a discharge point over natural existing grass. The outlet crest width (feet) shall be equal to four (4) times the drainage area (acres) with a minimum width of four (4) feet. The outlet shall be free of any restrictions to flow. The outlet lip must remain undisturbed and level. The volume of this trap shall be computed at the elevation of the crest of the outlet. Grass outlet sediment traps shall be limited to a five (5) acre maximum drainage area with a required storage of 3600 cubic feet per acre of drainage area.

### III. Catch Basin Sediment Trap

A Catch Basin Sediment Trap consists of a basin formed by excavation on natural ground that discharges through an opening in a storm drain inlet structure. This opening can either be the inlet opening or a temporary opening made by omitting bricks or blocks in the inlet.

A yard drain inlet or an inlet in the median strip of a dual highway could use the inlet opening for the type outlet. The trap should be out of the roadway so as not to interfere with future compaction or construction. Placing the trap on the opposite side of the opening and diverting water from the roadway to the trap is one means of doing this. Catch basin sediment traps shall be limited to a three (3) acre maximum drainage area. The volume of this trap is measured at the elevation of the crest of the outlet (invert of the inlet opening).

### IV. Stone Outlet Sediment Trap

A Stone Outlet Sediment Trap consists of a trap formed by an embankment or excavation. The outlet of this trap is over a stone section placed on level ground. The minimum length (feet) of the outlet shall be equal to four (4) times the drainage area (acres) with a required storage 3,600 cubic feet per acre of drainage area.

The outlet crest (top of stone in weir section) shall be level, at least one (1) foot below top of embankment and no more than one (1) foot above ground beneath the outlet. Stone used in the outlet shall be small riprap (4 in. x 8 in.). To provide more efficient trapping effect, a layer of filter cloth should be embedded one (1) foot back into the upstream face of the outlet stone or a one (1) foot thick layer of two (2) inch or finer aggregate shall be placed on the upstream face of the outlet.

Stone Outlet Sediment Traps may be interchangeable in the field with pipe or riprap outlet sediment traps provided they are constructed in accordance with the detail and specifications for those traps. Stone outlet sediment traps shall be limited to a five (5) acre maximum drainage area.

### V. Riprap Outlet Sediment Trap

A Riprap Outlet Sediment Trap consists of a trap formed by an excavation and embankment. The outlet for this trap shall be through a partially excavated channel lined with riprap. This outlet channel shall discharge onto a stabilized area or to a stable watercourse. The riprap outlet sediment trap may be used for drainage areas of up to a maximum of 15 acres.

#### Design Criteria for Riprap Outlet Sediment Trap

1. The total contributing drainage area (disturbed or undisturbed either on or off the developing property) shall not exceed 15 acres.
2. The storage needs for this trap shall be computed using 3600 cubic feet of required storage for each acre of drainage area. The storage volume provided can be figured by computing the volume of storage area available behind the outlet structure up to an elevation of one (1) foot below the level weir crest.
3. The maximum height of embankment shall not exceed five (5) feet.
4. The elevation of the top of any dike directing water

## Part 5 - Sediment Trap

to a riprap outlet sediment trap will equal or exceed the minimum elevation of the embankment along the entire length of this trap.

### Optional Dewatering Methods

Optional dewatering devices may be designed for use with sediment traps. Included in the details within this standard are two methods, which may be used.

#### Riprap Outlet Sediment Trap ST-V (for Stone Lined Channel)

Contributing of Drainage Area (ac.)	Depth of Channel (a) (ft.)	Length Weir (b) (ft.)
1	1.5	4.0
2	1.5	5.0
3	1.5	6.0
4	1.5	10.0
5	1.5	12.0
6	1.5	14.0
7	1.5	16.0
8	2.0	10.0
9	2.0	10.0
10	2.0	12.0
11	2.0	14.0
12	2.0	14.0
13	2.0	16.0
14	2.0	16.0
15	2.0	18.0

### Considerations

Select locations for sediment traps during site evaluation. Note natural drainage divides and select trap sites so that runoff from potential sediment-producing areas can easily be diverted into the traps. Make traps readily accessible for periodic sediment removal and other necessary maintenance. Plan locations for sediment disposal as part of trap site selection. Clearly designate all disposal areas on the plans.

Sediment trapping is achieved primarily by settling within a permanent pool formed by excavation, or by a combination of excavation and embankment. Sediment-trapping efficiency is a function of surface area and inflow rate. Installations that provide pools with large length to width ratios reduce short-circuiting and allow more of the pool surface area for settling. This optimizes efficiency.

The minimum length of flow through the trap should be 10 feet and the minimum length to width ratio should be 2:1. If site conditions permit a greater travel distance through the basin and greater length to width ratio the water quality benefit provided by the sediment trap will be enhanced. The average trap permanent pool depth should be a minimum of 3 feet to prevent resuspension of sediments.

Because well-planned sediment traps are key measures to preventing off-site sedimentation, they should be installed in the first stages of project development.

### Plans and Specifications

Plans and specifications for installing sediment traps shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Each trap shall be delineated on the plans in such a manner that it will not be confused with any other features. Each trap on a plan shall indicate all the information necessary to properly construct and maintain the structure. If the drawings are such that this information cannot be delineated on the drawings, then a table shall be developed. If a table is developed, then each trap on a plan shall have a number and the numbers shall be consecutive.

## Part 5 - Sediment Trap

The following information shall be shown for each trap in a summary table format on the plans.

1. Trap number.
2. Type of trap.
3. Drainage area.
4. Storage required.
5. Storage provided (if applicable).
6. Outlet length or pipe sizes.
7. Storage depth below outlet or cleanout elevation.
8. Embankment height and elevation (if applicable).
9. The construction detail for each type of sediment trap designated.

## Part 5 - Sediment Trap

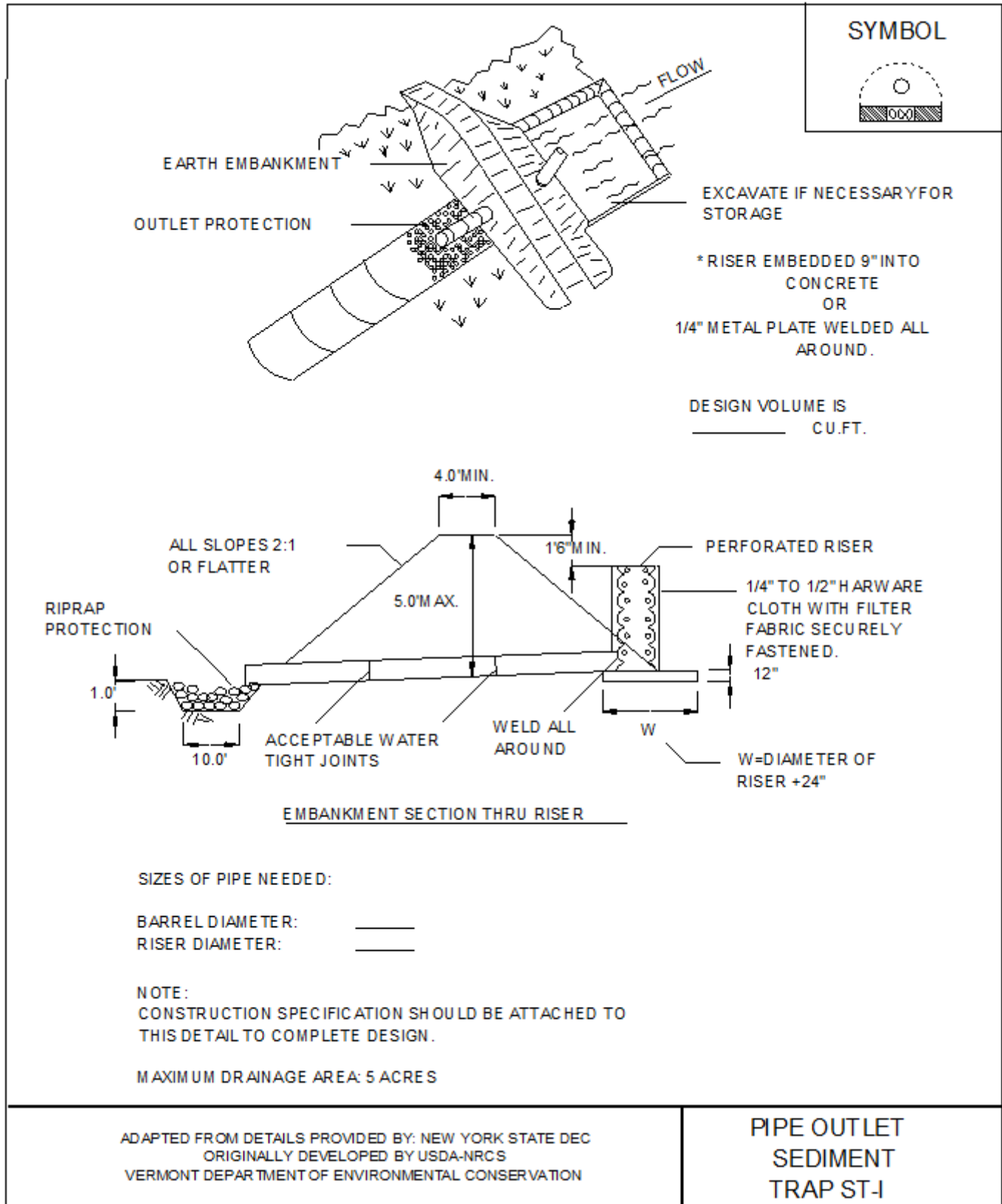



Figure 5.6a Pipe Outlet Sediment Trap ST-1

## Part 5 - Sediment Trap

<p style="text-align: center;"><b>CONSTRUCTION SPECIFICATIONS</b></p> <ol style="list-style-type: none"> <li>1. AREA UNDER EMBANKMENT SHALL BE CLEARED, GRUBBED AND STRIPPED OF ANY VEGETATION AND ROOT MAT. THE POOL AREA SHALL BE CLEARED.</li> <li>2. THE FILL MATERIAL FOR THE EMBANKMENT SHALL BE FREE OF ROOTS OR OTHER WOODY VEGETATION AS WELL AS OVER-SIZED STONES, ROCKS, ORGANIC MATERIAL, OR OTHER OBJECTIONABLE MATERIAL. THE EMBANKMENT SHALL BE COMPACTED BY TRAVERSING WITH EQUIPMENT WHILE IT IS BEING CONSTRUCTED.</li> <li>3. VOLUME OF SEDIMENT STORAGE SHALL BE 3600 CUBIC FEET PER ACRE OF CONTRIBUTORY DRAINAGE.</li> <li>4. SEDIMENT SHALL BE REMOVED AND TRAP RESTORED TO ITS ORIGINAL DIMENSIONS WHEN THE SEDIMENT HAS ACCUMULATED TO 1/2 THE DESIGN DEPTH OF THE TRAP. REMOVED SEDIMENT SHALL BE DEPOSITED IN A SUITABLE AREA AND STABILIZED.</li> <li>5. THE STRUCTURE SHALL BE INSPECTED AFTER EACH RAIN AND REPAIRS MADE AS NEEDED.</li> <li>6. CONSTRUCTION OPERATIONS SHALL BE CARRIED OUT IN SUCH A MANNER THAT EROSION AND SEDIMENT ARE CONTROLLED.</li> <li>7. THE STRUCTURE SHALL BE REMOVED AND AREA STABILIZED WHEN THE DRAINAGE AREA HAS BEEN PROPERLY STABILIZED.</li> <li>8. ALL FILL SLOPES SHALL BE 2:1 OR FLATTER; CUT SLOPES 1:1 OR FLATTER.</li> <li>9. ALL PIPE CONNECTIONS SHALL BE WATERTIGHT.</li> <li>10. THE TOP 2/3 OF THE RISER SHALL BE PERFORATED WITH ONE (1) INCH DIAMETER HOLES OR SLITS SPACED SIX (6) INCHES VERTICALLY AND HORIZONTALLY AND PLACED IN THE CONCAVE PORTION OF PIPE. NO HOLES WILL BE ALLOWED WITHIN SIX (6) INCHES OF THE HORIZONTAL BARREL.</li> <li>11. THE RISER SHALL BE WRAPPED WITH 1/4 TO 1/2 INCH HARDWARE CLOTH WIRE THEN WRAPPED WITH FILTER CLOTH (HAVING AN EQUIVALENT SIEVE SIZE OF 40-80). THE FILTER CLOTH SHALL EXTEND SIX (6) INCHES ABOVE THE HIGHEST HOLE AND SIX (6) INCHES BELOW THE LOWEST HOLE. WHERE ENDS OF THE FILTER CLOTH COME TOGETHER, THEY SHALL BE OVER-LAPPED, FOLDED AND STAPLED TO PREVENT BYPASS.</li> <li>12. STRAPS OR CONNECTING BANDS SHALL BE USED TO HOLD THE FILTER CLOTH AND WIRE FABRIC IN PLACE. THEY SHALL BE PLACED AT THE TOP AND BOTTOM OF THE CLOTH.</li> <li>13. FILL MATERIAL AROUND THE PIPE SPILLWAY SHALL BE HAND COMPACTED IN FOUR (4) INCH LAYERS. A MINIMUM OF TWO (2) FEET OF HAND COMPACTED BACKFILL SHALL BE PLACED OVER THE PIPE SPILLWAY BEFORE CROSSING IT WITH CONSTRUCTION EQUIPMENT.</li> <li>14. THE RISER SHALL BE ANCHORED WITH EITHER A CONCRETE BASE OR STEEL PLATE BASE TO PREVENT FLOTATION. FOR CONCRETE BASED THE DEPTH SHALL BE TWELVE (12) INCHES WITH THE RISER EMBEDDED NINE (9) INCHES. A 1/4 INCH MINIMUM THICKNESS STEEL PLATE SHALL BE ATTACHED TO THE RISER BY A CONTINUOUS WELD AROUND THE BOTTOM TO FORM A WATERTIGHT CONNECTION AND THEN PLACE TWO (2) FEET OF STONE, GRAVEL, OR TAMPED EARTH ON THE PLATE.</li> </ol>	<p style="text-align: center;"><b>SYMBOL</b></p> 
<p style="text-align: center;">ADAPTED FROM DETAILS PROVIDED BY: NEW YORK STATE DEC ORIGINALLY DEVELOPED BY USDA-NRCS VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION</p>	<p style="text-align: center;"><b>PIPE OUTLET SEDIMENT TRAP ST-1</b></p>

**Figure 5.6b Pipe Outlet Sediment Trap ST-1 Specifications**

## Part 5 - Sediment Trap

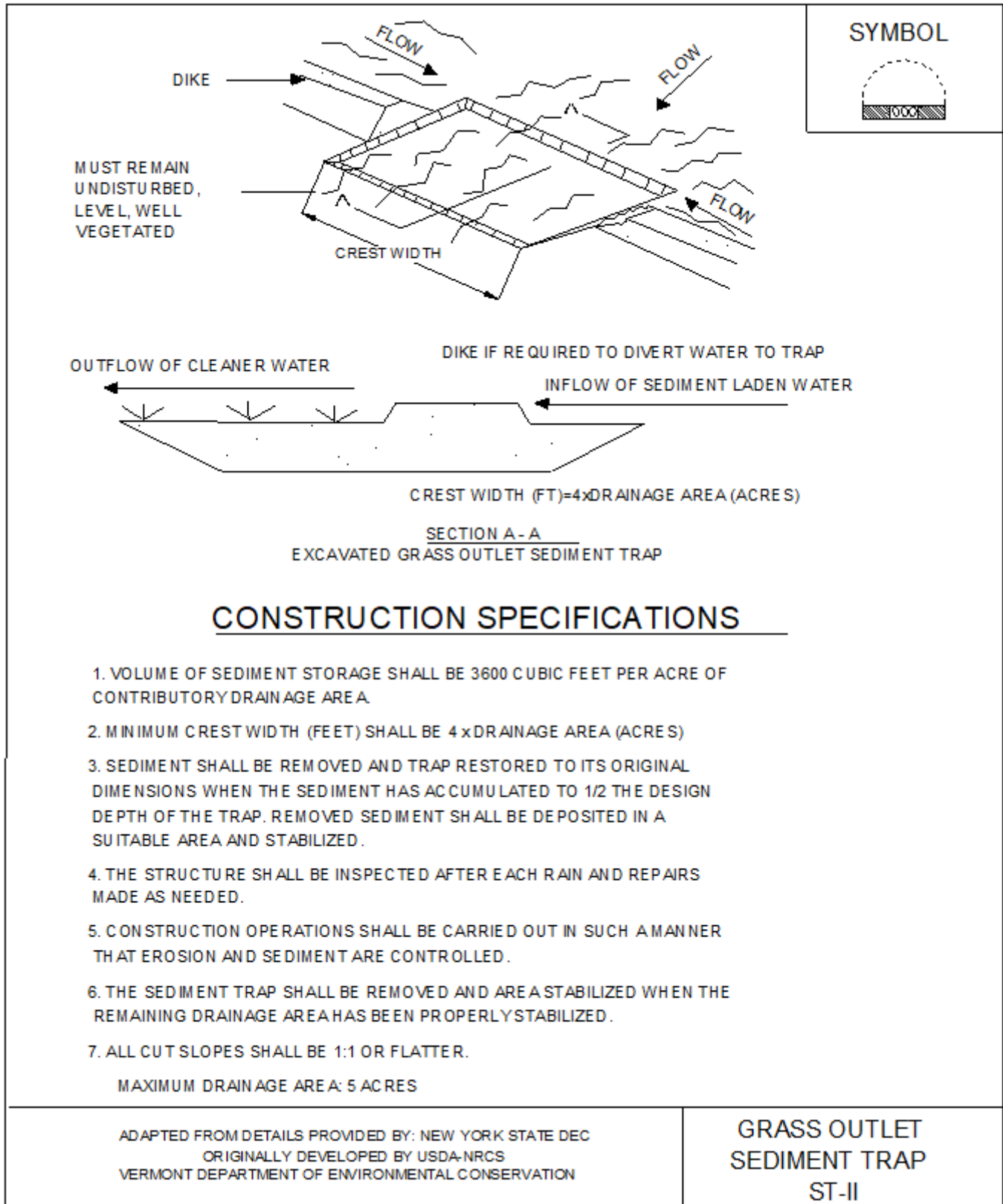
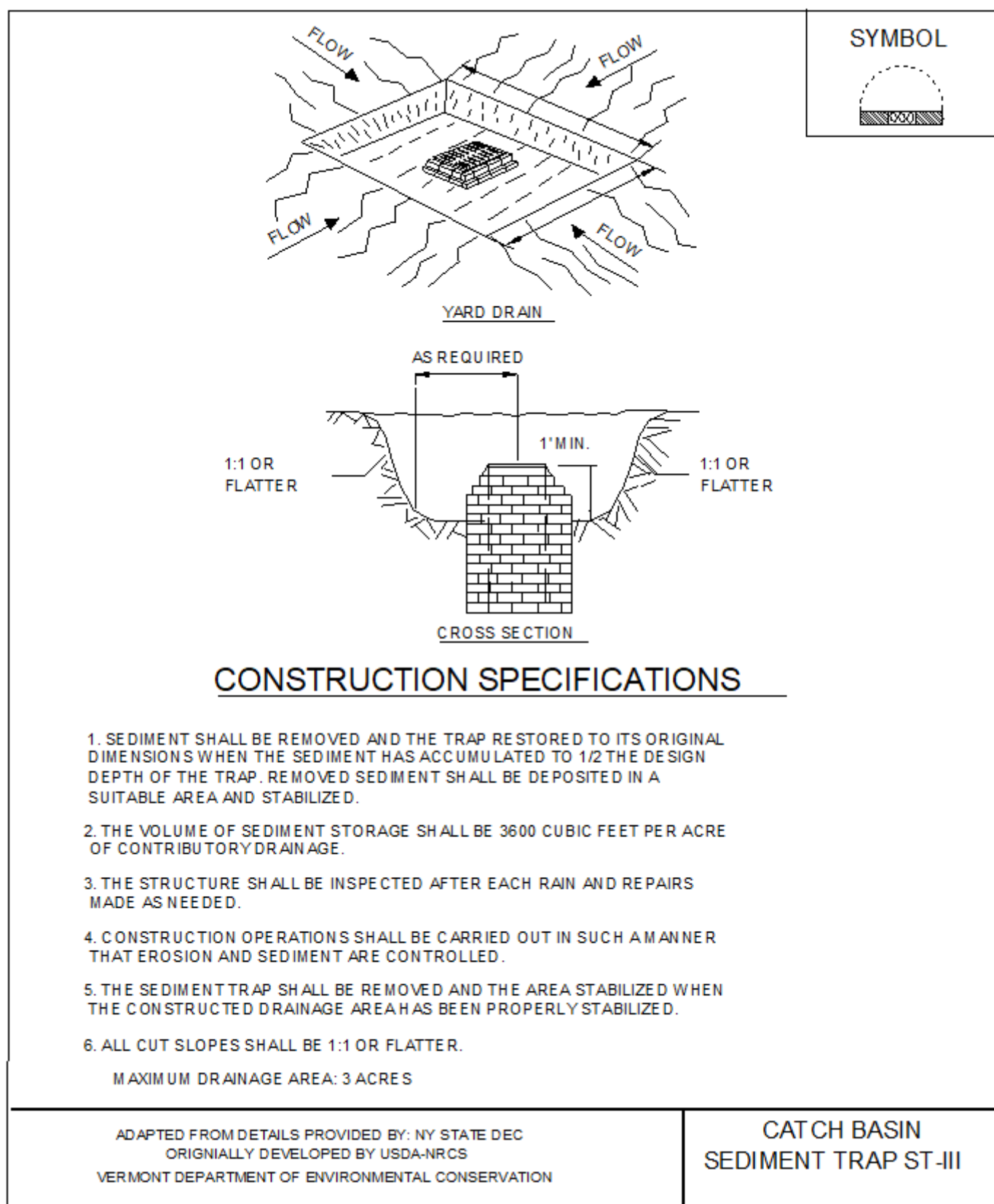


Figure 5.7 Grass Outlet Sediment Trap ST-II

## Part 5 - Sediment Trap



**Figure 5.8 Catch Basin Sediment Trap ST-III**

## Part 5 - Sediment Trap

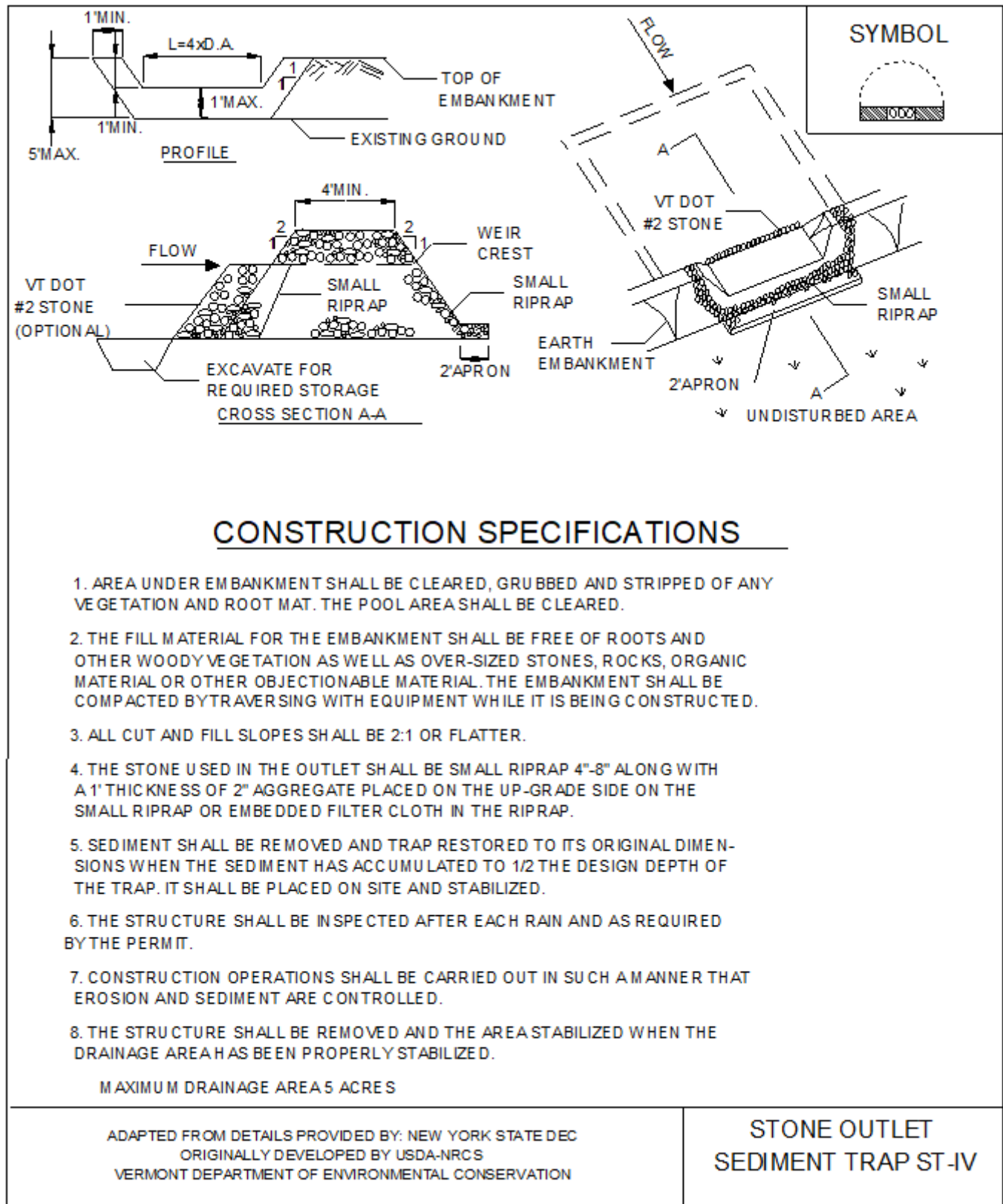


Figure 5.9 Stone Outlet Sediment Trap ST-IV

## Part 5 - Sediment Trap

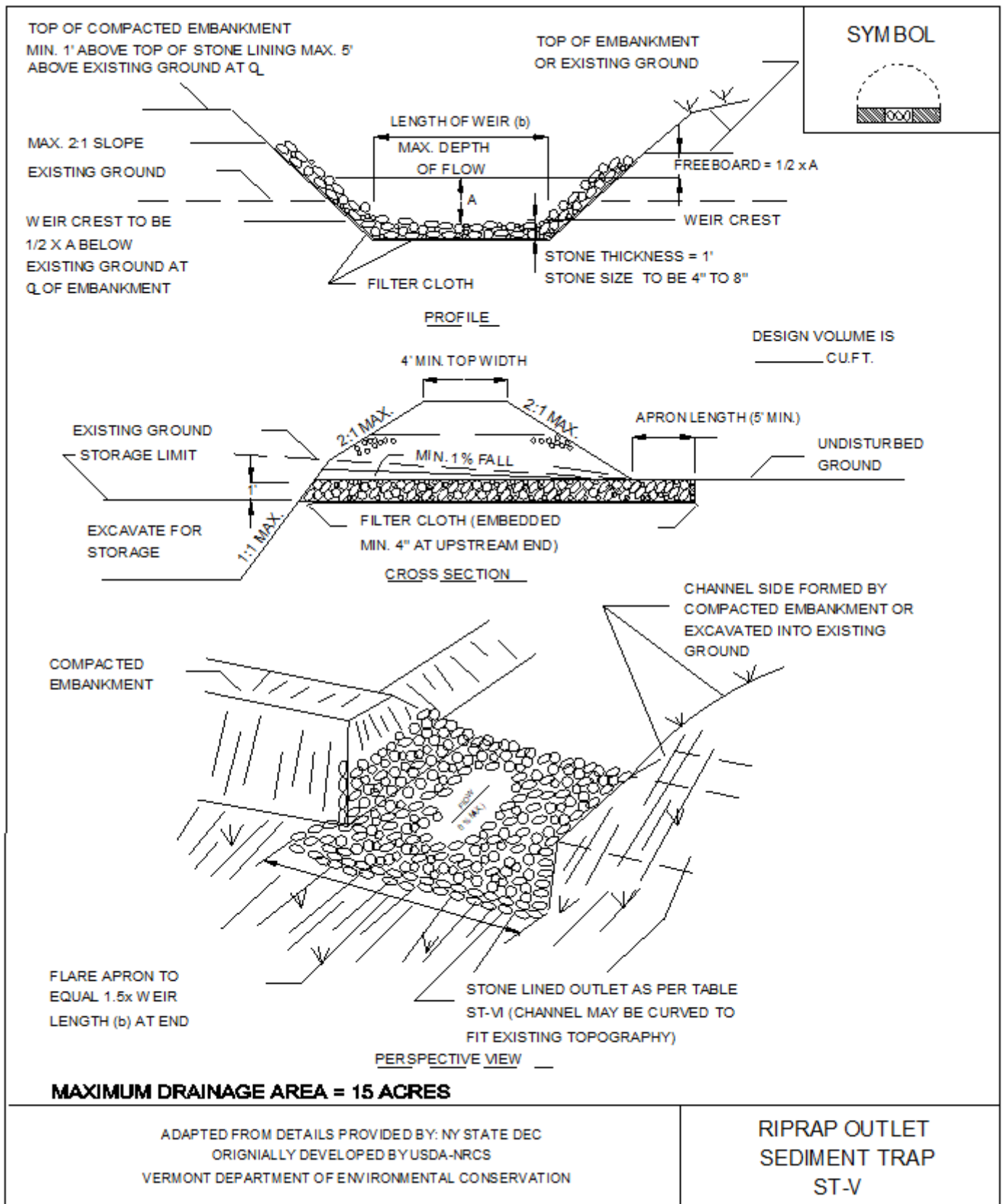


Figure 5.10a Rip Rap Outlet Sediment Trap ST-V

## Part 5 - Sediment Trap

### SYMBOL



### CONSTRUCTION SPECIFICATIONS

1. THE AREA UNDER EMBANKMENT SHALL BE CLEARED, GRUBBED AND STRIPPED OF ANY VEGETATION AND ROOT MAT. THE POOL AREA SHALL BE CLEARED.
2. THE FILL MATERIAL FOR THE EMBANKMENT SHALL BE FREE OF ROOTS OR OTHER WOODY VEGETATION AS WELL AS OVER-SIZED STONES, ROCKS, ORGANIC MATERIAL OR OTHER OBJECTIONABLE MATERIAL. THE EMBANKMENT SHALL BE COMPACTED BY TRAVERSING WITH EQUIPMENT WHILE IT IS BEING CONSTRUCTED. MAXIMUM HEIGHT OF OF EMBANKMENT SHALL BE FIVE (5) FEET, MEASURED AT CENTERLINE OF EMBANKMENT.
3. ALL FILL SLOPES SHALL BE 2:1 OR FLATTER, CUT SLOPES 1:1 OR FLATTER.
4. ELEVATION OF THE TOP OF ANY DIKE DIRECTING WATER INTO TRAP MUST EQUAL OR EXCEED THE HEIGHT OF EMBANKMENT.
5. STORAGE AREA PROVIDED SHALL BE FIGURED BY COMPUTING THE VOLUME AVAILABLE BEHIND THE OUTLET CHANNEL UP TO AN ELEVATION OF ONE (1) FOOT BELOW THE LEVEL WEIR CREST.
6. FILTER CLOTH SHALL BE PLACED OVER THE BOTTOM AND SIDES OF THE OUTLET CHANNEL PRIOR TO PLACEMENT OF STONE. SECTIONS OF FABRIC MUST OVERLAP AT LEAST ONE (1) FOOT WITH SECTION NEAREST THE ENTRANCE PLACED ON TOP. FABRIC SHALL BE EMBEDDED AT LEAST SIX (6) INCHES INTO EXISTING GROUND AT ENTRANCE OUTLET CHANNEL.
7. STONE USED IN THE OUTLET CHANNEL SHALL BE FOUR (4) TO EIGHT (8) INCH RIPRAP. TO PROVIDE A FILTERING EFFECT, A LAYER OF FILTER CLOTH SHALL BE EMBEDDED ONE (1) FOOT WITH SECTION NEAREST ENTRANCE PLACED ON TOP. FABRIC SHALL BE EMBEDDED AT LEAST SIX (6) INCHES INTO EXISTING GROUND AT ENTRANCE OF OUTLET CHANNEL.
8. SEDIMENT SHALL BE REMOVED AND TRAP RESTORED TO ITS ORIGINAL DIMENSIONS WHEN SEDIMENT HAS ACCUMULATED TO 1/2 THE DESIGN DEPTH OF THE TRAP. REMOVED SEDIMENT SHALL BE DEPOSITED IN A SUITABLE AREA AND STABILIZED.
9. THE STRUCTURE SHALL BE INSPECTED AFTER EACH RAIN AND REPAIRED AS NEEDED.
10. CONSTRUCTION OPERATIONS SHALL BE CARRIED OUT IN SUCH A MANNER THAT EROSION AND SEDIMENT ARE CONTROLLED.
11. THE STRUCTURE SHALL BE REMOVED AND THE AREA STABILIZED WHEN DRAINAGE AREA HAS BEEN PROPERLY STABILIZED.
12. DRAINAGE AREA FOR THIS PRACTICE IS LIMITED TO 15 ACRES OR LESS.

ADAPTED FROM DETAILS PROVIDED BY: NY STATE DEC  
ORIGINALLY DEVELOPED BY USDA-NRCS  
VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION

RIPRAP OUTLET  
SEDIMENT TRAP ST-V

Figure 5.10b Rip Rap Sediment Trap ST-V Specifications

## Part 5 - Sediment Trap

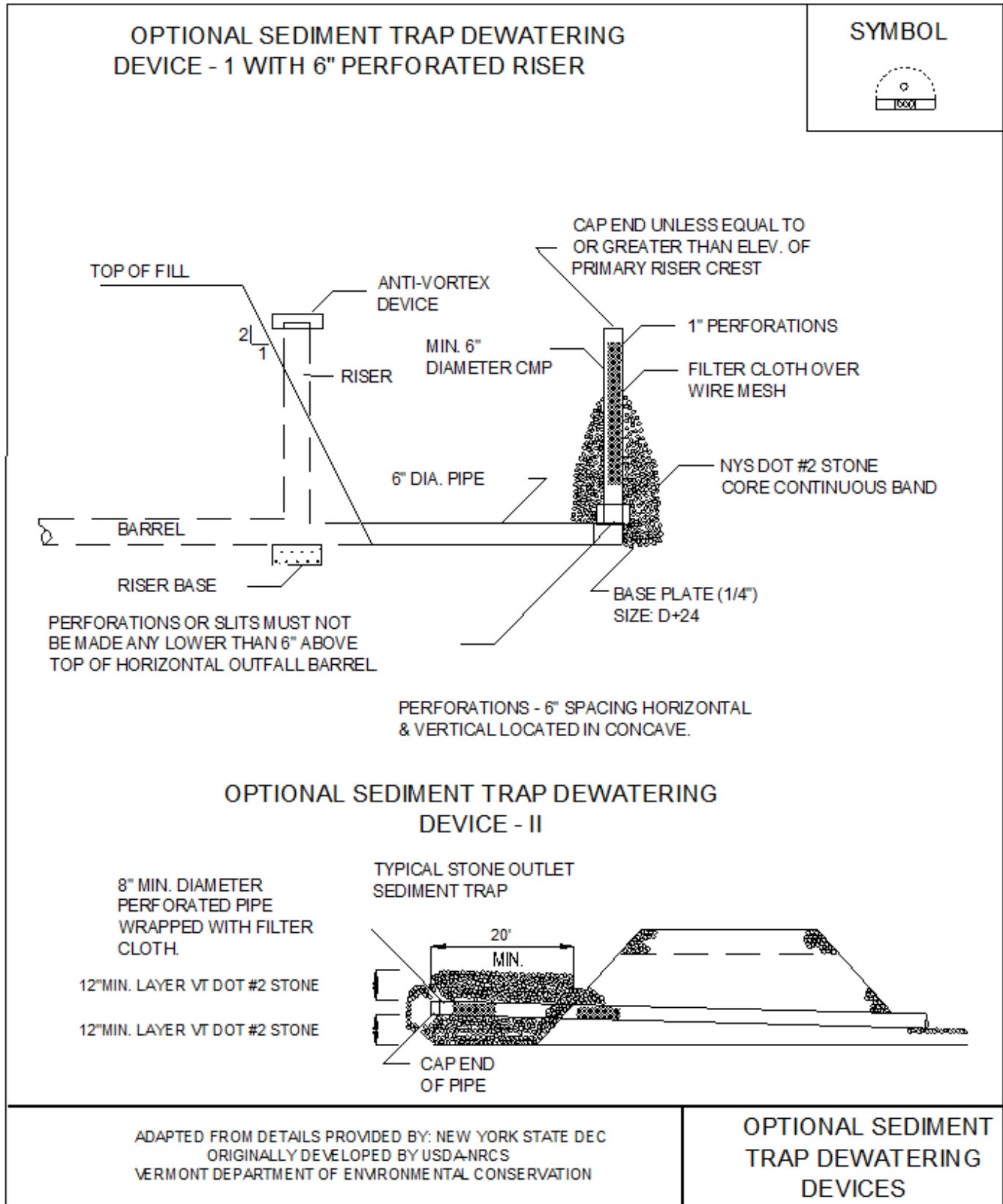


Figure 5.11 Optional Sediment Trap Dewatering Devices

# Part 5 - Dust Control

## Definition

The control of dust resulting from land-disturbing activities.

## Purpose

To prevent surface and air movement of dust from disturbed soil surfaces that may cause off-site damage, health hazards, and traffic safety problems.

## Conditions Where Practice Applies

On construction roads, access points, and other disturbed areas subject to surface dust movement and dust blowing where off-site damage may occur if dust is not controlled.

## Design Criteria

Buffer areas of vegetation should be left where practical. Temporary or permanent stabilization measures shall be installed. No specific design criteria is given; see construction specifications below for common methods of dust control.

Water quality must be considered when materials are selected for dust control.

Chemical applications, including the use of chloride, shall not be applied without written authorization from the VT DEC.

## Construction Specifications

A. Non-driving Areas – These areas use products and materials applied or placed on soil surfaces to prevent airborne migration of soil particles.

Vegetative Cover – For disturbed areas not subject to traffic, vegetation provides the most practical method of dust control.

Mulch – Mulch offers a fast effective means of controlling dust. This can also include rolled erosion control blankets.

Spray adhesives – These are products generally composed of polymers in a liquid or solid form that are mixed with water to form an emulsion that is sprayed on the soil surface with typical hydroseeding equipment. The mixing ratios and application rates will be in accordance with the manufacturer's recommendations for the specific soils on the site. In no case should the application of these adhesives be made on wet soils or if there is a probability of precipitation within 48 hours of its proposed use. Material Safety Data Sheets will be provided to all applicators and others working with the material.

B. Driving Areas – These areas utilize water, polymer emulsions, and barriers to prevent dust movement from the traffic surface into the air.

Sprinkling – The site may be sprayed with water until the surface is wet. This is especially effective on haul roads and access routes.

Polymer Additives – These polymers are mixed with water and applied to the driving surface by a water truck with a gravity feed drip bar, spray bar or automated distributor truck. The mixing ratios and application rates will be in accordance with the manufacturer's recommendations. Incorporation of the emulsion into the soil will be done to the appropriate depth based on expected traffic. Compaction after incorporation will be by vibratory roller to a minimum of 95%. The prepared surface shall be moist and no application of the polymer will be made if there is a probability of precipitation within 48 hours of its proposed use. Material Safety Data Sheets will be provided to all applicators working with the material.

Barriers – Woven geotextiles can be placed on the driving surface to effectively reduce dust throw and particle migration on haul roads. Stone can also be used for construction roads for effective dust control.

Windbreak – A silt fence or similar barrier can control air currents at intervals equal to ten times the barrier height. Preserve existing wind barrier vegetation as much as practical.

# Part 5 - Dust Control

## Maintenance

Maintain dust control measures through dry weather periods until all disturbed areas are stabilized.

## Considerations

The easiest way to control dust is to avoid exposed soil surfaces. This is not possible on most construction sites, but the area exposed can usually be reduced by careful planning of controlled traffic patterns and by the phasing of clearing and grading operations. Consider the use of undisturbed vegetative buffers (min. 50 ft.) between graded areas and protected areas.

## Plans and Specifications

Plans and specifications for dust control shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum the following items should be included:

1. The area to be treated.
2. The methods that are acceptable to use.

# Part 5 - Rock Dam

## Definition

A rock embankment located to capture sediment.

## Purpose

To retain sediment on the construction site and prevent sedimentation in off site water bodies.

## Conditions Where Practice Applies

The rock dam may be used instead of the standard sediment basin with barrel and riser. The rock dam is preferred when it is difficult to construct a stable, earthen embankment and rock materials are readily available. The site should be accessible for periodic sediment removal. This rock dam should not be located in a perennial stream. The top of the dam will serve as the overflow outlet. The inside of the dam will be faced with smaller stone to reduce the rate of seepage so a sediment pool forms during runoff events.

## Design Criteria

**Drainage Area:** The drainage area for this structure is limited to 50 acres.

**Location:** The location of the dam should:

1. Provide a large area to trap sediment.
2. Intercept runoff from disturbed areas.
3. Be accessible to remove sediment.
4. Not interfere with construction activities.

**Storage Volume:** The storage volume behind the dam shall be at least 3,600 cubic feet per acre of drainage area to the dam. This volume is measured one foot below the crest of the dam.

## Dam Section:

Top Width      5 feet minimum @ crest

Side Slopes      2:1 upstream slope  
3:1 downstream slope

Height          6' max to spillway crest

**Length of Crest:** The crest length should be designed to carry the 10 yr. peak runoff with a flow depth of 1 foot and 1 foot of freeboard.

Rock at the abutments should extend at least 2 feet above the spillway and be at least 2 feet thick. These rock abutments should extend at least one foot above the downstream slope to prevent abutment scour. A rock apron at least 1.5 feet thick should extend downstream from the toe of the dam a distance equal to the height of the dam to protect the outlet area from scour.

**Rock Fill:** The rock fill should be well graded, hard, erosion resistant stone with a minimum  $d_{50}$  size of 9 inches. A "key trench" lined with geotextile filter fabric should be installed in the soil foundation under the rock fill. The filter fabric must extend from the key trench to the downstream edge of the apron and abutments to prevent soil movement and piping under the dam.

The upstream face of the dam should be covered with fine gravel a minimum of 3 feet thick to reduce the drainage rate.

**Trapping Efficiency:** To obtain maximum trapping efficiency, design for a long detention period. Usually a minimum of eight (8) hours before the basin is completely drained. Maximize the length of travel of sediment laden water from the inlet to the drain. Achieve a surface area equal to 0.01 acres per cfs (inflow) based on the 10-year storm.

## Part 5 - Rock Dam

### Maintenance

Check the basin area after each rainfall event. Remove sediment and restore original volume when sediment accumulates to one-half the design volume. Check the structure for erosion, piping, and rock displacement after each significant event and replace immediately.

Remove the structure and any sediment immediately after the construction area has been permanently stabilized. All water should be removed from the basin prior to the removal of the rock dam. Sediment should be placed in designated disposal areas and not allowed to flow into streams or drainage ways during structure removal.

### Plans and Specifications

Plans and specifications for rock dams shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. At a minimum the following items should be included:

1. Location of the rock dam.
2. Construction detail.

## Part 5 - Rock Dam

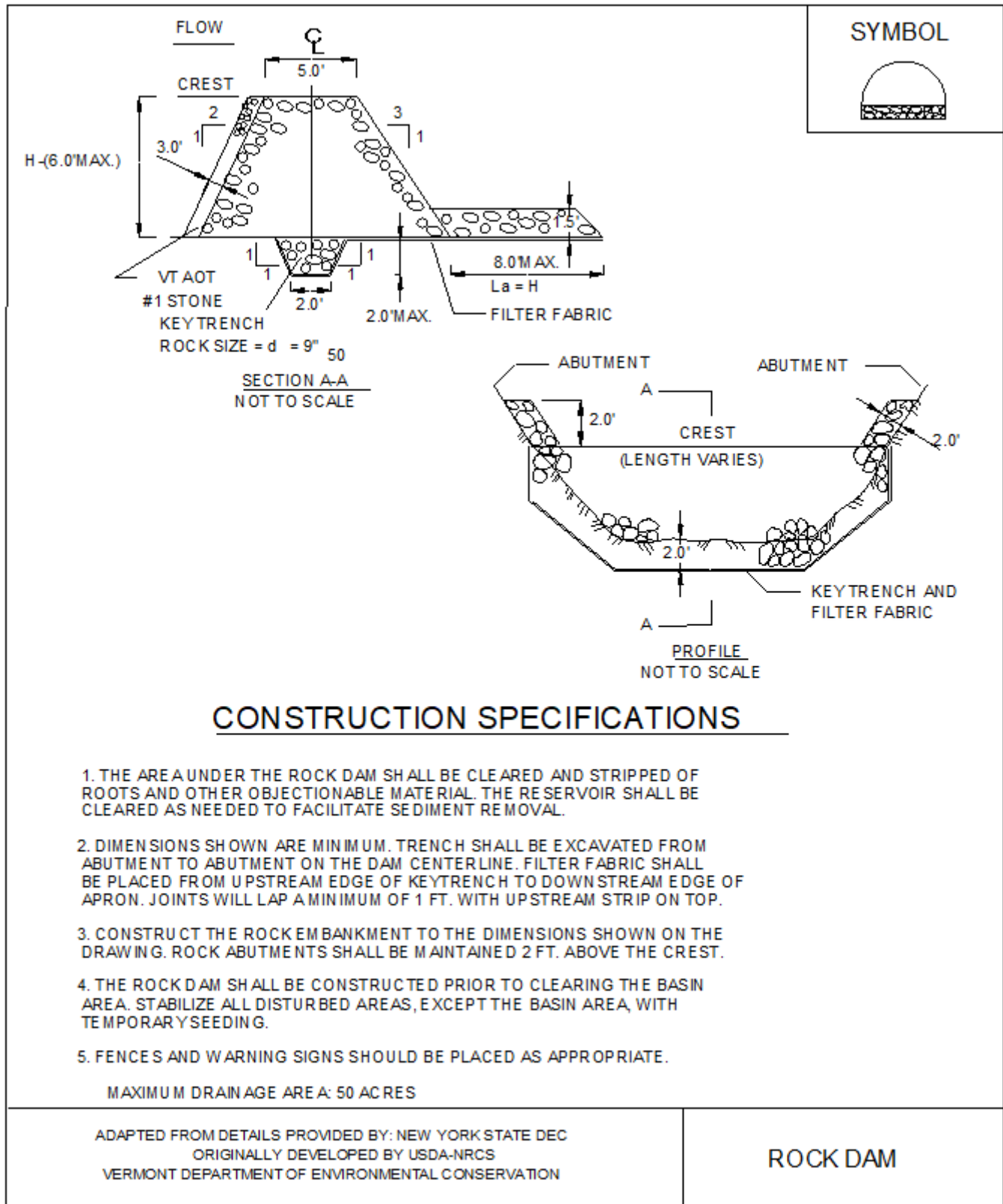


Figure 5.12 Rock Dam

## Part 5 - Sediment Basin

### Definition

A temporary barrier or dam constructed across a drainage way or at other suitable locations to intercept sediment laden runoff and to trap and retain the sediment.

### Purpose

The purpose of a sediment basin is to intercept sediment-laden runoff and reduce the amount of sediment leaving the disturbed area in order to protect drainage ways, properties, and rights-of-way below the sediment basin.

### Scope

This standard applies to the installation of temporary sediment basins on sites where: (a) failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities; (b) the drainage area does not exceed 100 acres; and (c) the basin is to be removed within 36 months after the beginning of construction of the basin.

Permanent (to function more than 36 months) sediment basins, or temporary basins exceeding the classification requirements for class 1 and 2, or structures that temporarily function as a sediment basin but are intended for use as a permanent pool shall be classified as permanent structures and shall conform to criteria appropriate for permanent structures. These structures shall be designed and constructed to conform to NRCS Standard And Specification No. 378 for Ponds in the National Handbook of Conservation Practices. Any impoundment, or pond that can contain 500,000 cubic feet of water may be required to obtain a permit from the VT DEC Dam Safety Program.

The total volume of permanent sediment basins shall be equal to or exceed the capacity requirements for temporary basins contained herein.

### Classification of Temporary Sediment Basins

For the purpose of this standard, temporary sediment basins are classified as follows:

Class	1	2
Max. Drainage Area (acres)	100	100
Max. Height <sup>1</sup> of Dam (ft.)	10	15
Min. Embankment Top Width	8	10
Embankment Side Slopes	2:1 or Flatter	2 ½:1 or Flatter
Anti-Seep Control Required	Yes	Yes

<sup>1</sup> Height is measured from the low point of original ground at the downstream toe of the dam to the top of the dam.

### Conditions Where Practice Applies

A sediment basin is appropriate where physical site conditions or land ownership restrictions preclude the installation of other erosion control measures to adequately control runoff, erosion, and sedimentation.

However, it is strongly encouraged to use a basin in addition to other EPSC measures if practicable. It may be used below construction operations which expose critical areas to soil erosion. The basin shall be maintained until the disturbed area is protected against erosion by permanent stabilization.

### Design Criteria

#### Compliance with Laws and Regulations

Design and construction shall comply with state and local laws, ordinances, rules and regulations, including permits.

## Part 5 - Sediment Basin

### Location

The sediment basin should be located to obtain the maximum storage benefit from the terrain and for ease of cleanout of the trapped sediment. It should be located to minimize interference with construction activities and construction of utilities. Whenever possible, sediment basins should be located so that storm drains may outfall or be diverted into the basin. Do not locate basins in perennial streams.

### Size and Shape of the Basin

The minimum runoff storage volume of the basin, as measured from the bottom of the basin to the elevation of the crest of the principal spillway shall be at least 3,600 cubic feet per acre draining to the basin. This 3,600 cubic feet is equivalent to one inch of runoff per acre of drainage area. The entire drainage area is used for this computation, rather than the disturbed area above, to maximize trapping efficiency. The length to width ratio shall be greater than 2:1, where length is the distance between the inlet and outlet. A wedge shape shall be used with the inlet located at the narrow end.

### Surface Area

The following relationship between surface area and peak inflow rate gives a trapping efficiency of 75% for silt loam soils, and greater than 90% for loamy sand soils:

$$A = 0.01 Q_p \quad \text{or} \quad A = 0.015 \times D.A. \\ \text{(whichever is greater)}$$

where,

A = the basin surface area, acres, measured at the service spillway crest; and

$Q_p$  = the peak inflow rate for the design storm. (The minimum design storm will be a 10-year, 24-hour storm under construction conditions).

D.A. = contributing drainage area.

One half of the design sediment storage volume (67 cubic yards per acre drainage area) shall be in the form of a permanent pool, and the remaining half as drawdown volume.

Sediment basins shall be cleaned out when the permanent pool volume remaining as described above is reduced by 50 percent, except in no case shall the sediment level be permitted to build up higher than one foot below the principal spillway crest. At this elevation, cleanout shall be performed to restore the original design volume to the sediment basin.

The elevation corresponding to the maximum allowable sediment level shall be determined and shall be stated in the design data as a distance below the top of the riser and shall be clearly marked on the riser.

The basin dimensions necessary to obtain the required basin volume as stated above shall be clearly shown on the plans to facilitate plan review, construction, and inspection.

### Spillway Design

Runoff shall be computed by the method outlined in: Chapter 2, Estimating Runoff, Engineering Field Handbook available in the Natural Resources Conservation Service offices or, by TR-55, Urban Hydrology for Small Watersheds. Runoff computations shall be based upon the worst soil cover conditions expected to prevail in the contributing drainage area during the anticipated effective life of the structure. The combined capacities of the principal and emergency spillway shall be sufficient to pass the peak rate of runoff from a ten-year frequency storm.

1. Principal spillway: A spillway consisting of a vertical pipe or box type riser joined (watertight connection) to a pipe (barrel) which shall extend through the embankment and outlet beyond the downstream toe of the fill. The minimum capacity of the principal spillway shall be 0.2 cfs per acre of drainage area when the water surface is at the emergency spillway crest elevation. For those

## Part 5 - Sediment Basin

basins with no emergency spillway, the principal spillway shall have the capacity to handle the peak flow from a ten-year frequency rainfall event. The minimum size of the barrel shall be 8 inches in diameter.

- a. Crest elevation: When used in combination with an emergency spillway, the crest elevation of the riser shall be a minimum one foot below the elevation of the control section of the emergency spillway.
- b. Watertight riser and barrel assembly: The riser and all pipe connections shall be completely watertight except for the inlet opening at the top, or a dewatering opening. There shall not have any other holes, leaks, rips, or perforations in the structure.
- c. Dewatering the basin: The drawdown volume will be discharged over a 10 hour period. The size of the orifice to provide this control can be approximated as follows:

$$A_o = \frac{A_s \times 2h^{0.5}}{T \times C_d \times 20,428} \quad \text{therefore,} \quad A_o = \frac{A_s \times 2h^{0.5}}{122,568}$$

where,

$A_o$  = surface area of the dewatering orifice

$A_s$  = surface area of the basin

$h$  = head of water above orifice

$C_d$  = coefficient of contraction for an orifice (0.6)

$T$  = detention time needed to dewater the basin (10 hours)

- d. Anti-vortex device and trash rack: An anti-vortex device and trash rack shall be securely installed on top of the riser and shall be the concentric type as shown in the details.
- e. Base: The riser shall have a base attached with a watertight connection and shall have sufficient weight to prevent flotation of the riser. Two approved bases for risers ten feet or less in

height are: 1) a concrete base 18 in. thick with the riser embedded 9 in. in the base, and 2) a ¼" minimum thickness steel plate attached to the riser by a continuous weld around the circumference of the riser to form a watertight connection. The plate shall have 2.5 feet of stone, gravel, or compacted earth placed on it to prevent flotation. In either case, each side of the square base shall be twice the riser diameter.

For risers greater than ten feet high, computations shall be made to design a base which will prevent flotation. The minimum factor of safety shall be 1.20 (Downward forces = 1.20 x upward forces).

- f. Anti-Seep Collars: Anti-seep collars shall be installed around all conduits through earth fills of impoundment structures according to the following criteria:

- 1) Collars shall be placed to increase the seepage length along the conduit by a minimum of 15 percent of the pipe length located within the saturation zone.
- 2) Collar spacing shall be between 5 and 14 times the vertical projection of each collar.
- 3) All collars shall be placed within the saturation zone.
- 4) The assumed normal saturation zone (phreatic line) shall be determined by projecting a line at a slope of 4 horizontal to 1 vertical from the point where the normal water (riser crest) elevation touches the upstream slope of the fill to a point where this line intersects the invert of the pipe conduit. All fill located within this line may be assumed as saturated.

## Part 5 - Sediment Basin

When anti-seep collars are used, the equation for revised seepage length becomes:

$$2(N)(P)=1.15(L_s) \text{ or,} \\ N=(0.075)(L_s)/P$$

Where:

$L_s$  = Saturated length is length, in feet, of pipe between riser and intersection of phreatic line and pipe invert.

$N$  = number of anti-seep collars.

$P$  = vertical projection of collar from pipe, in feet.

- 5) All anti-seep collars and their connections shall be watertight. Seepage diaphragms may be used in lieu of anti-seep collars. They shall be designed in accordance to USDA NRCS Pond Standard 378.

- g. Outlet: An outlet shall be provided, including a means of conveying the discharge in an erosion free manner to an existing stable channel. Where discharge occurs at the property line, drainage easements will be obtained in accordance with local ordinances. Adequate notes and references will be shown on the erosion and sediment control plan.

Protection against scour at the discharge end of the pipe spillway shall be provided. Measures may include basin, riprap, revetment, excavated plunge pools, or other approved methods.

2. Emergency Spillways: The entire flow area of the emergency spillway shall be constructed in undisturbed ground (not fill). The emergency spillway cross-section shall be trapezoidal with a minimum bottom width of eight feet. This spillway channel shall have a straight control section of at least 20 feet in length; and a straight outlet section

for a minimum distance equal to 25 feet.

- a. Capacity: The minimum capacity of the emergency spillway shall be that required to pass the peak rate of runoff from the 10-year 24-hour frequency storm, less any reduction due to flow in the pipe spillway.

Emergency spillway dimensions may be determined by using the method described in the detail.

- b. Velocities: The velocity of flow in the exit channel shall not exceed 5 feet per second for vegetated channels. For channels with erosion protection other than vegetation, velocities shall be within the non-erosive range for the type of protection used.
- c. Erosion Protection: Erosion protection shall be provided for by vegetation as prescribed in this publication or by other suitable means such as riprap, asphalt or concrete.
- d. Freeboard: Freeboard is the difference between the design high water elevation in the emergency spillway and the top of the settled embankment. If there is no emergency spillway, it is the difference between the water surface elevation required to pass the design flow through the pipe and the top of the settled embankment. Freeboard shall be at least one foot.

### Embankment Cross-Section

Class 1 Basins: The minimum top width shall be eight feet. The side slopes shall not be steeper than 2:1.

Class 2 Basins: The minimum top width shall be ten feet. The side slopes shall not be steeper than 2 ½:1.

### Entrance of Runoff into Basin

Points of entrance of surface runoff into excavated sediment basins shall be protected to prevent erosion.

## Part 5 - Sediment Basin

Considerable care should be given to the major points of inflow into basins. In many cases the difference in elevation of the inflow and the bottom of the basin is considerable, thus creating a potential for severe gullyng and sediment generation. Often a riprap drop at major points of inflow would eliminate gullyng and sediment generation.

Diversions, grade stabilization structures or other water control devices shall be installed as necessary to ensure direction of runoff and protect points of entry into the basin. Points of entry should be located so as to ensure maximum travel distance of entering runoff to point of exit (the riser) from the basin.

### Disposal

The sediment basin plans shall indicate the method(s) of disposing of the sediment removed from the basin. The sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the basin, adjacent to a stream or floodplain. Disposal sites will be covered by an approved sediment control plan.

The sediment basin plans shall also show the method of dismantling of the sediment basin after the drainage area is stabilized, and shall include the stabilization of the sediment basin site. Water contained within the storage areas shall be removed from the basin by pumping, cutting the top of the riser, or other appropriate method prior to removing or breaching the embankment. Sediment shall not be allowed to flush into a stream or drainage way.

### Chemical Treatment

Chemical applications shall not be applied without written authorization from the VT DEC.

Precipitation of sediment is enhanced with the use of specific chemical flocculants that can be applied to the sediment basin in liquid, powder, or solid form. Flocculants include polyacrylimides, aluminum sulfate (alum), and polyaluminum chloride. Cationic

polyelectrolytes have a greater toxicity to fish and other aquatic organisms than anionic polyelectrolytes because they bind to the gills of fish resulting in respiratory failure. Chemical treatment shall not be substituted for proper erosion and sediment control. To reduce the need for flocculants, proper controls include planning, phasing, sequencing and practice design in accordance to these Standards.

### Safety

Sediment basins are attractive to children and can be very dangerous. Local ordinances and regulations must be adhered to regarding health and safety. The developer or owner shall check with local building officials on applicable safety requirements. If fencing of sediment basins is required, the location of and type of fence shall be shown on the plans.

### Construction Specifications

#### Site Preparation

Areas under the embankment shall be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots, or other objectionable material. In order to facilitate cleanout and restoration, the pool area (measured at the top of the pipe spillway) will be cleared of all brush, trees, and other objectionable materials.

#### Cutoff-Trench

A cutoff trench shall be excavated along the centerline of earth fill embankments. The minimum depth shall be two feet. The cutoff trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be four feet, but wide enough to permit operation of excavation and compaction equipment. The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for embankment. The trench shall be dewatered during the back-filling/compaction operations.

#### Embankment

## Part 5 - Sediment Basin

The fill material shall be taken from approved areas shown on the plans. It shall be clean mineral soil free of roots, woody vegetation, oversized stones, rocks, or other objectionable material. Relatively pervious materials such as sand or gravel (Unified Soil Classes GW, GP, SW & SP) shall not be placed in the embankment. Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material shall contain sufficient moisture so that it can be formed by hand into a ball without crumbling. If water can be squeezed out of a ball, it is too wet for proper compaction. Fill material shall be placed in six to eight-inch thick continuous layers over the entire length of the fill. Compaction shall be obtained by routing and hauling the construction equipment over the fill so that the entire surface of each layer of the fill is traversed by at least one wheel or tread track of the equipment or by the use of a compactor. The embankment shall be constructed to an elevation 10 percent higher than the design height to allow for settlement.

### Pipe Spillway

The riser shall be securely attached to the barrel or barrel stub by welding the full circumference making a watertight structural connection. The barrel stub must be attached to the riser at the same percent (angle) of grade as the outlet conduit. The connection between the riser and the riser base shall be watertight. All connections between barrel sections must be achieved by approved watertight bank assemblies. The barrel and riser shall be placed on a firm, smooth foundation of impervious soil. Pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the pipe or anti-seep collars. The fill material around the pipe spillway shall be placed in four-inch layers and compacted under and around the pipe to at least the same density as the adjacent embankment.

A minimum depth of two feet of hand compacted backfill shall be placed over the pipe spillway before crossing it with construction equipment. Steel base plates on risers shall have at least 2 ½ feet of

compacted earth, stone, or gravel placed over it to prevent flotation.

### Emergency Spillway

The emergency spillway shall be installed in undisturbed ground. The achievement of planned elevations, grades, design width, entrance and exit channel slopes are critical to the successful operation of the emergency spillway and must be constructed within a tolerance of +/- 0.2 feet.

### Vegetative Treatment

Stabilize the embankment and emergency spillway in accordance with the appropriate vegetative standard and specification immediately following construction. In no case shall the embankment remain unstabilized for more than seven (7) days.

### Erosion and Pollution Control

Construction operations shall be carried out in such a manner that erosion and water pollution will be minimized. State and local laws shall be complied with concerning pollution abatement.

### Safety

State and local requirements shall be met concerning fencing and signs, warning the public of hazards of soft sediment and floodwater.

### Maintenance

1. Repair all damages caused by soil erosion and construction equipment at or before the end of each working day.
2. Sediment shall be removed from the basin when it reaches the specified distance below the top of the riser (shall not exceed 50 percent capacity). This sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the embankment, adjacent to a stream or floodplain.

## Part 5 - Sediment Basin

### Final Disposal

When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankment and resulting sediment deposits are to be leveled or otherwise disposed of in accordance with the approved sediment control plan. The proposed use of a sediment basin site will often dictate final disposition of the basin and any sediment contained therein. If the site is scheduled for future construction, then the basin material and trapped sediments must be removed, safely disposed of, and backfilled with a structural fill. When the basin area is to remain open space, the pond may be pumped dry, graded, and back filled.

### Plans and Specifications

Sediment basin designs and construction plans submitted for review to VT DEC shall include the following:

1. Specific location of the basin.
2. Plan view of the storage basin and emergency spillway, showing existing and proposed contours.
3. Cross section of dam, principal spillway, emergency spillway, and profile of emergency spillway.
4. Details of pipe connections, riser to pipe connections, riser base, anti-seep control, trash rack cleanout elevation, and anti-vortex device.
5. Runoff calculations for 1 and 10-year frequency storms, if required.
6. Storage Computation
  - a. Total required
  - b. Total Available
  - c. Level of sediment at which cleanout shall be required; to be stated as a distance from the riser crest to the sediment surface.
7. Calculations showing design of pipe and emergency spillway.

## Part 5 - Sediment Basin

### TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET

Computed \_\_\_\_\_ Date \_\_\_\_\_ Checked by \_\_\_\_\_ Date \_\_\_\_\_  
 Project \_\_\_\_\_  
 Sub Watershed# \_\_\_\_\_ Location \_\_\_\_\_  
 Total Area draining to basin \_\_\_\_\_ Acres

#### BASIN SIZE DESIGN

1. Minimum sediment storage volume = 134 cu. yds. x \_\_\_\_\_ acres of drainage area = \_\_\_\_\_ cu. yds.
2. a. Cleanout at 50 percent of minimum required volume = \_\_\_\_\_ cu. yds.  
 b. Elevation corresponding to scheduled time to clean out \_\_\_\_\_  
 c. Distance below top of riser \_\_\_\_\_ feet
3. Minimum surface area is larger of  $0.01 Q_{(1)}$  \_\_\_\_\_ or,  $0.015 DA$  = \_\_\_\_\_ use \_\_\_\_\_ acres

#### DESIGN OF SPILLWAYS & ELEVATIONS

##### Runoff

4.  $Q_{p(10)}$  = \_\_\_\_\_ cfs  
 (EFH, Ch. 2, TR-55; Attach runoff computation sheet)

##### Pipe Spillway ( $Q_{sp}$ )

5. Min. pipe spillway cap.,  $Q_{sp} = 0.2 \times$  \_\_\_\_\_ ac. Drainage = \_\_\_\_\_ cfs  
 Note: If there is no emergency spillway, then req'd  $Q_{sp} = Q_{p(10)} =$  \_\_\_\_\_ cfs.
6. H = \_\_\_\_\_ ft. Barrel length = \_\_\_\_\_ ft
7. Barrel: Diam. \_\_\_\_\_ inches;  $Q_{sp} = (Q) \times$  (cor fac.) \_\_\_\_\_ = \_\_\_\_\_ cfs.
8. Riser: Diam. \_\_\_\_\_ inches; Length \_\_\_\_\_ ft; h = \_\_\_\_\_ ft. Crest Elev. \_\_\_\_\_
9. Trash Rack: Diam. \_\_\_\_\_ inches; H = \_\_\_\_\_ inches

##### Emergency Spillway Design

10. Emergency Spillway Flow,  $Q_{es} = Q_{sp} - Q_{sp} =$  \_\_\_\_\_ - \_\_\_\_\_ = \_\_\_\_\_ cfs.
11. Width \_\_\_\_\_ ft.; H = \_\_\_\_\_ ft. Crest elevation \_\_\_\_\_; Design High Water Elev. \_\_\_\_\_  
 Entrance channel slope \_\_\_\_\_ %; Top of Dam Elev. \_\_\_\_\_  
 Exit channel slope \_\_\_\_\_ %

#### ANTI-SEEP COLLAR/ SEEPAGE DIAPHRAGM DESIGN

##### Collars:

12. y = \_\_\_\_\_ ft; z = \_\_\_\_\_:1; pipe slope = \_\_\_\_\_ %,  $L_s =$  \_\_\_\_\_ ft.  
 Use \_\_\_\_\_ collars, \_\_\_\_\_ - \_\_\_\_\_ inches square; projection = \_\_\_\_\_ ft

##### Diaphragms:

# \_\_\_\_\_ width \_\_\_\_\_ ft height \_\_\_\_\_ ft

#### DEWATERING ORIFICE SIZING

13.  $A_o = \frac{A_s \times (2h)^{0.5}}{122,568}$  = \_\_\_\_\_ sq. ft.; h = \_\_\_\_\_ ft.; therefore use, \_\_\_\_\_

# Part 5 - Temporary Sediment Basin

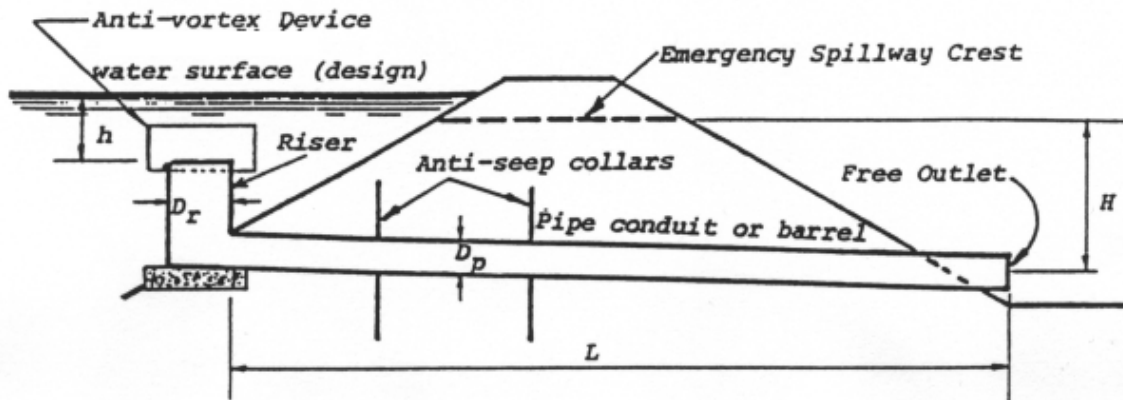
## Design Data Sheet

### Instructions for Use of Form

1. Minimum required sediment storage volume is 134 cubic yards (3600 cubic feet) per acre from each acre of drainage area. Values larger than 134 cubic yards per acre may be used for greater protection. Compute volume using entire drainage area although only part may be disturbed.
2. The volume of a naturally shaped basin (no excavation in basin) may be approximated by the formula  $V = (0.4)(A)(d)$ , where  $V$  is in cubic feet,  $A$  is the surface area of the basin, in square feet, and  $d$  is the maximum depth of the basin, in feet. Volume may be computed from contour information or other suitable methods.
3. If volume of basin is not adequate for required storage, excavate to obtain the required volume.
4. The minimum surface area of the basin pool at the storage volume elevation will be the larger of the two elevations shown.
5. USDA-NRCS TR-55 or the NRCS Engineering Field Handbook, Chapter 2, or comparable method, are the preferred methods for runoff computation. Runoff curve numbers will be computed for the drainage area that reflects the maximum construction condition.
6. Required minimum discharge from pipe spillway equals 0.2 cfs/ac. times total drainage area. (This is equivalent to a uniform runoff of 5 in. per 24 hours). The pipe shall be designed to carry  $Q_p$  if site conditions preclude installation of an emergency spillway to protect the structure.
7. Determine value of "H" from field conditions; "H" is the interval between the centerline of the outlet pipe and the emergency spillway crest, or if there is no emergency spillway, to the design high water.
8. See Pipe Spillway Design Charts.
9. See Riser Inflow Curves.
10. Compute the orifice size required to dewater the basin over a 10 hour period.
11. See Trash Rack and Anti-Vortex Device Design details.
12. Compute  $Q_{es}$  by subtracting actual flow carried by the pipe spillway from the total inflow,  $Q_p$ .
13. Use appropriate tables to obtain values of  $H_p$ , bottom width, and actual  $Q_{es}$ . If no emergency spillway is to be used, so state, giving reason(s).
14. See Anti-Seep Collar / Seepage Diaphragm Design.
15. Fill in design elevations. The emergency spillway crest must be set no closer to riser crest than value of  $h$ , which causes pipe spillway to carry the minimum, required  $Q$ . Therefore, the elevation difference between spillways shall be equal to the value of  $h$ , or one foot, whichever is greater. Design high water is the elevation of the emergency spillway crest plus the value of  $H_p$ , or if there is no emergency spillway, it is the elevation of the riser crest plus  $h$  required to handle the 10-year storm. Minimum top of dam elevation requires 1.0 ft. of freeboard above design high water.

# Part 5 - Pipe Spillway Design

## Pipe Spillway Design



$H$  = Head on pipe spillway (pipe flow), ft. (centerline of outlet to emergency spillway crest or to design high water if no emergency spillway)

$h$  = Head over riser crest, ft.

$L$  = Length of pipe in ft.

$D_p$  = Diameter of pipe conduit (barrel)

$D_r$  = Diameter of riser

### To use charts for pipe spillway design:

- Enter chart, Figures 5.14 and 5.15 with  $H$  and required discharge.
- Find diameter of pipe conduit that provides equal or greater discharge
- Enter chart, Figure 5.13 with actual pipe discharge. Read across to select smallest riser that provides discharge within weir flow portion of rating curve. Read down to find corresponding  $h$  required. This  $h$  must be 1 foot or less.

### Example:

Given:  $Q$  (required) = 5.8 cfs,  $L$  = 60 ft.,  $H$  = 9 ft. to centerline of pipe = Free outlet  
Find: Pipe size, actual  $Q$  and size of riser, use corrugated metal pipe,  $n$  = 0.025

$Q$  of 12 in. pipe = 5.95 cfs x (correction factor) 1.07 = 6.4 cfs from the Pipe Flow Chart. From Riser Inflow Curves smallest riser = 18 in. (@  $h$  = 0.60).

### Design Example #1

Snooks Pond is a senior citizen assisted living center under construction. A sediment basin will be utilized as a component of the erosion and sediment control plan for the project. The Drainage area to the basin is 20 acres, the one year storm peak discharge is 32 cubic feet per second, and 88 cfs for the 10 year storm based on analysis of the site under maximum construction condition. Design the sediment basin when the overall head ( $H$ ) is 10 feet and the smooth steel pipe spillway is used. An emergency spillway can be constructed on the site. Base the design volumes and elevations on the stage storage

curve developed for the natural topography or as excavated.

### Design Example # 2

Use the same data as example #1, but no emergency spillway is possible.

#### Notes:

1. Use a 1.0 foot minimum between riser crest and emergency spillway crest, thus riser crest = 1.0 ft
2. To provide 50% of the storage as permanent pool, the dewatering orifice is set at the out elevation.

## Part 5 - Temporary Sediment Basin

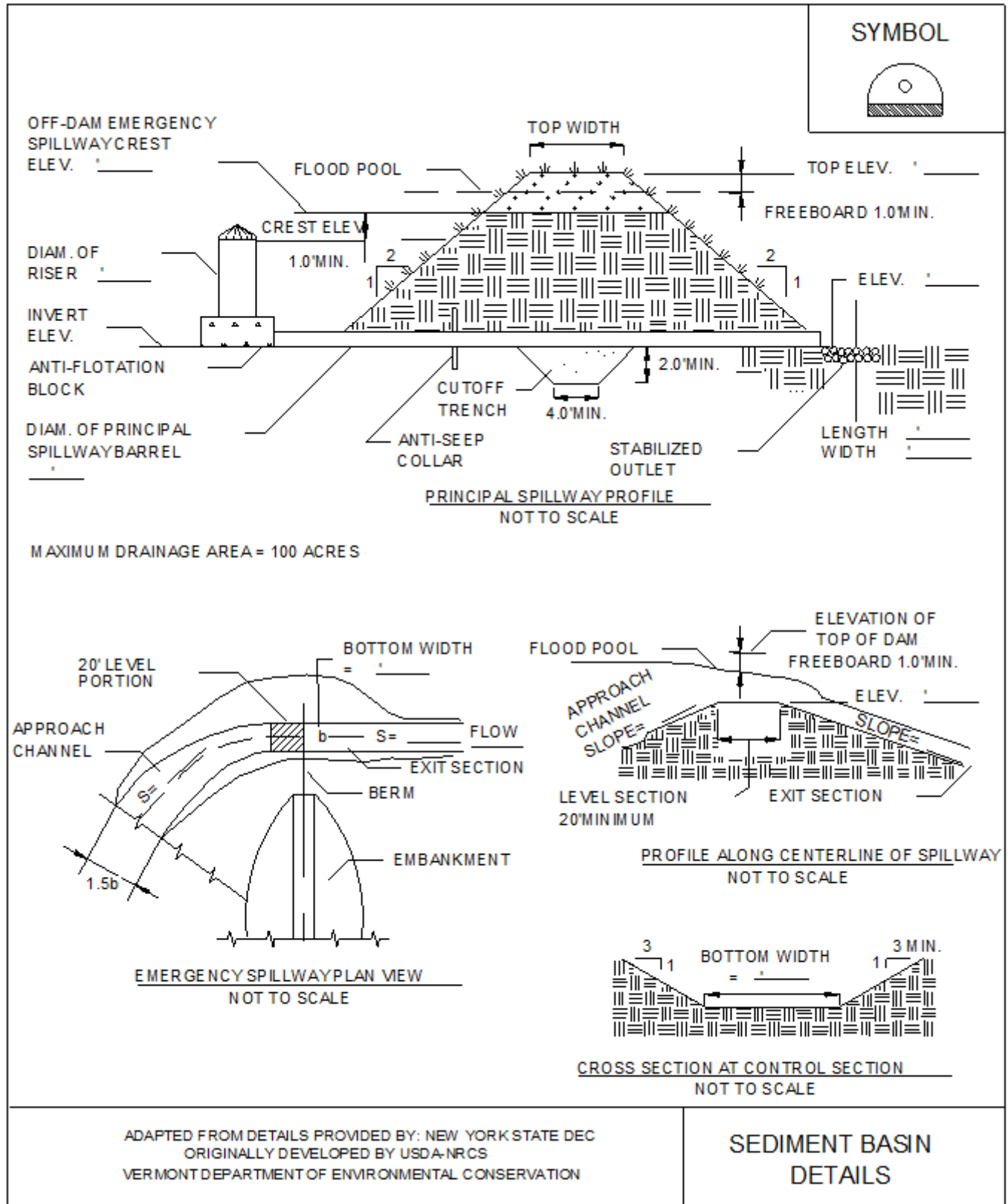


Figure 5.13 Sediment Basin

# Part 5 - Temporary Sediment Basin

## TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET

Computed JQP Date 7-06 Checked by ANR Date 7-06  
 Project HAPPY ACRES  
 Sub Watershed# 3 Location WATERBURY, VT  
 Total Area draining to basin 20 Acres

### BASIN SIZE DESIGN

1. Minimum sediment storage volume = 134 cu. yds. x 20 acres of drainage area = 2,680 cu.yds.
2. a. Cleanout at 50 percent of minimum required volume = 1,340 cu. yds.  
 b. Elevation corresponding to scheduled time to clean out 96.5  
 c. Distance below top of riser 3.5 feet
3. Minimum surface area is larger of 0.01  $Q_{(1)}$  0.32 or, 0.015 DA = 0.30 use 0.32 acres

### DESIGN OF SPILLWAYS & ELEVATIONS

#### Runoff

4.  $Q_{p(10)}$  = 88 cfs  
 (EFH, Ch. 2, TR-55, or Section 4; Attach runoff computation sheet)

#### Pipe Spillway ( $Q_{ps}$ )

5. Min. pipe spillway cap.,  $Q_{ps} = 0.2 \times$  20 ac. Drainage = 4 cfs  
 Note: If there is no emergency spillway, then req'd  $Q_{ps} = Q_{p(10)} = — cfs.  
 6. H = 10 ft. Barrel length = 85 ft  
 7. Barrel: Diam. 12 inches;  $Q_{ps} = (Q)$  10.2 x (cor.fac.) .945 = 9.6 cfs.  
 8. Riser: Diam. 21 inches; Length 9 ft.; h = 1.0 ft. Crest Elev. 100.0  
 9. Trash Rack: Diam. 30 inches; H = 11 inches$

#### Emergency Spillway Design

10. Emergency Spillway Flow,  $Q_{es} = Q_p - Q_{ps} =$  88 - 10 = 78 cfs.  
 11. Width 20 ft.;  $H_p$  1.4 ft Crest elevation 101.0; Design High Water Elev. 102.4  
 Entrance channel slope 2 %; Top of Dam Elev. 103.4  
 Exit channel slope 72.7 %

### ANTI-SEEP COLLAR/

### SEEPAGE DIAPHRAGM DESIGN

#### Collars:

12. y = 8 ft.; z = 2 :1; pipe slope = 1 %,  $L_s =$  50 ft.  
 Use — collars, — inches square; projection = — ft.

#### Diaphragms:

# 1 width 7 ft. height 10 ft.

### DEWATERING ORIFICE SIZING

13.  $A_o = \frac{A_s \times (2h)^{0.5}}{122,568} =$  0.30 sq. ft.; h = 3.5 ft.; therefore use, 7.4" → USE 6" ORIFICE

Figure 5.14a Sediment Basin Design Example #1

# Part 5 - Temporary Sediment Basin

## TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET

Computed JQP Date 7-06 Checked by ANR Date 7-06  
 Project HAPPY ACRES  
 Sub Watershed# 4 Location WATERBURY, VT  
 Total Area draining to basin 20 Acres

### BASIN SIZE DESIGN

- Minimum sediment storage volume = 134 cu. yds. x 20 acres of drainage area = 2,680 cu.yds.
- a. Cleanout at 50 percent of minimum required volume = 1,340 cu. yds.  
 b. Elevation corresponding to scheduled time to clean out 96.5  
 c. Distance below top of riser 3.5 feet
- Minimum surface area is larger of 0.01  $Q_{(1)}$  0.32 or, 0.015 DA = 0.30 use 0.32 acres

### DESIGN OF SPILLWAYS & ELEVATIONS

#### Runoff

4.  $Q_{p(10)}$  = 88 cfs  
 (EFH, Ch. 2, TR-55, or Section 4; Attach runoff computation sheet)

#### Pipe Spillway ( $Q_{ps}$ )

5. Min. pipe spillway cap.,  $Q_{ps} = 0.2 \times$  20 ac. Drainage = 4 cfs  
 Note: If there is no emergency spillway, then req'd  $Q_{ps} = Q_{p(10)}$  = \_\_\_\_\_ cfs.  
 6. H = 10 ft. Barrel length = 85 ft  
 7. Barrel: Diam. 36 inches;  $Q_{ps} = (Q)$  91.2 x (cor.fac.) 0.955 = 87.1 cfs.  
 8. Riser: Diam. 54 inches; Length 9 ft.; h = 1.7 ft. Crest Elev. 100.0  
 9. Trash Rack: Diam. 78 inches; H = 25 inches

#### Emergency Spillway Design

10. Emergency Spillway Flow,  $Q_{es} = Q_p - Q_{ps}$  = \_\_\_\_\_ - \_\_\_\_\_ = \_\_\_\_\_ cfs.  
 11. Width \_\_\_\_\_ ft.;  $H_p$  \_\_\_\_\_ ft Crest elevation \_\_\_\_\_; Design High Water Elev. \_\_\_\_\_  
 Entrance channel slope \_\_\_\_\_ %; Top of Dam Elev. \_\_\_\_\_  
 Exit channel slope \_\_\_\_\_ %

### ANTI-SEEP COLLAR/ SEEPAGE DIAPHRAGM DESIGN

#### Collars:

12. y = 8 ft.; z = 2:1; pipe slope = 1 %,  $L_s$  = 50 ft.  
 Use 2 collars, 4' - 6 inches square; projection = 1.8 ft.

#### Diaphragms:

# 1 width 7 ft. height 10 ft.

### DEWATERING ORIFICE SIZING

13.  $A_o = \frac{A_s \times (2h)^{0.5}}{122,568}$  = 0.30 sq. ft.; h = 3.5 ft.; therefore use, 7.4" → USE 6" ORIFICE

Figure 5.14b Sediment Basin Design Example #2

## Part 5 - Riser Inflow Chart

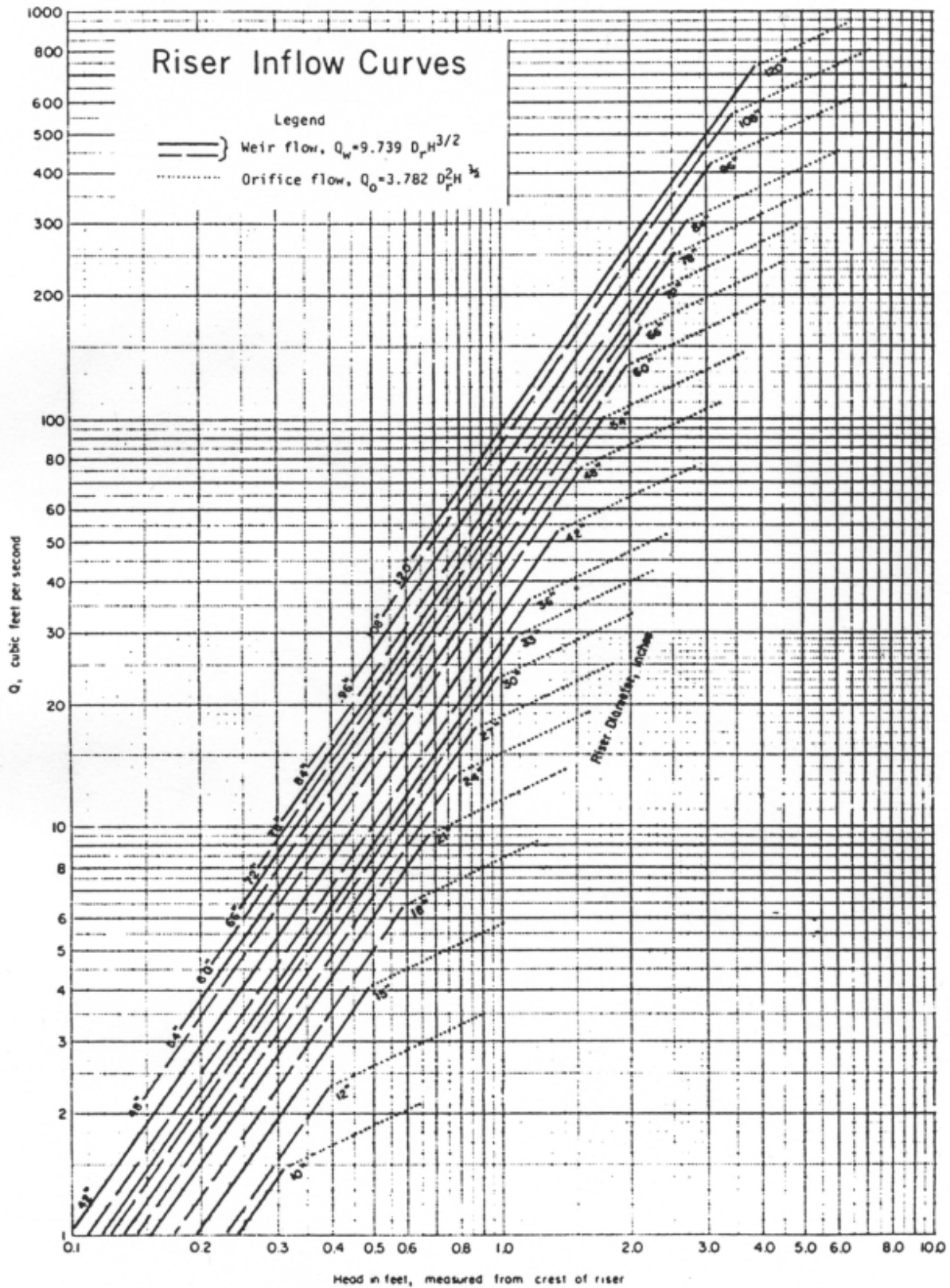


Figure 5.15 Riser Inflow Chart (USDA-NRCS)

# Part 5 - Pipe Flow Chart

PIPE FLOW CHART  $n = 0.025$   
FOR CORRUGATED METAL PIPE INLET  $K_m = K_e + K_b = 1.0$  AND 70 FEET OF CORRUGATED METAL PIPE CONDUIT (full flow assumed)  
Note: correction factors for pipe lengths other than 70 feet

H, in feet	6"	8"	10"	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"	102"										
1	0.33	0.70	1.25	1.90	3.48	5.47	7.99	11.0	18.8	28.8	41.1	55.7	72.6	91.8	113	137	163	191	222	255	290										
2	0.47	0.99	1.76	2.80	4.92	7.74	11.3	15.6	26.6	40.8	58.2	78.8	103	130	160	194	231	271	314	360	410										
3	0.58	1.22	2.16	3.43	6.02	9.48	13.8	19.1	32.6	49.7	71.2	96.5	126	159	196	237	282	331	384	441	502										
4	0.67	1.40	2.49	3.97	6.96	10.9	16.0	22.1	37.6	57.7	82.3	111	145	184	226	274	326	383	444	510	580										
5	0.74	1.57	2.79	4.41	7.78	12.2	17.9	24.7	42.1	64.5	92.0	125	162	205	253	306	365	428	496	570	648										
6	0.82	1.72	3.05	4.86	8.52	13.4	19.6	27.0	46.1	70.6	101	136	178	225	277	336	399	469	544	624	710										
7	0.88	1.86	3.30	5.25	9.20	14.5	21.1	29.2	49.8	76.3	109	147	192	243	300	362	431	506	587	674	767										
8	0.94	1.99	3.53	5.61	9.84	15.5	22.6	31.2	53.2	81.5	116	158	205	260	320	388	461	541	628	721	820										
9	1.00	2.11	3.74	5.95	10.4	16.4	24.0	33.1	56.4	86.5	123	167	218	275	340	411	489	574	666	764	870										
10	1.05	2.22	3.94	6.27	11.0	17.3	25.3	34.9	59.5	91.2	130	176	230	290	358	433	516	605	702	806	917										
11	1.10	2.33	4.13	6.58	11.5	18.2	26.5	36.6	62.4	95.6	136	185	241	304	376	454	541	635	736	845	962										
12	1.15	2.43	4.32	6.87	12.1	19.0	27.7	38.2	65.2	99.9	142	193	252	318	392	475	565	663	769	883	1004										
13	1.20	2.53	4.49	7.15	12.6	19.7	28.8	39.8	67.8	104	148	201	262	331	408	494	588	690	800	919	1045										
14	1.25	2.63	4.66	7.42	13.0	20.5	29.9	41.3	70.4	108	154	208	272	343	424	513	610	716	830	953	1085										
15	1.29	2.72	4.83	7.68	13.5	21.2	30.9	42.8	72.8	112	159	216	281	355	439	531	631	741	860	987	1123										
16	1.33	2.81	4.99	7.93	13.9	21.9	32.0	44.2	75.2	115	165	223	290	367	453	548	652	765	888	1019	1160										
17	1.37	2.90	5.14	8.18	14.3	22.6	32.9	45.5	77.5	119	170	230	299	378	467	565	672	789	915	1051	1195										
18	1.41	2.98	5.29	8.41	14.8	23.2	33.9	46.8	79.8	120	174	236	308	389	480	581	692	812	942	1081	1230										
19	1.45	3.06	5.43	8.64	15.2	23.9	34.8	48.1	82.0	126	179	243	316	400	494	597	711	834	967	1111	1264										
20	1.49	3.14	5.57	8.87	15.6	24.5	35.7	49.4	84.1	129	184	249	325	410	506	613	729	856	993	1139	1297										
21	1.53	3.22	5.71	9.09	15.9	25.1	36.6	50.6	86.2	132	188	255	333	421	519	628	747	877	1017	1168	1329										
22	1.56	3.29	5.85	9.30	16.3	25.7	37.5	51.8	88.2	135	193	261	341	430	531	643	765	898	1041	1195	1360										
23	1.60	3.37	5.98	9.51	16.7	26.2	38.3	53.0	90.2	138	197	267	348	440	543	657	782	918	1064	1222	1390										
24	1.63	3.44	6.11	9.72	17.0	26.8	39.1	54.1	92.1	141	201	273	356	450	555	671	799	937	1087	1248	1420										
25	1.66	3.51	6.23	9.92	17.4	27.4	39.9	55.2	94.0	144	206	279	363	459	566	685	815	957	1110	1274	1450										
26	1.70	3.58	6.36	10.1	17.7	27.9	40.7	56.3	95.9	147	210	284	370	468	577	699	831	976	1132	1299	1478										
27	1.73	3.65	6.48	10.3	18.1	28.4	41.5	57.4	97.7	150	214	290	377	477	588	712	847	994	1153	1324	1507										
28	1.76	3.72	6.60	10.5	18.4	29.0	42.3	58.4	99.5	153	218	295	384	486	599	725	863	1013	1174	1348	1534										
29	1.79	3.78	6.71	10.7	18.7	29.5	43.0	59.5	101	155	221	300	391	494	610	738	878	1030	1195	1372	1561										
30	1.82	3.85	6.83	10.9	19.1	30.0	43.7	60.5	103	158	225	305	398	503	620	750	893	1048	1216	1396	1588										
L, in feet																						Correction Factors For Other Pipe Lengths									
20	1.69	1.63	1.58	1.53	1.47	1.42	1.37	1.34	1.28	1.24	1.20	1.18	1.16	1.14	1.13	1.11	1.10	1.09	1.08	1.08	1.08										
30	1.44	1.41	1.39	1.36	1.32	1.29	1.27	1.24	1.21	1.18	1.15	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.07	1.06	1.06										
40	1.26	1.27	1.25	1.23	1.21	1.20	1.18	1.17	1.14	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.05	1.05	1.05	1.04										
50	1.16	1.16	1.15	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.05	1.05	1.04	1.04	1.04	1.03	1.03	1.03										
60	1.07	1.07	1.07	1.06	1.06	1.05	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.01										
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00										
80	.94	.94	.95	.95	.95	.95	.96	.96	.96	.97	.97	.97	.98	.98	.98	.98	.98	.98	.99	.99	.99										
90	.89	.89	.90	.90	.91	.91	.92	.92	.93	.94	.94	.95	.95	.96	.96	.96	.97	.97	.97	.97	.97										
100	.85	.85	.86	.86	.87	.88	.88	.89	.90	.91	.92	.93	.93	.94	.94	.95	.95	.96	.96	.96	.94										
120	.78	.79	.79	.80	.81	.82	.83	.83	.85	.86	.87	.89	.89	.90	.91	.91	.92	.93	.93	.94	.92										
140	.72	.73	.74	.75	.76	.77	.78	.79	.81	.82	.84	.85	.86	.87	.88	.88	.89	.90	.91	.91	.90										
160	.68	.69	.69	.70	.71	.73	.74	.75	.77	.79	.80	.82	.83	.84	.85	.85	.87	.88	.89	.89	.89										

Figure 5.16 Pipe Flow Chart; "n" = 0.025 (USDA-NRCS)

# Part 5 - Pipe Flow Chart

PIPE FLOW CHART  $n = 0.013$   
FOR REINFORCED CONCRETE PIPE INLET  $K_{in} = K_b + K_d = 1.00$  AND 70 FEET OF REINFORCED CONCRETE PIPE CONDUIT (full flow assumed)

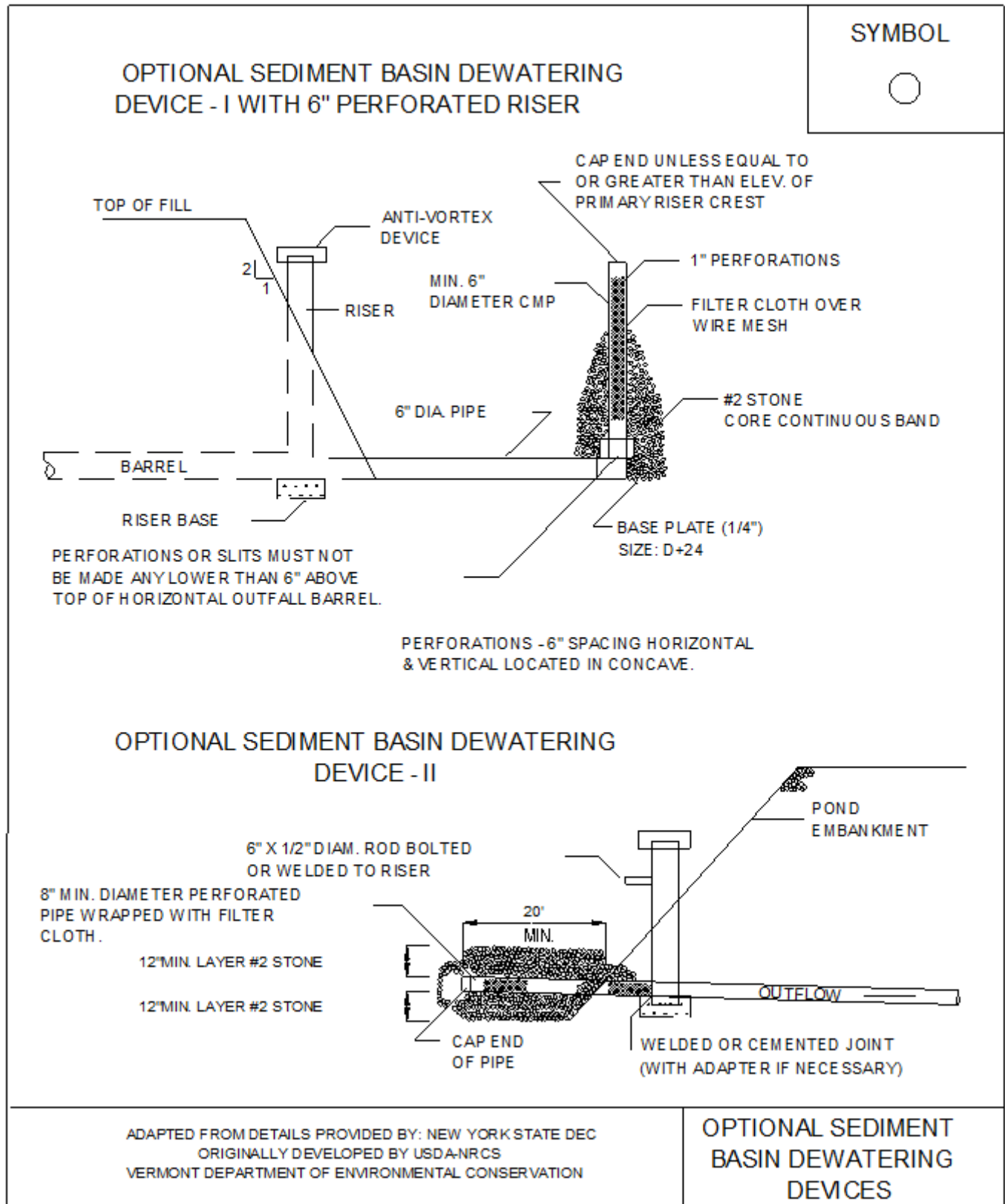
Note: correction factors for pipe lengths other than 70 feet  
diameter of pipe in inches

H, in feet	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"	102"
1	3.22	5.44	8.29	11.8	15.9	26.0	38.6	53.8	71.4	91.5	114	139	167	197	229	264	302	342
2	4.55	7.69	11.7	16.7	22.5	36.8	54.6	76.0	101	129	161	197	236	278	324	374	427	483
3	5.57	9.42	14.4	20.4	27.5	45.0	66.9	93.1	124	159	198	241	289	341	397	458	523	592
4	6.43	10.9	16.6	23.5	31.8	52.0	77.3	108	143	183	228	278	334	394	459	529	604	683
5	7.19	12.2	18.5	26.3	35.5	58.1	86.4	120	160	205	255	311	373	440	513	591	675	764
6	7.88	13.3	20.3	28.8	38.9	63.7	94.6	132	175	224	280	341	409	482	562	647	739	837
7	8.51	14.4	21.9	31.1	42.0	68.8	102	142	189	242	302	368	441	521	607	699	798	904
8	9.10	15.4	23.5	33.3	44.9	73.5	109	152	202	259	323	394	472	557	648	748	854	966
9	9.65	16.3	24.9	35.3	47.7	78.0	116	161	214	275	342	418	500	590	688	793	905	1025
10	10.2	17.2	26.2	37.2	50.2	82.2	122	170	226	289	361	440	527	622	725	836	954	1080
11	10.7	18.0	27.5	39.0	52.7	86.2	128	178	237	304	379	462	553	653	761	877	1001	1133
12	11.1	18.9	28.7	40.8	55.0	90.1	134	186	247	317	395	482	578	682	794	916	1045	1184
13	11.6	19.6	29.9	42.4	57.3	93.7	139	194	257	330	411	502	601	710	827	953	1088	1232
14	12.0	20.4	31.0	44.1	59.4	97.3	145	201	267	342	427	521	624	736	858	989	1129	1278
15	12.5	21.1	32.1	45.6	61.5	101	150	208	277	354	442	539	646	762	888	1024	1169	1323
16	12.9	21.8	33.2	47.1	63.5	104	155	215	286	366	457	557	668	787	917	1057	1207	1367
17	13.3	22.4	34.2	48.5	65.5	107	159	222	294	377	471	574	688	812	946	1090	1244	1409
18	13.7	23.1	35.2	49.9	67.4	110	164	228	303	388	484	591	708	835	973	1121	1280	1450
19	14.0	23.7	36.1	51.3	69.2	113	168	234	311	399	497	607	727	858	1000	1152	1315	1489
20	14.4	24.3	37.1	52.6	71.0	116	173	240	319	409	510	623	746	880	1026	1182	1350	1528
21	14.7	24.9	38.0	53.9	72.8	119	177	246	327	419	523	638	764	902	1051	1211	1383	1566
22	15.1	25.5	38.9	55.2	74.5	122	181	252	335	429	535	653	782	923	1076	1240	1415	1603
23	15.4	26.1	39.8	56.5	76.2	125	186	258	342	439	547	668	800	944	1100	1268	1447	1639
24	15.8	26.7	40.6	57.7	77.8	127	189	263	350	448	559	682	817	964	1123	1295	1478	1674
25	16.1	27.2	41.5	58.9	79.4	130	193	269	357	458	571	696	834	984	1147	1322	1509	1708
26	16.4	27.7	42.3	60.0	81.0	133	197	274	364	467	582	710	850	1004	1169	1348	1539	1742
27	16.7	28.1	43.1	61.2	82.5	135	201	279	371	476	593	723	867	1023	1192	1373	1568	1775
28	17.0	28.6	43.9	62.3	84.1	138	204	285	378	484	604	737	883	1041	1214	1399	1597	1808
29	17.3	29.3	44.7	63.4	85.5	140	208	290	384	493	615	750	898	1060	1235	1423	1625	1840
30	17.6	29.8	45.4	64.5	87.0	142	212	294	391	501	625	763	913	1078	1256	1448	1653	1871
L, in feet	20	1.30	1.24	1.21	1.18	1.15	1.12	1.10	1.08	1.07	1.06	1.05	1.05	1.04	1.04	1.03	1.03	1.03
30	1.22	1.18	1.15	1.13	1.12	1.09	1.08	1.06	1.05	1.05	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02
40	1.15	1.13	1.11	1.10	1.08	1.07	1.05	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.01	1.01	1.01	1.01
50	1.09	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01
60	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	.96	.97	.97	.97	.98	.98	.98	.98	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99
90	.93	.94	.94	.94	.95	.95	.95	.95	.96	.96	.96	.96	.96	.96	.96	.96	.96	.96
100	.90	.91	.92	.92	.93	.93	.93	.93	.94	.94	.94	.94	.94	.94	.94	.94	.94	.94
120	.86	.86	.87	.87	.88	.88	.88	.88	.89	.89	.89	.89	.89	.89	.89	.89	.89	.89
140	.80	.82	.83	.83	.84	.84	.84	.84	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85
160	.76	.78	.80	.80	.81	.81	.81	.81	.82	.82	.82	.82	.82	.82	.82	.82	.82	.82

Correction Factors For Other Pipe Lengths

Figure 5.17 Pipe Flow Chart; "n" = 0.013 (USDA-NRCS)

## Part 5 - Optional Sediment Basin Dewatering



**Figure 5.18 Optional Sediment Basin Dewatering Methods**

## Part 5 - Concentric Trash Rack and Anti-Vortex Device

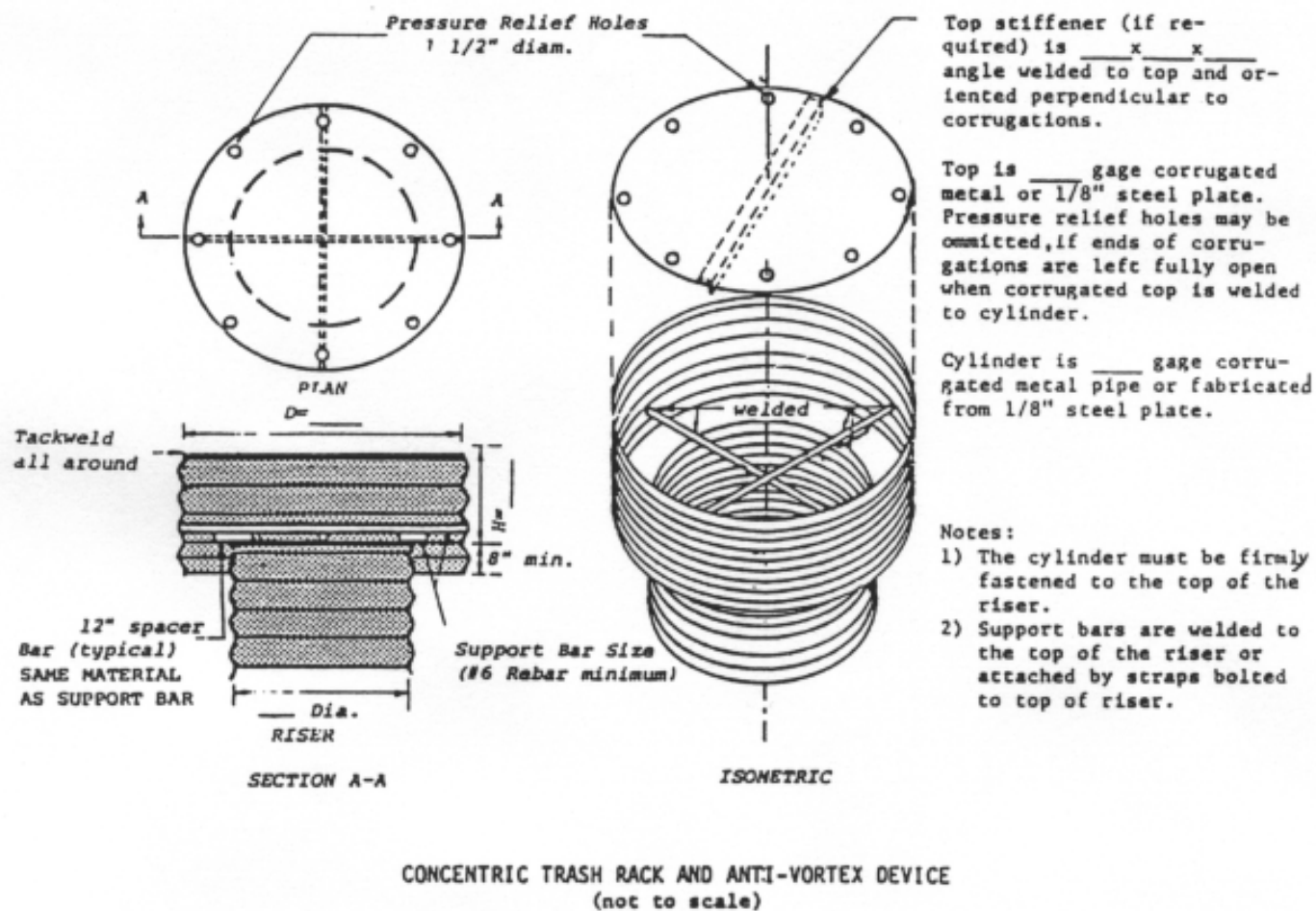


Figure 5.19 Concentric Trash Rack and Anti-Vortex Device (USDA-NRCS)

## Part 5 - Concentric Trash Rack and Anti-Vortex Device

Riser Diam.(in.)	Cylinder Diam.(in.)	Thick. Gage	H.(in.)	Minimum Size Support Bar	Minimum Top Thickness	Stiffener
12	18	16	6	#6 Rebar	16 ga.	—
15	21	16	7	#6 Rebar	16 ga.	—
18	27	16	8	#6 Rebar	16 ga.	—
21	30	16	11	#6 Rebar	16 ga.	—
24	36	16	13	#6 Rebar	14 ga.	—
27	42	16	15	#6 Rebar	14 ga.	—
36	54	14	17	#8 Rebar	12 ga.	—
42	60	14	19	#8 Rebar	12 ga.	—
48	72	12	21	1 1/4" pipe or 1 1/4x1 1/4x1/4 angle	10 ga.	—
54	78	12	25	See 48" Riser	10 ga.	—
60	90	12	29	1 1/2" pipe or 1 1/2x1 1/2x1/2 angle	8 ga.	—
66	96	10	33	2" pipe or 2x2x3/16 angle	8 ga. w/stiffener	2x2x1/4 angle
72	102	10	36	—See 66" Riser—		2 1/2x2 1/2x1/4 angle
78	114	10	39	2 1/2" pipe or 2x2x1/4 angle	See 72" Riser	See 72" Riser
84	120	10	42	2 1/2" pipe or 2 1/2x2 1/2x1/4 angle	See 72" Riser	2 1/2x 5/16 angle

Note: The criteria for sizing the cylinder is that the area between the inside of the cylinder and the outside of the riser is equal to or greater than the area inside the riser. Therefore, the above table is invalid for use with concrete pipe risers.

Figure 5.20 Concentric Trash Rack and Anti-Vortex Device Design Table (USDA-NRCS)

## Part 5 - Riser Base Detail - Sediment Basin

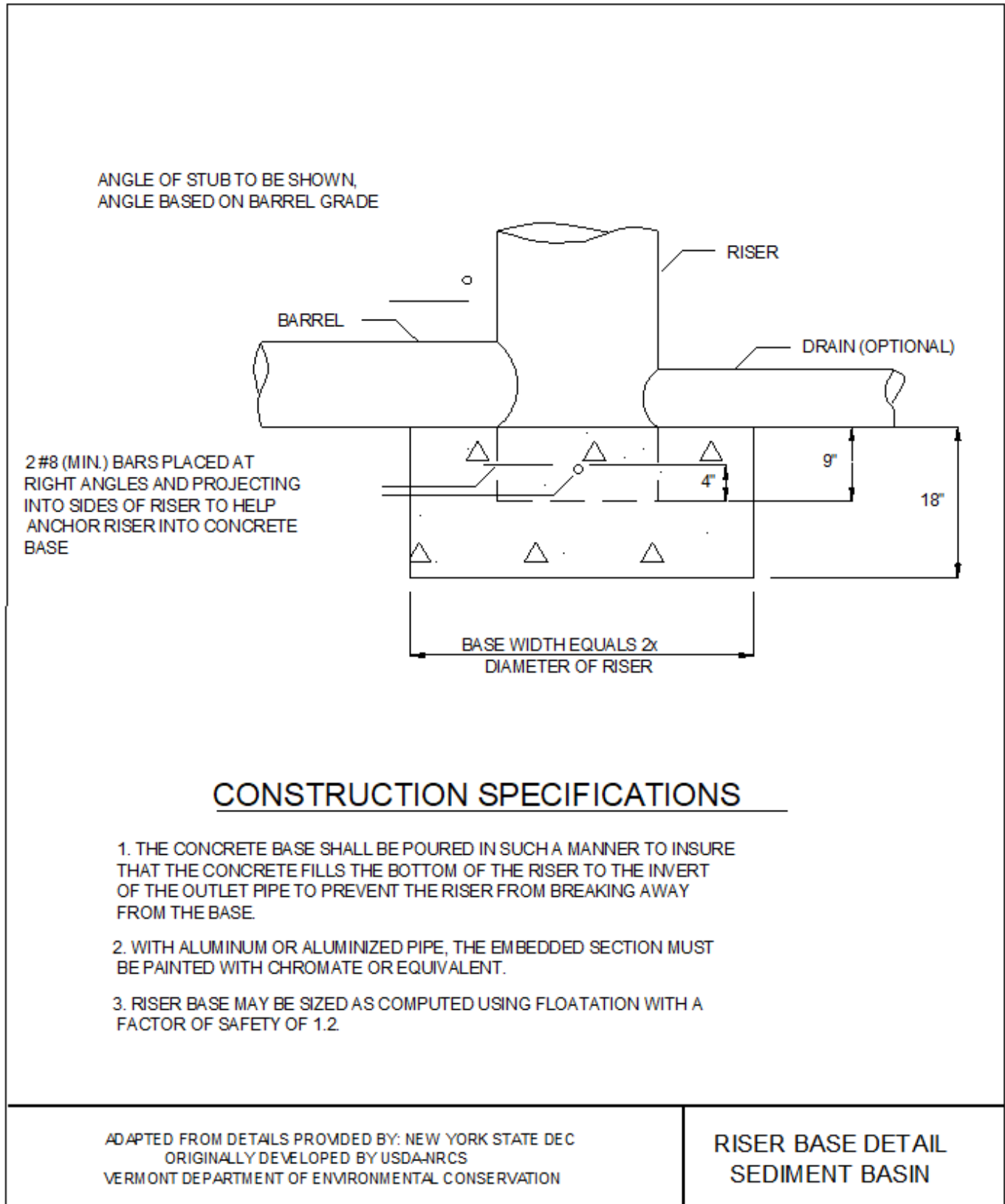


Figure 5.21 Riser Base Detail - Sediment Basin

## Part 5 - Anti-Seep Collar Design

This procedure provides the anti-seep collar dimensions for only temporary sediment basins to increase the seepage length by 15% for various pipe slopes, embankment slopes and riser heights.

The first step in designing anti-seep collars is to determine the length of pipe within the saturated zone of the embankment. This can be done graphically or by the following equation, assuming that the upstream slope of the embankment intersects the invert of the pipe at its upstream end. (See embankment-invert intersection on the drawing below:

$$L_s = y (z + 4) \left[ 1 + \frac{\text{pipe slope}}{0.25 - \text{pipe slope}} \right]$$

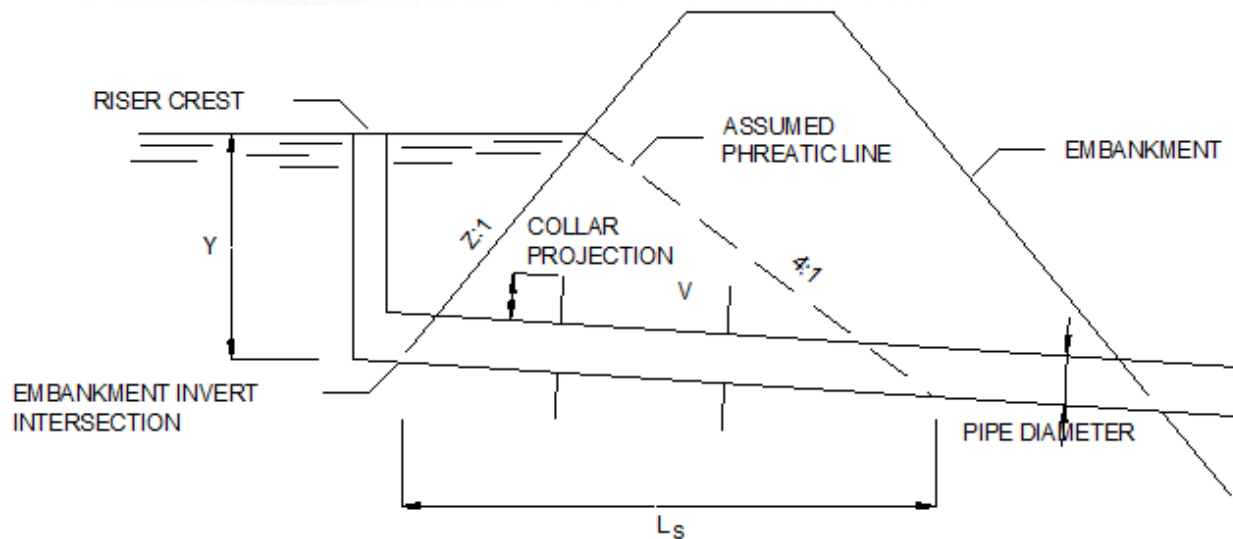
Where:  $L_s$  = length of pipe in the saturated zone (ft.)

$y$  = distance in feet from upstream invert of pipe to highest normal water level expected to occur during the life of the structure, usually the top of the riser.

$z$  = slope of upstream embankment as a ratio of  $z$  ft. horizontal to one ft. vertical.

pipe slope = slope of pipe in feet per foot.

This procedure is based on the approximation of the phreatic line as shown in the drawing below:



ADAPTED FROM DETAILS PROVIDED BY: NEW YORK STATE DEC  
ORIGINALLY DEVELOPED BY USDA-NRCS  
VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION

ANTI-SEEP  
COLLAR DESIGN

Figure 5.22a Anti-Seep Collar Design

## Part 5 - Anti-Seep Collar Design

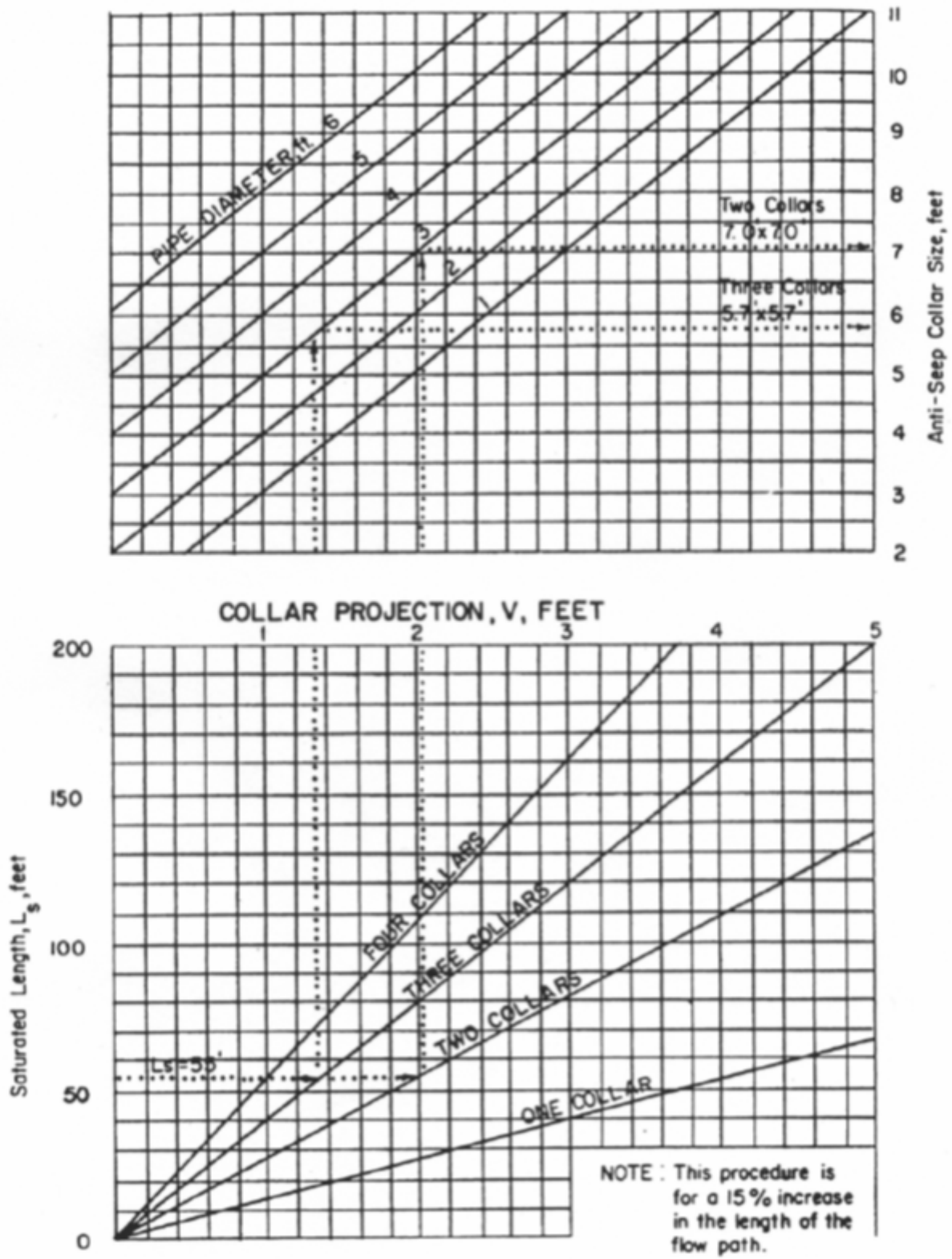


Figure 5.22b Anti-Seep Collar Design Charts (USDA-NRCS)

## Part 5 - Anti-Seep Collar Design

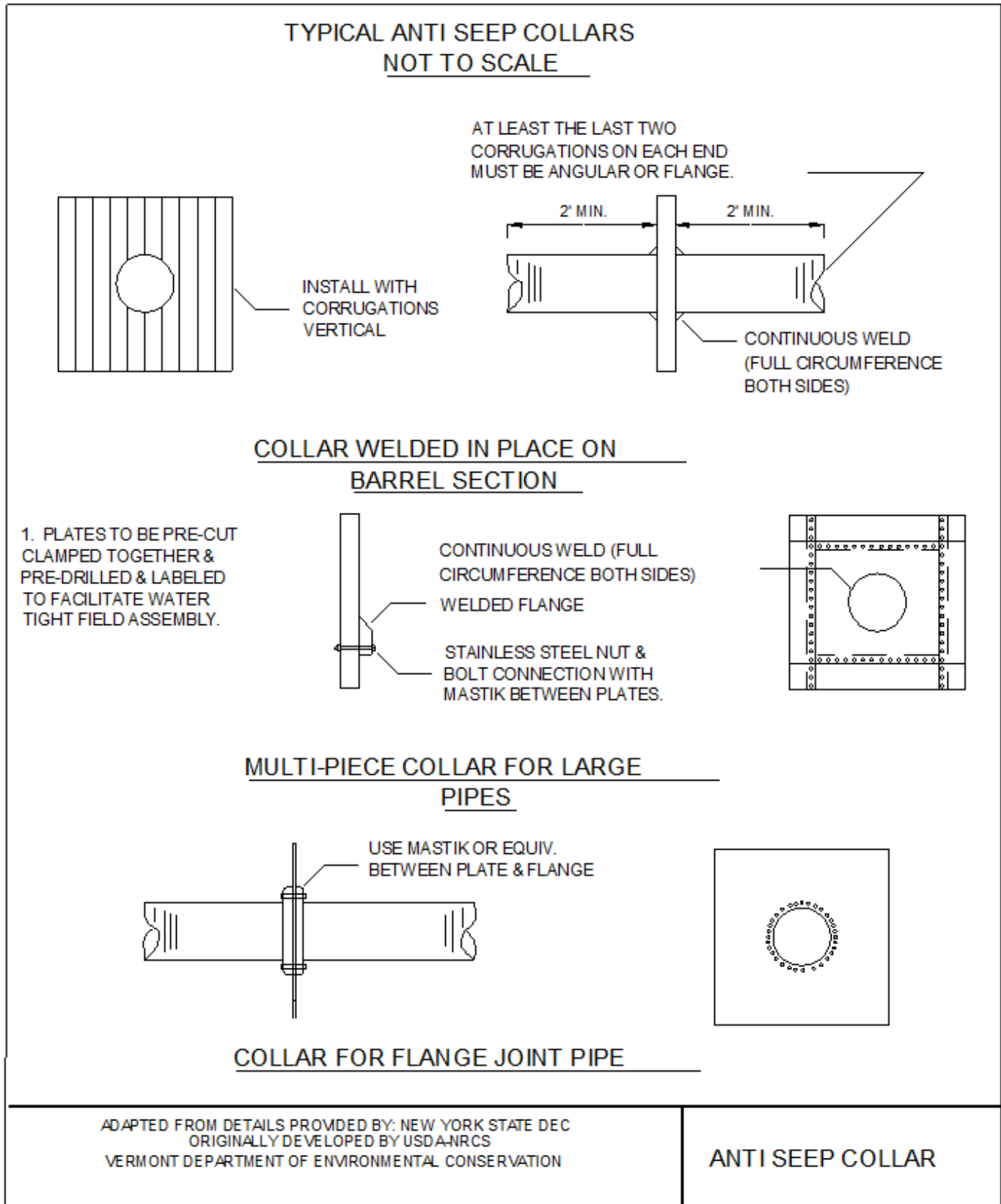
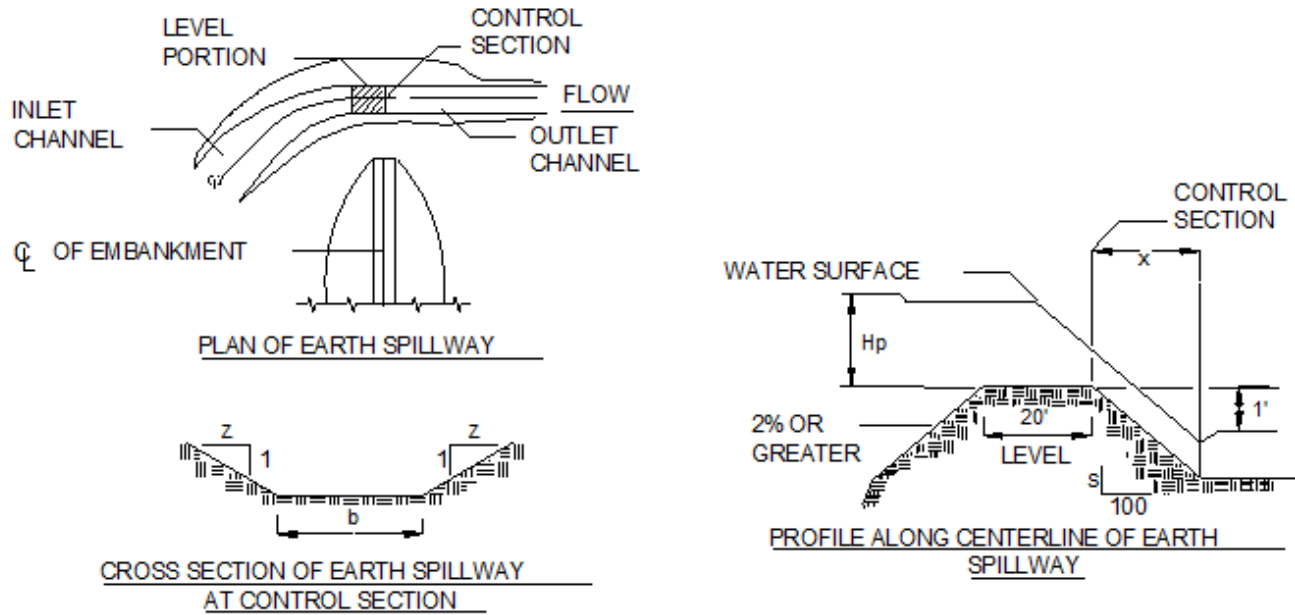


Figure 5.22c Anti-Seep Collar Design (USDA-NRCS)

## Part 5 - Earth Spillway Design



### LEGEND

$n$  = MANNING'S COEFFICIENT OF ROUGHNESS.

$H_p$  = DIFFERENCE IN ELEVATION BETWEEN CREST OF EARTH SPILLWAY AT THE CONTROL SECTION AND WATER SURFACE IN RESERVOIR, IN FEET.

$b$  = BOTTOM WIDTH OF EARTH SPILLWAY AT THE CONTROL SECTION, IN FEET.

$Q$  = TOTAL DISCHARGE, IN cfs.

$V$  = VELOCITY, IN FEET PER SECOND, THAT WILL EXIST IN CHANNEL BELOW CONTROL SECTION, AT DESIGN  $Q$ , IF CONSTRUCTED TO SLOPE ( $S$ ) THAT IS SHOWN.

$S$  = FLATTEST SLOPE ( $S$ ), IN %, ALLOWABLE FOR CHANNEL BELOW CONTROL SECTION.

$X$  = MINIMUM LENGTH OF CHANNEL BELOW CONTROL SECTION, IN FEET.

$z$  = SIDE SLOPE RATIO.

### NOTES:

1) FOR A GIVEN  $H_p$  A DECREASE IN THE EXIT SLOPE FROM  $S$  AS GIVEN IN THE TABLE DECREASES SPILLWAY DISCHARGE BUT INCREASING THE EXIT SLOPE FROM  $S$  DOES NOT INCREASE DISCHARGE. IF AN EXIT SLOPE ( $S_e$ ) STEEPER THAN  $S$  IS USED, THEN VELOCITY ( $V_e$ ) IN THE EXIT CHANNEL WILL INCREASE ACCORDING TO THE FOLLOWING RELATIONSHIP:

$$V_e = V \cdot 0.3 \left( \frac{S_e}{S} \right)$$

ADAPTED FROM DETAILS PROVIDED BY: NEW YORK STATE DEC  
ORIGINALLY DEVELOPED BY USDA-NRCS  
VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION

DESIGN DATA FOR  
EARTH SPILLWAYS

Figure 5.23a Design Data for Earth Spillways

## Part 5 - Vegetated Spillway Design Data

Discharge Q CFS	Slope Range		Bottom Width Feet	Stage Feet	Discharge Q CFS	Slope Range		Bottom Width Feet	Stage Feet
	Minimum Percent	Maximum Percent				Minimum Percent	Maximum Percent		
15	3.3	12.2	8	.83	80	2.8	5.2	24	1.24
	3.5	18.2	12	.89		2.8	5.9	28	1.14
20	3.1	8.9	8	.97		2.9	7.0	32	1.08
	3.2	13.0	12	.81	90	2.5	2.8	12	1.84
	3.3	17.3	16	.70		2.5	3.1	16	1.61
25	2.9	7.1	8	1.09		2.6	3.8	20	1.45
	3.2	9.9	12	.91		2.7	4.5	24	1.32
	3.3	13.2	16	.79		2.8	5.3	28	1.22
	3.3	17.2	20	.70		2.8	6.1	32	1.14
30	2.9	6.0	8	1.20	100	2.5	2.8	16	1.71
	3.0	8.2	12	1.01		2.6	3.3	20	1.54
	3.0	10.7	16	.88		2.6	4.0	24	1.41
	3.3	13.8	20	.78		2.7	4.8	28	1.30
35	2.8	5.1	8	1.30		2.7	5.3	32	1.21
	2.9	6.9	12	1.10		2.8	6.1	36	1.13
	3.1	9.0	16	.94	120	2.5	2.8	20	1.71
	3.1	11.3	20	.85		2.6	3.2	24	1.56
	3.2	14.1	24	.77		2.7	3.8	28	1.44
40	2.7	4.5	8	1.40		2.7	4.2	32	1.34
	2.9	6.0	12	1.18		2.7	4.8	36	1.26
	2.9	7.6	16	1.03	140	2.5	2.7	24	1.71
	3.1	9.7	20	.91		2.5	3.2	28	1.58
	3.1	11.9	24	.83		2.6	3.6	32	1.47
45	2.8	4.1	8	1.49		2.6	4.0	36	1.38
	2.8	5.3	12	1.25		2.7	4.5	40	1.30
	2.9	6.7	16	1.09	160	2.5	2.7	28	1.70
	3.0	8.4	20	.96		2.5	3.1	32	1.58
	3.0	10.4	24	.89		2.6	3.4	36	1.49
50	2.7	3.7	8	1.57		2.6	3.8	40	1.40
	2.8	4.7	12	1.33		2.7	4.3	44	1.33
	2.8	6.0	16	1.16	180	2.4	2.7	32	1.72
	2.9	7.3	20	1.03		2.4	3.0	36	1.60
	3.1	9.0	24	.94		2.5	3.4	40	1.51
60	2.6	3.1	8	1.73		2.6	3.7	44	1.43
	2.7	3.9	12	1.47	200	2.5	2.7	36	1.70
	2.7	4.8	16	1.28		2.5	2.9	40	1.60
	2.9	5.9	20	1.15		2.5	3.3	44	1.52
	2.9	7.3	24	1.05		2.6	3.6	48	1.45
	3.0	8.6	28	.97	220	2.4	2.6	40	1.70
70	2.5	2.8	8	1.88		2.5	2.9	44	1.61
	2.6	3.3	12	1.60		2.5	3.2	48	1.53
	2.6	4.1	16	1.40	240	2.5	2.6	44	1.70
	2.7	5.0	20	1.26		2.5	2.9	48	1.62
	2.8	6.1	24	1.15		2.6	3.2	52	1.54
	2.9	7.0	28	1.05	260	2.4	2.6	48	1.70
80	2.5	2.9	12	1.72		2.5	2.9	52	1.62
	2.6	3.6	16	1.51	280	2.4	2.6	52	1.70
	2.7	4.3	20	1.35	300	2.5	2.6	56	1.69

Figure 5.23b Design Data for Vegetated Spillways Excavated in Erosion Resistant Soils

Side Slopes of 3 horizontal: 1 vertical (USDA-NRCS)

## Part 5 - Vegetated Spillway Design Data

Discharge Q CFS	Slope Range		Bottom Width Feet	Stage Feet
	Minimum Percent	Maximum Percent		
10	3.5	4.7	8	.68
15	3.4	4.4	12	.69
	3.4	5.9	16	.60
20	3.3	3.3	12	.80
	3.3	4.1	16	.70
	3.5	5.3	20	.62
25	3.3	3.3	16	.79
	3.3	4.0	20	.70
	3.5	4.9	24	.64
30	3.3	3.3	20	.78
	3.3	4.0	24	.71
	3.4	4.7	28	.65
	3.4	5.5	32	.61
35	3.2	3.2	24	.77
	3.3	3.9	28	.71
	3.5	4.6	32	.66
	3.5	5.2	36	.62
40	3.3	3.3	28	.76
	3.4	3.8	32	.71
	3.4	4.4	36	.67
	3.4	5.0	40	.64
45	3.3	3.3	32	.76
	3.4	3.8	36	.71
	3.4	4.3	40	.67
	3.4	4.8	44	.64
50	3.3	3.3	36	.75
	3.3	3.8	40	.71
	3.3	4.3	44	.68
60	3.2	3.2	44	.75
	3.2	3.7	48	.72
70	3.3	3.3	52	.75
80	3.1	3.1	56	.78

**Figure 5.23c Design Data for Vegetated Spillways Excavated in Very Erodible Soils**

Side Slopes of 3 horizontal: 1 vertical (USDA-NRCS)

## Part 5 - Procedure for Determining or Altering Sediment Basin Shape

As specified in the Standard and Specification, the pool area at the elevation of the crest of the principal spillway shall have a length to width ratio of at least 2.0 to 1. The purpose of this requirement is to minimize the “short circuiting” effect of the sediment laden inflow to the riser and thereby increase the effectiveness of the sediment basin. The purpose of this procedure is to prescribe the parameters, procedures, and methods of determining and modifying the shape of the basin.

The length of the flow path ( $L$ ) is the distance from the point of inflow to the riser (outflow point). The point of inflow is the point that the stream enters the normal pool (pool level at the riser crest elevation). The pool area ( $A$ ) is the area of the normal pool. The effective width ( $W_e$ ) is found by the equation:

$$W_e = A/L \text{ and } L:W \text{ ratio} = L/W_e$$

In the event there is more than one inflow point, any inflow point that conveys more than 30 percent of the total peak inflow rate shall meet the length to width ratio criteria.

The required basin shape may be obtained by proper site selection by excavation or by constructing a baffle in the basin. The purpose of the baffle is to increase the effective flow length from the inflow point to the riser. Baffles (see Figure 5.24 on following page) shall be placed midway between the inflow point around the end of the baffle to the outflow point.

Then:

$$W_e = A/L_e \text{ and } L:W \text{ ratio} = L_e/W_e$$

Three examples are shown on the following page. Note that for the special case in example C the water is allowed to go around both ends of the baffle and the effective length,  $L_e = L_1 + L_2$ . Otherwise, the length to width ratio computations are the same as shown

above. This special case procedure for computing  $L_e$  is allowable only when the two flow paths are equal, i.e., when  $L_1 = L_2$ .

## Part 5 - Sediment Basin Baffle

Examples: Plan Views - not to scale

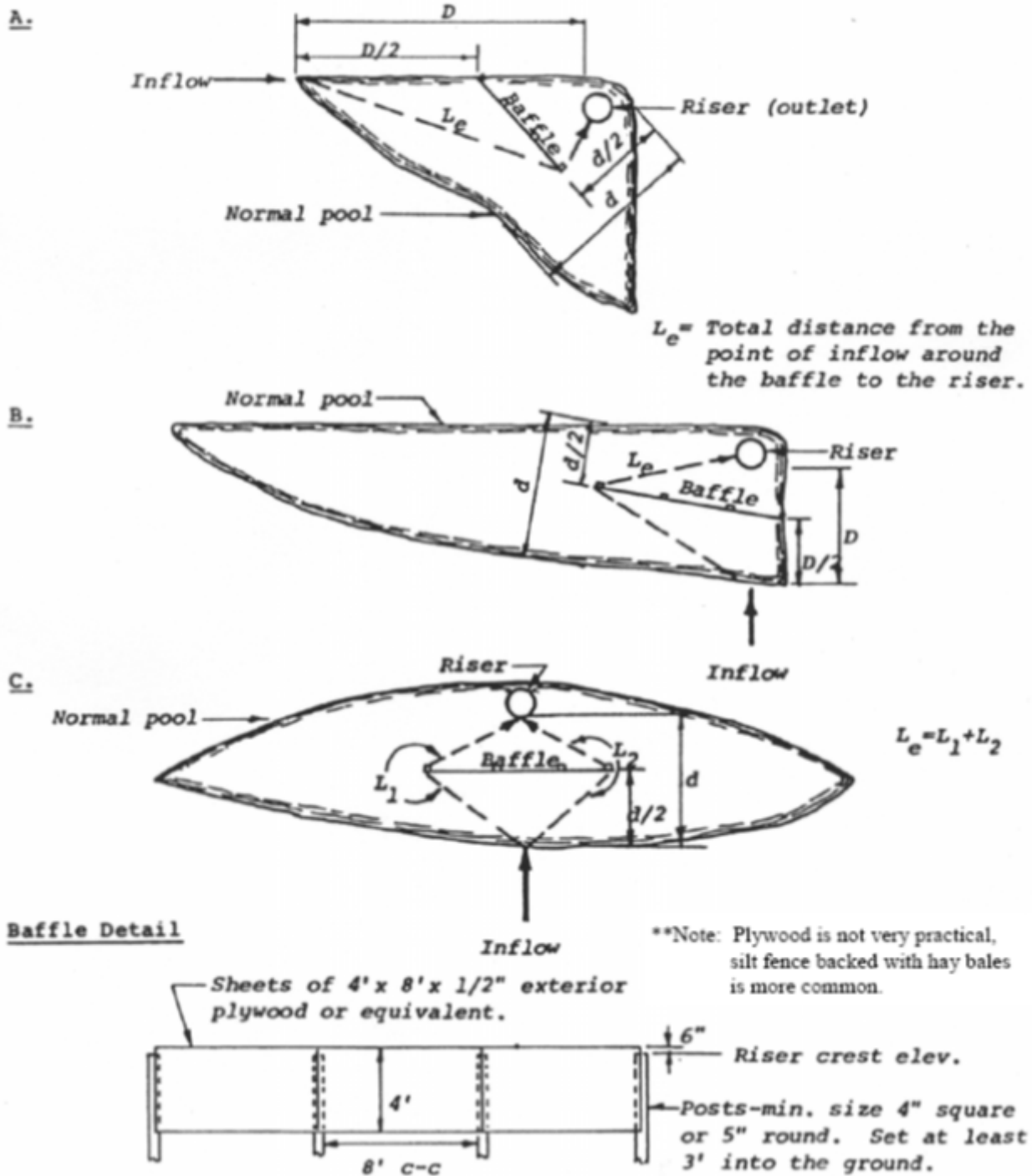


Figure 5.24 Sediment Basin Baffle Details (USDA-NRCS)

Vermont DEC  
Standards and Specifications for Sediment and Erosion Control  
2019

# **Vermont Erosion Prevention and Sediment Control Field Guide**

**August 2006**



# Vermont Erosion Prevention and Sediment Control Field Guide

The purpose of the VT Erosion Prevention and Sediment Control (EPSC) Field Guide is to describe the basic EPSC practices that can be implemented on a construction site and to assist the On-Site Coordinator at a construction site in making discretionary changes to the EPSC Plan.

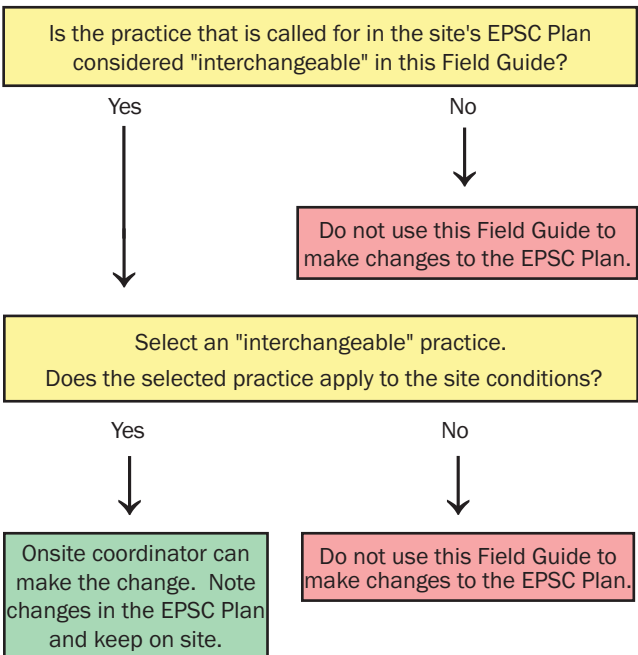
Sections 1 and 2 include information on pre-construction planning and phasing of construction operations.

Sections 3 - 8 include detailed information on practices that are considered interchangeable for preventing erosion and controlling sediment on the construction site. The On-Site Coordinator may substitute a practice called for in the site's EPSC Plan with a practice listed as "interchangeable" in this Field Guide.

If there is not an interchangeable practice listed in this guide for a practice that is called for in the site's EPSC Plan and a change needs to be made to the plan, the change must be designed and certified by a Plan Designer, Professional Engineer, or Certified Professional in Erosion and Sediment Control (CPESC).

All plan changes must be kept on-site with the EPSC Plan.

Use the following chart to determine if a practice can be substituted in the field.



*This guide does not replace the Vermont Standards and Specifications for Erosion Prevention and Sediment Control nor does it replace the prepared Erosion Prevention and Sediment Control Plan.*

## Clean runoff starts with you.

This *Field Guide* will take you through the erosion prevention and sediment control process. The guide starts out with sections on pre-project planning and operational activities. The rest of the guide discusses erosion prevention and sediment control by starting at the top of the hill, above the project site, and proceeding down the slope through the bare soil area, ditches and channels, and down to the waterways below. The drawing below summarizes this approach.

**Preserve existing vegetation**

**Divert upland runoff around exposed soil**

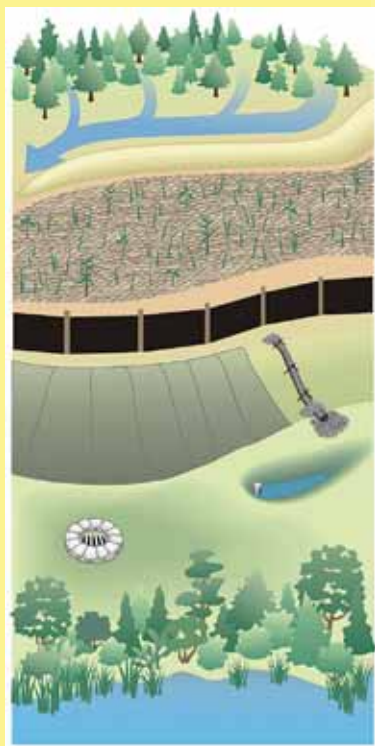
**Seed/mulch/cover bare soil immediately**

**Use sediment barriers to trap soil in runoff**

**Protect slopes and channels from gulying**

**Install sediment traps and settling basins**

**Preserve vegetation near all waterways**



## Why do we need to control erosion and sediment losses from construction sites?

*Sediment washing into streams is one of the largest water quality problems in Vermont.* Sediment can kill or weaken fish and other organisms and impact aquatic wildlife habitat. It is not difficult to reduce erosion and prevent sediment from leaving construction sites. Follow the basic approach shown above. Sites with steep slopes near waterways need more controls than flat sites farther away.

Observe basic principles such as: 1) Preserve existing vegetation as much as possible; 2) Mulch or seed bare soil immediately for the best and cheapest erosion protection; 3) Use silt fences, brush barriers, or other approaches to intercept and filter sediment from runoff; 4) Install silt check dams made of rock, brush, or other products to prevent ditch erosion and remove sediment; 5) Protect inlets and outlets; and 6) Settle out soil particles in sediment traps and basins.

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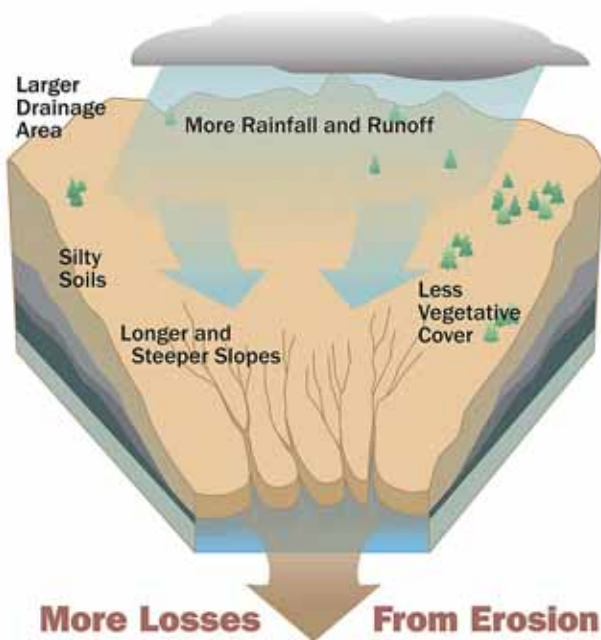
- Vegetating Low Grade Channels
- [Interchangeable Practices](#)
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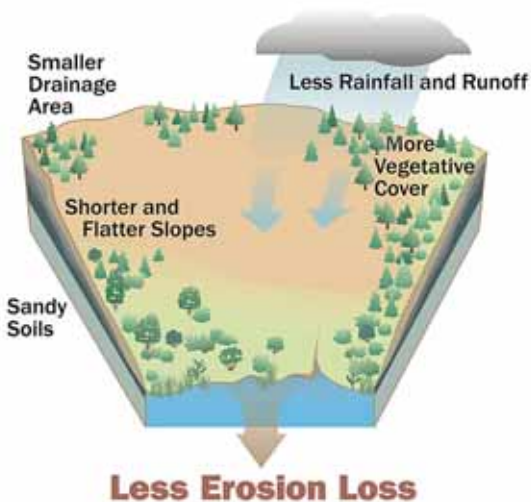
**10. Closing Out Your Construction Project . . . . . 67**

- Final site stabilization
- Vegetated cover considerations for close-out
- Removing temporary sediment controls

# What contributes to erosion?



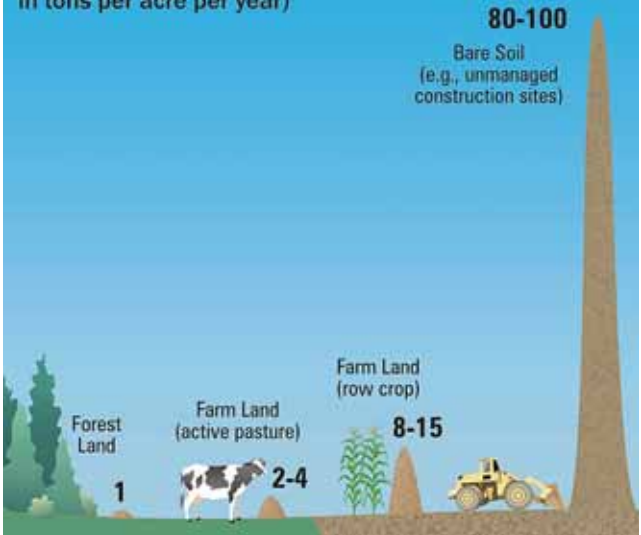
*Factors influencing erosion. Heavy rainfall, steep slopes, removal of most existing vegetation, and erodible soils result in higher soil losses from erosion.*



*Lower rainfall amounts, flatter slopes, preserving existing vegetation, and less erodible soils result in lower soil losses from erosion.*

## Typical erosion rates for land-based activities

(soil loss from various land areas, in tons per acre per year)



## What contributes to erosion?

- Removing vegetation
- Removing topsoil and organic matter
- Changes to drainage
- Exposing subsoil to precipitation
- Failure to cover bare soil areas
- Allowing gullies to form and grow larger
- Removing vegetation along stream banks

## What other factors affect erosion?

Rainfall frequency and intensity

Slope (steep = more erosion; flat = less erosion)

Soil structure and type of soil (silty = more erosion)

Vegetation (more vegetation = less erosion)

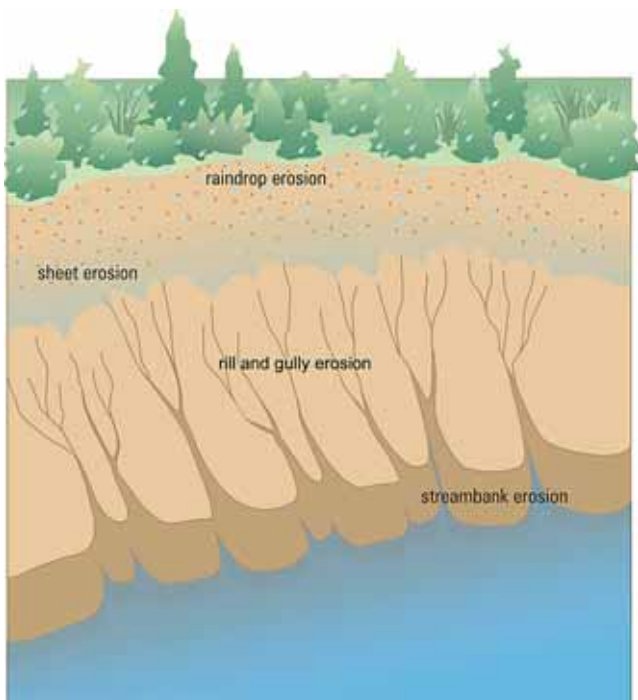
### *Erosion and sediment controls for runoff:*

- Soak it in—maximize seeding and mulching
- Sift it out—use silt fences
- Slow it down—don't let gullies form
- Spread it around—break up concentrated flows
- Settle it out—use sediment traps and basins

# Types of Erosion



Types of erosion. Raindrop erosion (top) breaks down soil structure. Slope runoff creates sheet erosion, which can lead to the formation of small rill channels and larger gullies (below). Erosion of unprotected stream banks can be caused by removing vegetation and higher flows caused by runoff from pavement, sidewalks, and roofs in newly developed areas.



## Pre-Construction Planning

Planning your construction project can help you avoid costly mistakes in controlling erosion and sediment loss to nearby waterways. Follow the steps below before you begin clearing, grading, and excavation work. If your project is one acre or larger, you will need a construction stormwater permit from the Vermont Department of Environmental Conservation (VT DEC) Stormwater Section (802-828-1535, or see [dec.vermont.gov/watershed/stormwater](http://dec.vermont.gov/watershed/stormwater))

### Assess soils and slopes on the construction site

The erosion potential on your construction site depends in part on the soil type and slope steepness at your site. See the table below.

#### Erosion Potential for slope and soil conditions

Soil Type and Parameters	Slope %		
	0 - 5 %	5 - 15%	> 15%
Gravelly	Low	Low	Medium
Sandy	Medium	High	High
Silty	Medium	High	Very High
Clay	Low	Medium	High
Dispersive Clay Soils	High	Very High	Extreme

*Note: there are other factors that contribute to erosion, such as slope length and rainfall intensity and duration. Also, even though there may be low potential for erosion, there can be a high risk to water quality when the soil disturbance is close to water resources.*

### Identify nearby streams and drainage control points

Walk over the site and find where ditches or other concentrated flows leave the site. These are the final sediment control points. Sediment traps or basins should be installed just above these control points. Your site may drain to an underground storm sewer system. In this case, the storm drain inlets that drain runoff from your site are the control points and must be protected (see Section 7). These are also the compliance points for any permits issued for the site.

Install clean water diversions, sediment traps/basins, grassed ditches, silt check dams, and sediment barriers such as silt fences *before* clearing and excavation work begins!

### **Preserve existing vegetation wherever possible**

Only dig or grade where necessary. Existing trees, bushes, and grass help keep erosion to a minimum. Protect large trees by marking off a no-dig root protection zone that is twice as large as the outer perimeter of the branches. Plan your project to limit the amount of bare soil area exposed to the weather, and limit the amount of exposure time. Do not clear vegetation or excavate areas near streams, rivers, lakes, or wetlands without getting the required state and federal permits!

### **Preserve vegetated buffers**

Preserve existing vegetation near waterways wherever possible. This vegetation is the last barrier to capture sediment runoff before it enters the lake, river, stream, or wetland. Where vegetation has been removed or where it is absent, plant native species of trees, shrubs, and grasses.

### **Design projects to fit the natural topography**

Minimize clearing and grading to preserve mature vegetation and save money. Identify natural landscape features you want to keep, like large trees, wildflower areas, grasslands, streams, and wetlands. Plan ways to fit your project around these features, so they remain in place after construction is completed. Be sure to mark off these areas with colored ribbon or stakes and warn equipment operators of their location!

### **Minimize impervious surfaces**

Keep the amount of roof area, parking lots, driveways, and roads to a minimum. Design these hard surfaces so that rain water they collect is directed onto landscaped or yard areas, not into ditches or streams. For example, design roads slightly higher than adjacent lawn areas, and use swales instead of curbs along roadways.

## Promote infiltration in project design

Moving storm water runoff from hard surfaces to landscaped or yard areas helps runoff soak into the soil. This promotes groundwater recharge, filters sediment and other pollutants from runoff, and helps to prevent flooding.






## Develop an erosion and sediment control plan

Develop a written site plan for your project that shows the drainage patterns and slopes, areas of disturbance (cuts/fills, grading), location of erosion and sediment controls, location of surface waters and wetlands, and the location of storm water drainage control points. Your site plan must be updated as conditions change at the site.

Design specifications for erosion prevention and sediment control are included in the **Vermont Standards and Specifications for Erosion Prevention and Sediment Control**.

This manual is available for download at: [dec.vermont.gov/watershed/stormwater](http://dec.vermont.gov/watershed/stormwater).

### Prioritization of erosion and sediment controls for construction sites

Practice	Cost	Effectiveness
Limiting disturbed areas through <b>phasing</b>	\$	
Protecting disturbed areas through <b>mulching and revegetation</b>	\$ \$	
<b>Installing diversion</b> around disturbed areas.	\$ \$ \$	
Sediment removal through <b>detention</b> of all site drainage	\$ \$ \$ \$	
Other <b>structural controls</b> to treat sediment-laden flow	\$ \$ \$ \$ \$	

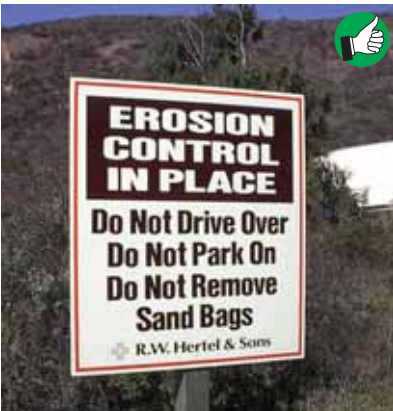
*The cheapest erosion and sediment controls are the most effective. For example, limiting the amount of bare soil by phasing your project and preserving existing vegetation are less expensive and work better than installing large storm water control basins or ponds.*



*Limiting the amount of bare soil exposed to the weather by working in phases reduces erosion and sediment control expenses. In this residential subdivision, only a few home sites are under construction at one time.*



*Preserving existing vegetation at the site makes the final development more attractive and saves money by reducing clearing, excavation, and erosion control expenses.*



*Erosion and sediment controls are required for all construction sites one acre or larger under new federal, state, and local regulations. Erosion Prevention and Sediment Control plans must be written up before the project begins. Permit coverage is also required before clearing, grading, or other cut/fill activities start.*

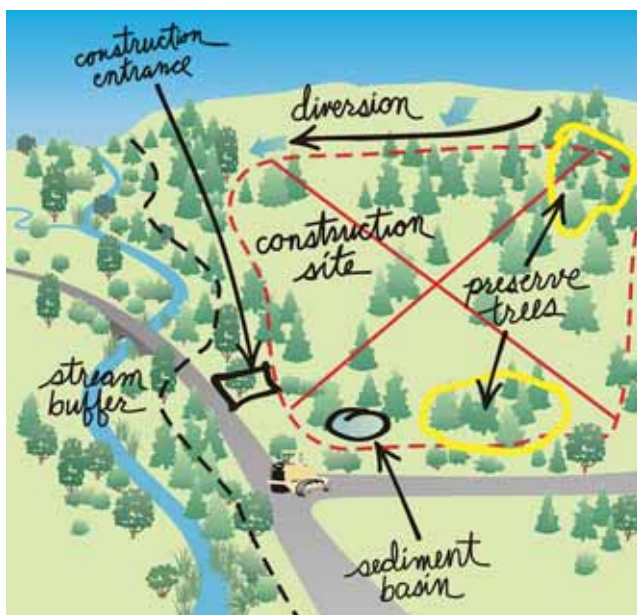


*A sign displaying a copy of the project's Notice of Intent (NOI) must be conspicuously placed near the main entrance of the construction site. See your construction permit for posting requirements. A copy of the EPSC plan and all amendments must be kept on site from the date of commencement of construction activities to the date of final stabilization.*

## Construction Phase Operations

Divide your construction site into natural drainage areas, so you can deal with each one individually. You will be controlling erosion on bare soil areas by applying seed, mulch, or sediment barriers, and minimizing the time bare soil is exposed to the weather. Control points for sediment in runoff will be at the curb inlets or in the ditches, channels, or sediment traps/basins installed where concentrated flow leaves the site.

**Install clean water diversions, sediment traps/basins and stabilize drainage channels with grass, liners, and silt check dams *before* excavation, fill, or grading work begins** (see Section 8). Install silt fences and other sediment barriers downhill from bare soil areas before clearing or excavation work begins (see Section 5).



*Identify drainage areas and drainage ditches and channels. Install diversions, grassed channels, sediment traps/basins, downslope sediment barriers, and rock construction entrance before beginning work.*

### Phase your construction work to minimize exposed soil areas

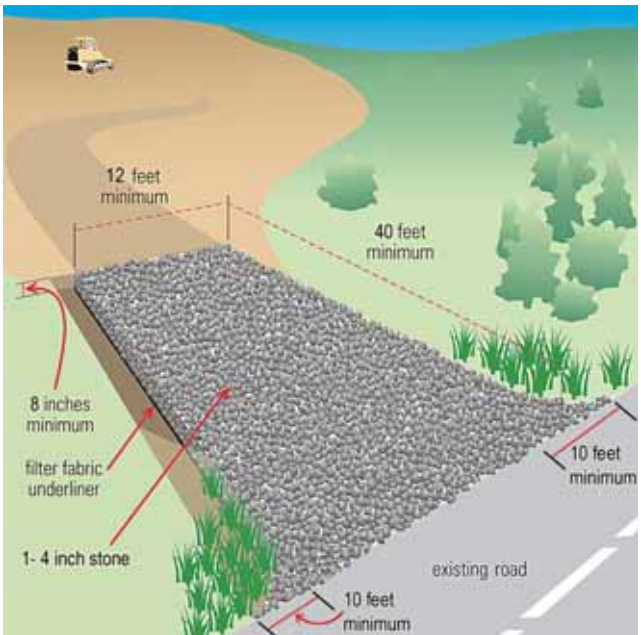
Excavate or place fill material at the site in stages, to avoid exposing large areas of bare soil to the elements. Projects should be cleared and graded as

construction progresses. Check your EPSC Plan for your site's permitted disturbance area. Establish final grade quickly, then seed, mulch, or cover bare soil. If work will proceed over several weeks or months, apply temporary seeding or mulch until final grade work is completed. **Seed and mulch as soon as possible and as per your permit requirements.**

Excavation and grading work should be done during dry weather if possible. Prepare for rainy weather by making sure sediment controls are in place and that all exposed areas are mulched.

### Install construction entrances and control dust

Mud tracked onto roads is the number one complaint from citizens regarding construction site operations. Use a matrix of 1 to 4 inch stone for entrance/exit pads leading to roads. Pads should be at least 12 feet wide, 40 feet long, and 8 inches deep. Entrance pads shall not be narrower than the construction entrance. On residential properties, pads may be shorter than 40 feet, as long as they are the length of the driveway. Install filter fabric under the rock to keep it from sinking into the soil below. Rake rock with a grubbing attachment or add new rock if the pad fills with sediment.



*Construction entrance detail. Entrance/exit pad must keep mud from tracking onto both paved and dirt roads.*



Good stabilized construction exit. Adequate width to accommodate construction traffic and prevent mud tracking onto neighboring streets. Ensure that the pad is 8 inches thick and 40 feet long.



Poor construction entrance. Rock pad is poorly constructed; rock is too small. Use filter fabric under 1 - 4 inch rock. No mud should be tracked onto roads.



Rock sizing and placement look OK for residential site, and very little mud appears on the road. The pad should be at least 8 inches thick and 12 feet wide. Ensure that pad is used as the entrance and exit points - note track marks near curb. Entire area needs seed and mulch.



*Rock pad was installed properly with right sized rock, but lack of filter fabric underliner is causing rock to spread and sink into the soil. Note tracking of mud onto the road. Mud tracked on roadways violates the permit requirements and is a potential legal liability.*

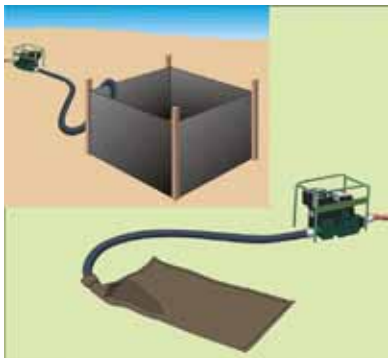
Control dust during hot, dry weather by seeding or mulching bare areas promptly or by wetting haul roads as needed.

## Dewatering operations and discharges

Water pumped from collection basins or other areas must not be pumped into storm sewers, streams, lakes, or wetlands unless sediment is removed prior to discharge. **Discharges to streams, lakes, wetlands, or storm sewers needs to be part of the authorized EPSC Plan.**

Use sock filters or sediment filter bags on discharge pipes, discharge water into silt fence enclosures installed in vegetated areas away from waterways, or discharge water into a de-silting basin. Remove accumulated sediment after water has dispersed and stabilize or seed the discharge area. Dispose of sediment in areas where it won't wash into waterways, then grade the area and seed.

*Pump water from dewatering operations away from waterways into a silt fence enclosure or use a bag filter or other device to remove sediment. Allow discharge to soak into the ground if possible. Do not pump discharge from dewatering operations into curb inlets, storm sewers, creeks, lakes, or rivers.*



## Inspection and maintenance of EPSC practices

For sites one acre or larger, the Vermont Construction General Permit requires that you regularly inspect and repair/replace all sedimentation and erosion control measures identified in the EPSC Plan. Discharge locations must also be inspected to ascertain whether erosion control measures are effective in preventing significant impacts to waters of the State.

Your inspection reports must be in writing, and kept with your EPSC Plan at the site. Refer to your construction permit for inspection requirements.

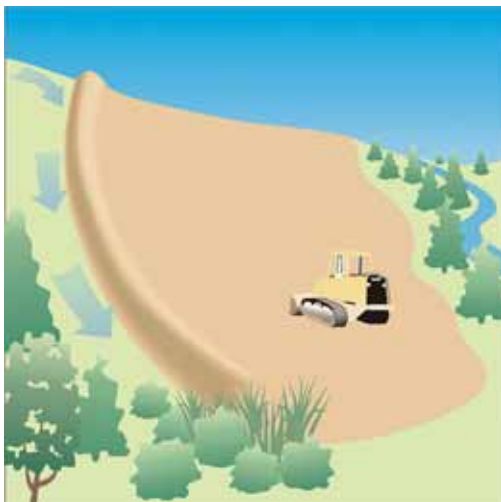
## Diverting Runoff Around Exposed Soils

Keep clean runoff from flowing through your construction site, or route it through stable ditches so it won't pick up sediment. Below are some simple, interchangeable approaches for dealing with upland sources of runoff.

Interchangeable practice	Condition where practice applies			
	Around disturbed area	Across disturbed area	Through the site	Roads and Trails
Earth Dike	x			
Diversion Swale	x	x	x	
Perimeter Dike & Swale	x			
Water Bar				x

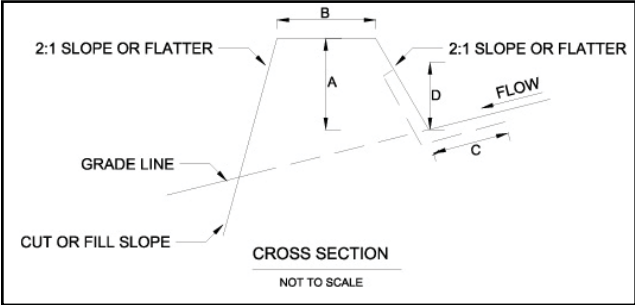
### Earth Dikes

An earth dike or berm is a long, mounded “collar” of compacted soil located uphill from the excavated area. The dike is designed to intercept overland runoff and direct it around the construction site. This prevents “clean” water from becoming muddied with soil from the construction site. Earth dikes can be temporary or permanent landscape features of the site.



*Berms and ditches diverting clean upland runoff around construction sites reduce erosion and sedimentation problems. Stabilize berms and ditches after construction.*

Earth Dike Detail



Design Criteria

	Dike I.	Dike II.
Drainage Area	< 5 Acres	5 - 10 Acres
Dike Height (A)	1.5 feet	3 feet
Dike Width (B)	2 feet	3 feet
Flow Width (C)	4 feet	6 feet
Flow Depth in Channel (D)	8 inches	15 inches
Side Slopes	2:1 or flatter	2:1 or flatter
Grade	0.5% Min 20% Max	0.5% Min 20% Max

Channel Stabilization

	Flow Channel	
Channel Grade	Dike I.	Dike II.
0.5 - 3%	Seed & Straw Mulch	Seed & Straw Mulch
3.1 - 5%	Seed & Straw Mulch	Seed & cover with Rolled Erosion Control Products (RECP), sod or line with plastic or 2 inch stone
5.1 - 8%	Seed & cover with RECP, sod or line with plastic or 2 inch stone	Line with 4-8 inch stone or geotextile
8.1 - 20%	Line with 4-8 inch stone or geotextile	Site specific engineering design

### Construction Specifications

1. Compact the dike with earth-moving equipment.
2. Stabilize the channel as per the specifications in the table within 48 hours of installation.
3. Top width may be wider and side slopes flatter if desired to facilitate crossing by construction traffic.
4. Ensure the dike has positive drainage to an outlet.
5. Ensure that there is no erosion at the outlet.
6. Runoff shall be conveyed to a sediment trapping device if the dike channel or drainage area above the dike is not adequately stabilized.
7. The earth dike shall remain in place until the disturbed areas are completely stabilized.



*Good construction, seeding, and stabilization of earth dike. Note that diversion ditch is lined with grass on flatter part of slope, and with rock on steeper part.*



*Well built vegetated dike diverting runoff. Diversion berms and ditches should be seeded after construction. Use stone, RECP, or geotextile if slopes are steep.*

## Diversion Swales

Diversion swales are similar to dikes—they are designed to intercept and divert upland runoff around bare soil areas. Swales are cut above cleared or fill areas and designed with a gentle slope to carry water away from work areas.

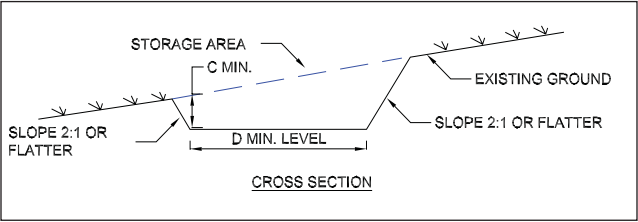
Stabilized, lined swales can also be used to move upland water through your site without getting muddy. Construct and line “pass-through” swales before general clearing or grading work begins.

Swales should discharge to areas with thick vegetation or flat surfaces to promote dispersal and infiltration. Gullies must be repaired as soon as they appear.



*Good installation of rock-lined berm to divert rain runoff around residential construction site on steep slope near a river. Diversion ditches can be lined with grass if channel slopes are 5% or less, and with stone or geotextile if they are steeper.*

Diversion Swale Detail



Design Criteria

	Swale A	Swale B
Drainage Area	< 5 Acres	5 - 10 Acres
Bottom Width of Flow Channel (D)	4 feet	6 feet
Depth of Flow Channel (C)	1 foot	1 foot
Side Slopes	2:1 or flatter	2:1 or flatter
Grade	0.5% Min 20% Max	0.5% Min 20% Max

Channel Stabilization (see Earth Dike)

Construction Specifications

1. Compact the swale with earth-moving equipment.
2. Stabilize the swale as per the specifications for channel stabilization (see Earth Dike).
3. Ensure that the swale has uninterrupted positive drainage to an outlet.
4. Ensure that there is no erosion at the outlet.
5. Diverted runoff from a disturbed area shall be conveyed to a sediment trapping device.
6. All earth removed and not needed for construction shall be stabilized and placed so that it will not interfere with the functioning of the swale.

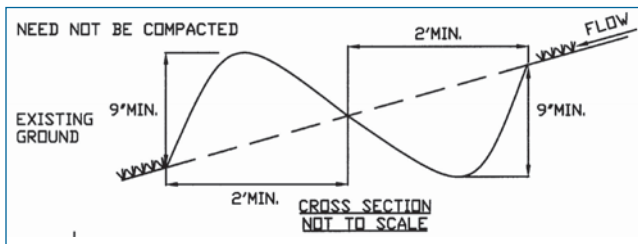


## Perimeter Dike and Swale

A perimeter dike is a temporary ridge of soil excavated from an adjoining swale located along the perimeter of the site or disturbed area.



### Perimeter Dike / Swale Detail



### Design Criteria

**Drainage area** - less than 2 acres

**Height** - 18 inches minimum

(measure from bottom of swale to top of dike)

**Bottom width of dike** - 2 feet minimum

**Width of swale** - 2 feet minimum

**Grade** - not to exceed 8%. Swale shall have positive drainage to a stabilized outlet.

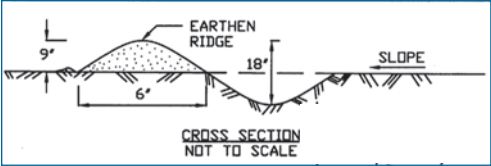
### Construction Specifications

1. Stabilize the dike and swale within 48 hours of installation.
2. Install berm on the contour (along the slope).
3. Diverted runoff from a stabilized upland area shall outlet directly onto an undisturbed, stabilized area at a non-erosive velocity.
4. Diverted runoff from a disturbed upland area shall be conveyed to a sediment trapping device.

## Water Bar

A water bar is a ridge or a ridge and channel constructed diagonally across a sloping road that is subject to erosion. Water bars limit the erosive velocity of water by diverting surface runoff at pre-designed intervals.

### Water Bar Detail



### Water Bar Design Criteria

**Height** - 18 inches min height

(measure from channel bottom to ridge top)

**Side Slopes** - 2:1 or flatter; 4:1 where vehicles cross

**Base width of ridge** - 6 feet min

**Grade of water bar** - not to exceed 2%

Slope	Spacing between bars
< 5%	125 feet
5 - 10%	100 feet
10 - 20%	75 feet
20 - 35%	50 feet
> 35%	25 feet

### Construction Specifications

1. Install the water bar as soon as the road or trail is cleared and graded.
2. Disk or strip the sod from the base for the constructed ridge before placing fill.
3. Track the ridge to compact it to the design cross section.
4. The outlet shall be located on an undisturbed area. Field spacing will be adjusted to use the most stable outlet areas. Outlet protection will be provided when natural areas are not adequate.
5. Vehicle crossing shall be stabilized with gravel. Exposed areas shall be immediately seeded and mulched.
6. Periodically inspect water bars for erosion damage and sediment. Check outlet areas and make repairs as needed to restore operation.

# Protecting Soils With Seed, Mulch, or Other Products

Seeding or covering bare soil with mulch, erosion control matting or blankets, or other products as soon as possible is the cheapest and best way to prevent erosion. **Grass seeding alone can reduce erosion by more than 90 percent.** The following practices can be used interchangeably for stabilizing exposed soil.

	Condition where practice applies	
Interchangeable Practices	Slopes shallower than 3:1	Slopes 3:1 or steeper
Seeding and Mulching	x	
Erosion Control Matting and Blankets	x	x
Turf Reinforcement Mats	x	x
Sodding	x	
Bonded Fiber Matrices	x	x

## Soil cover requirements

All areas of disturbance must have temporary or permanent stabilization within 14 days of initial disturbance. After this time, any disturbance in the area must be stabilized at the end of each work day.

The following exceptions apply:

- Stabilization is not required if earthwork is to continue in the area within the next 24 hours and there is no precipitation forecast for the next 24 hours.
- Stabilization is not required if the work is occurring in a self-contained excavation (i.e. no outlet) with a depth of 2 feet or greater (e.g. house foundation excavation, utility trenches).

All areas of disturbance must have permanent stabilization within 48 hours of reaching final grade.

NOTE: If the authorization you receive has more protective time limits, then those must be followed.

## Seed types and application

Prepare bare soil for planting by disking across slopes, scarifying, or tilling if soil has been sealed or

crusted over by rain. Seedbed must be dry with loose soil to a depth of 12 inches.

Soil amendments should be incorporated into the upper 2 inches of soil when feasible. **The soil should be tested to determine the amounts of amendments needed.** Apply ground agricultural limestone to attain a pH of 6.0 in the upper 2 inches of soil. Check seed bag tags to make sure correct seed is used. Mix seed thoroughly prior to loading seeders. Use the following tables to calculate seed application rates and mixture portions. Apply seed by hand, seeder, drill, or hydro-seed. Drilled seed should be ½ inch deep. Mulch seeded areas as soon as possible.

**Apply more seed to channels, ditches, lawn, and landscaped areas.** Apply less seed to areas that are flat or that will not be mowed very often. Water seeded areas during dry conditions to ensure seed germination and early growth. Re-seed areas that do not show growth within 14 days after rain or watering.

Protect bare areas during the winter by sowing winter rye at 120 lbs per acre (2.0 lbs/1000 sq. ft.). Seed by September 15 to ensure vegetative cover for winter.



*Hydroseeding exposed soil is a good option for stabilizing large areas. Hydroseed is a mixture of seed, fertilizer, water and a tackifier to hold the seed in place before it germinates. Photo courtesy of Hydrograss Technologies.*

Seed mixes for wildflower and native plant plots are also available. They are more expensive, but are very hardy, require little mowing or watering, and add beauty to landscaped and other areas. Most mixes require mowing only once per year, to control tree and brush growth.

Suggested seeding rates and other information for various species and seed mixtures				
Seed species & mixtures	Seed variety	Rate in lbs. per acre	Per 1000 sq. ft.	When and where to use
Temporary seeding				
Ryegrass (annual or perennial) Winter rye (cereal rye)		20	0.5	Sow May 1 - September 15 Sow September 15 - May 1
		120	2.0	
Mix #1				
Creeping red fescue Perennial ryegrass	Ensylva, Pennlawn, Boreal Pennfine, Linn	10	.25	This mix is used extensively for shaded areas.
		10	.25	
Mix #2				
Switchgrass	Shelter, Pathfinder, Trailblazer, or Blackwell	20	.05	This rate is in pure live seed. Good for upland edge of a wetland to filter runoff and provide wildlife benefits. In areas where erosion may be a problem, a companion seeding of sand lovegrass should be added to provide quick cover at a rate of 2 lbs. per acre (0.05 lbs. per 1000 sq.ft.)

Mix #3					
Switchgrass	Shelter, Pathfinder, Trailblazer, or Blackwell	4			This mix has been successful on sand and gravel plantings. It is very difficult to seed without a warm season grass seeder such as a Traux seed drill. Broadcasting this seed is very difficult due to the fluffy nature of some of the seed, such as bluestems and indianguass.
Big bluestern	Niagra	4			
Little bluestern	Aldous or Camper	2			
Indiangrass	Rumsey	4			
Coastal panicgrass	Atlantic	2			
Sideoats grama	El Reno or Trailway	2			
Wildflower mix		.5			
Mix #4					
Switchgrass	Shelter, Pathfinder, Trailblazer, or Blackwell	10			This mix is salt tolerant, a good choice along the upland edge of tidal areas and roadsides.
Coastal panicgrass	Atlantic	10			
Mix #5					
Creeping red fescue	Ensylva, Pennlawn, Boreal	20			General purpose erosion control mix. Not to be used for a turf planting or play grounds.
Tall fescue	KY - 31, Rebel	20			
Perennial ryegrass	Pennfine, Linn	5			
Birdsfoot trefoil	Empire, Pardee	10			



*Good tracking up and down slope. Tracking slows down runoff and promotes infiltration. More mulch is needed.*

For slopes steeper than 3:1, walk bulldozer or other tracked vehicle up and down slopes before seeding to create tread-track depressions for catching and holding seed. Mulch slopes after seeding to conserve moisture and provide initial erosion control.

### **Mulch types and application**

Mulch by itself or applied over seed provides excellent erosion protection (see table). To apply, bring site to final grade and clear rocks, wood, trash, and other debris. Apply seed first. Straw or hay should be hand scattered or blown to obtain a depth of 1 inch (see table). In winter, straw or hay mulch should be applied to obtain a depth of 3 inches. Wood chips or shavings should be applied to a depth of 2 inches. In general, apply mulch so that at least 80 to 90 percent of the ground is covered. **\*Perform regular maintenance and reapply mulch as needed to ensure bare soil is 80 to 90% covered.**



*Stabilize exposed soil with mulch immediately. Excellent application of hay mulch. Good mulch cover and sediment barrier around soil stockpile.*



*Excellent application of hand-scattered straw mulch in new residential subdivision. Work sites must be seeded and mulched as soon as final grade is established. Crimp mulch into soil with dozer tracking or disk harrows set straight to prevent straw from blowing.*



*Very good treatment of roadside areas with blown straw after seeding. In areas near lakes, streams, and rivers, straw in roadway must be cleaned up after application.*

Mulch Material	Quality Standards	per 1000 sq. ft.	per Acre	Depth of Application	Remarks
Wood chips or shavings	Air-dried. Free of objectionable coarse material	500-900 lbs.	10-20 tons	2-7"	Used primarily around shrub and tree plantings and recreations trails to inhibit weed competition. Resistant to wind blowing. Decomposes slowly.
Wood fired cellulose (partially digested wood fibers)	Made from natural wood usually with green dye and dispersing agent	50 lbs.	2,000 lbs.	----	Apply with hydromulcher. No tie down required. Less erosion control provided than 2 tons of hay or straw.
Gravel, Crushed Stone or Slag	Washed; Size 2B or 3A —1 1/2"	9 cu. yds.	405 cu. yds.	6"	Excellent mulch for short slopes and high traffic construction areas. Use 2B where subject to traffic. (Approximately 2,000 lbs./cu.yd.). Must be used over filter fabric..
Hay or Straw	Air-dried; free of undesirable seeds & coarse materials	90-100 lbs. 2-3 bales	2 tons (100-120 bales)	2" (cover about 90% surface)	Use small grain straw where mulch is maintained for more than three months. Subject to wind blowing unless anchored. Most commonly used mulching material. Provides the best micro-environment for germinating seeds.

Mulch Material	Quality standards	per 1000 sq. ft.	per Acre	Depth of Application	Remarks
Jute matting	Undyed, unbleached plain weave. Warp 78 ends/yd., Weft 41 ends/ yd. 60-90 lbs./roll	48" x 50 yds. or 48" x 75 yds.	---	---	Use without additional mulch. Tie down as per manufacturers specifications. Good for center line of concentrated water flow.
Excelsior wood fiber mats	Interlocking web of excelsior fibers with photodegradable plastic	8" x 100" 2-sided plastic, 48" x 180" 1-sided plastic	---	---	Use without additional mulch. Excellent for seeding establishment. Tie down as per manufacturers specifications. Approximately 72 lbs./roll for excelsior with plastic on both sides. Use two sided plastic for centerline of waterways.
Compost	Up to 3" pieces, moderately to highly stable	3-9 cu. yds.	130-400 cu. yds.	1-3"	Coarser textured mulches may be more effective in reducing weed growth and wind erosion.
Straw or coconut fiber, or combination	Photodegradable plastic net on one or two sides	Most are 6.5 ft. x 3.5 ft.	81 rolls	---	Designed to tolerate higher velocity water flow, centerlines of waterways, 60 sq. yds. per roll.

## Erosion control blankets

Erosion control blankets are used to protect steep slopes (up to 3:1; check product information sheets), drainage ditches with less than 20:1 slopes, and other areas where erosion potential is high. Most are designed to provide temporary stabilization until vegetation is established. Blankets degrade within 6 to 24 months, depending on their makeup. They usually consist of a layer of straw, coconut fiber, wood fiber, or jute sandwiched between layers of plastic or fiber mesh.

For short slopes (8 feet or less) above channels, install blankets across the slope (horizontal). Install up and down the hill (vertical) for long slopes.



*Install blankets and mats vertically on long slopes. Unroll from top of hill, staple as you unroll it. Do not stretch blankets.*



*Excellent use of erosion control matting. Make sure to walk erosion control rolls downhill and secure with staples as per manufacturer instructions. Remember to trench matting in at top of hills.*

Walk blankets down to ensure good contact with the soil. Use plenty of staples to keep blankets flat. Overlap blankets at 6 to 8 inches on sides, tops, and bottoms. Do not stretch blankets, and do not exceed manufacturer’s directions on maximum slope angle for the product.

Site conditions	Blanket installation notes
Ditches and channels (from high flow line to ditch bottom—see Section 8)	<ul style="list-style-type: none"><li>• Grade, disk, and prepare seedbed.</li><li>• Seed the area first</li><li>• Install horizontally (across slope).</li><li>• Start at ditch bottom.</li><li>• Staple down blanket center line first.</li><li>• Staple &amp; bury top in 8 inch deep trench.</li><li>• Uphill layers overlap bottom layers.</li><li>• Side overlap should be 6–8 inches.</li><li>• Staple thru both blankets at overlaps.</li><li>• Follow manufacturer's specifications.</li></ul>
Long slopes, including areas above ditch flow levels	<ul style="list-style-type: none"><li>• Grade, disk, and prepare seedbed.</li><li>• Seed the area first.</li><li>• Install vertically (up &amp; down hill).</li><li>• Walk down from top of hill.</li><li>• Staple down center line of blanket first.</li><li>• Staple &amp; bury top in 8 inch deep trench.</li><li>• Uphill layers overlap downhill layers.</li><li>• Overlaps should be 6–8 inches.</li><li>• Staple thru both blankets at overlap.</li><li>• Follow manufacturer's specifications.</li></ul>



Blankets installed along stream banks or other short slopes can be laid horizontally. Install blankets vertically on longer slopes. Ensure 6 inch minimum overlap.



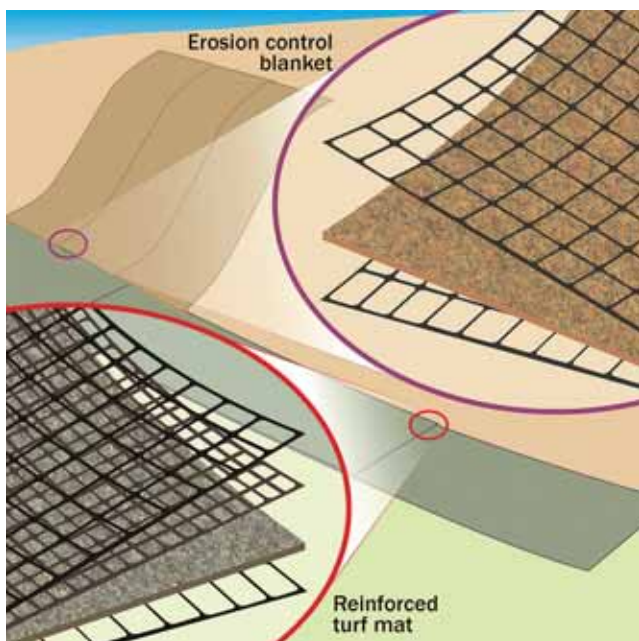
*Excellent soil coverage at stabilization project using hand scattered straw, jute matting, and erosion blanket.*



*Very good installation of erosion control blanket in seeded ditch below well-mulched slope on highway project.*



*Good application of erosion control blanket to stabilize shoulder and protect storm drain, but too few staples used along the top edge. Trench in top edge of blanket on steep slopes.*



*Erosion control blankets are thinner and usually degrade quicker than turf reinforcement mats. Check manufacturer's product information for degradation rate (life span), slope limitations, and installation. Prepare soil and seed before covering with blankets or mats!*

## Turf reinforcement mats

Turf reinforcement mats are similar to erosion control blankets, but are thicker and sturdier because they have more layers and sturdier fill material. Mats provide greater protection than blankets because of their heavier construction, and last longer in the field.

Mats are used for steep slopes (3:1 or steeper) and ditches or channels with 15:1 to 10:1 slopes. Mats are installed just like blankets (see previous table). Additional staking or stapling is needed for applications in channels that carry flowing water, and on steep slopes.

## Sod application

Sod reduces the potential for erosion to near zero. To install, bring soil to final grade and clear of trash, wood, rock, and other debris. Test soil, apply topsoil and fertilize in accordance with soil test results.

Use sod within 36 hours of cutting. Lay sod in straight lines. Butt joints tightly, but do not overlap joints or stretch sod. Stagger joints in adjacent rows in a brickwork type pattern. Use torn or uneven pieces on the end of the row. Notch into existing grass.

On sloping areas where erosion may be a problem, sod shall be laid with the long edges parallel to the contour and with staggered joints. Roll or tamp sod after installation and water immediately. Soak to a depth of 4 to 6 inches.

Replace sod that grows poorly. Do not cut or lay sod in extremely wet or cold weather. Do not mow regularly until sod is well established.

## Bonded Fiber Matrices



*Installing sod immediately after grading work is complete can reduce erosion and sediment loss to near zero.*

Other engineered products are available that are similar to blankets and mats. For example, bonded fiber matrices and other hydraulically applied products contain a mix of soil binders, mulch fibers, and even seed and fertilizer that can provide a stable crust that cements soil particles and prevents erosion. Apply seed prior to hydraulic mats or mulches, if seed is not included in the mix. Consult the manufacturer's installation instructions for product applicability and installation instructions.

SECTION 5

Using Silt Fence and Other Sediment Barriers

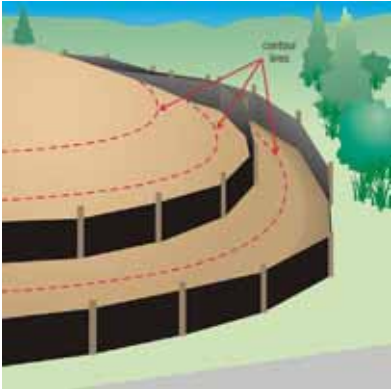
The use of silt fences and other sediment barriers involves simple observation and common sense. However, as Will Rogers once noted, “common sense ain’t so common.” The following practices may be used as interchangeable sediment barriers.

Interchangeable Practices	Condition where practice applies		
	Downhill edge of bare soil	Across disturbed area	Around stockpiles
Silt Fence	x	x	x
Perimeter Dike & Swale	x	x	x

Sediment barrier placement

Sediment barriers are required below (downhill from) areas of bare soil. Hay or straw bales must not be used as sediment barriers due to their inherent weakness and tendency to fall apart. There are several factors to consider in placing silt fences or perimeter dikes and swales:

- Place barriers on downhill edge of bare soil areas.
- Make sure the barrier catches all the runoff.
- The goal is to intercept runoff and settle sediment out.
- Install multiple sediment barriers on long slopes.
- Put barriers across slopes, on the contour (level).



Silt fences should be installed on the contour below bare soil areas. Use multiple fences on long slopes. Remove accumulated sediment before it reaches halfway up the fence.

## Silt Fence

Each 100-foot section of silt fence can intercept runoff from about  $\frac{1}{4}$  acre. To install a silt fence correctly, follow these steps:

- Note the location & extent of the bare soil area.
- Mark silt fence location just below bare soil area or 10 feet below the bottom of a steep slope.
- Make sure fence will catch all flows from area.
- Place fence across the slope.
- Dig trench 6 inches deep and 4 inches wide.
- Unroll silt fence along trench.
- Join fencing by rolling the end stakes together.
- Make sure stakes are on downhill side of fence.
- Drive stakes in against downhill side of trench.
- Drive stakes until 16 inches of fabric is in trench.
- Push fabric into trench; spread along bottom.
- Fill trench with soil and tamp down.

### Silt fencing should not be installed:

- Up and down hills.
- Above (uphill from) areas of bare soil.
- In ditches, channels, or streams.
- In stream buffers.
- Directly at the toe (bottom) of the slope. Additional storage capacity is needed and can be provided for by placing the fence 10 feet below toe. (Place fence directly at toe if near water or stream buffer)

If runoff flows along the uphill side of a silt fence, install “J-hooks” every 40 to 80 feet. These are curved sections of silt fence that act as small dams to stop, pond, and settle out flows.

*Use J-hooks to trap runoff flowing along uphill side of silt fence. Turn ends of silt fence toward the uphill side to prevent bypassing. Use multiple J-hooks every 40 to 80 feet for heavier flows.*

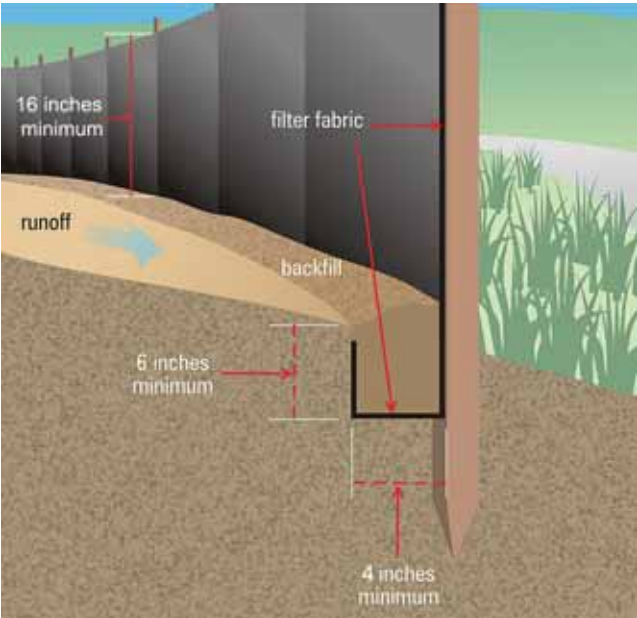




Very good installation of multiple silt fences on long slope. Turn ends of fencing uphill to prevent bypass. Leave silt fences up until grass is well established on all areas of the slope. Re-seed bare areas as soon as possible. Remove or spread accumulated sediment and remove silt fence after all grass is up.

Maximum allowable slope lengths contributing runoff to a silt fence placed on a slope

Slope Steepness	Maximum Length (feet)
2:1	25
3:1	50
4:1	75
5:1 or flatter	100



Remember: stakes go on the downhill side. Dig trench first, install fence in downhill side of trench, tuck fabric into trench, then backfill on the uphill side (the side toward the bare soil area).



*Excellent example of J-hook installation to intercept muddy runoff flowing along silt fence. Good temporary seeding and mulching (right side).*



*Tractor mounted silt fence slicing devices cut a slit into the ground and push fabric in. Installation is quicker and performance is better than the open trench method, making this approach attractive for large sites.*

## Silt fence slicing devices

New tractor-mounted equipment that “slices” silt fence into the ground can provide a better installation than the open trench method. The equipment uses a chisel-point or vibratory plow to create a narrow slit in the ground. Rolled silt fencing is pushed into the slit, creating a very tight seal that prevents water from blowing out the bottom of the fence. Posts are driven and attached to the fence after the fencing is installed.

Besides better performance, the slicing method is also faster. For slicing and all other applications, posts are spaced 6 feet apart or less.



*Silt fences don't have to be on the property line. Placing them on slopes with the ends turned up to trap sheet flow provides better performance. Stagger fence sections to ensure total coverage. Clean out before sediment reaches halfway up. Repair as needed, and remove when grass is well established.*



*Very good use of continuous “super” (reinforced) silt fence. Note that wire fencing is installed between the filter fabric and the posts.*



*Good use of J-hook in silt fence to trap sediment in water running along fence. Sediment must be removed before it reaches halfway to top of fence.*



*Sediment barrier installed backwards. Silt fence fabric should face bare soil area. Stakes go on downhill side. Straw bales can be used to back up fence on downhill side, but not alone.*



*Very poor attention to silt fence maintenance. Fences and other sediment controls must be inspected and repaired weekly; activities should be logged.*



*Poor sediment filter installation, no curb inlet protection. Bales alone provide poor protection (note mud on pavement). Very good seed application.*



Good installation of silt fence at toe of slope. Do not pile soil or other material on silt fences! Also, if space is available move fence back from toe of slopes to allow room for sediment accumulation and maintenance. Leaving a strip of vegetation between bare soil and fence also improves performance.



Poor installation where silt fences are joined. Roll end stakes together before driving in to create an unbroken sediment barrier or lap curved sections to prevent bypasses. Leaving grass strip between silt fence and bare soil area is a good idea.

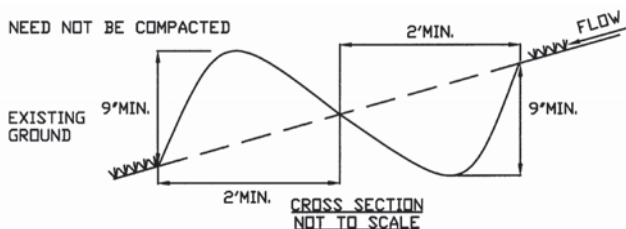


Poor installation of silt fencing, fair to good seeding. Silt fence must be trenched in along bottom. Straw bales are not approved as sediment barriers.

## Perimeter Dike and Swale

A perimeter dike is a temporary ridge of soil excavated from an adjoining swale located along the perimeter of the site or disturbed area. The purpose of a perimeter dike and swale is to prevent off site storm runoff from entering a disturbed area and to prevent sediment laden storm runoff from leaving the construction site or disturbed area.

### Perimeter Dike and Swale Detail



### Perimeter Dike and Swale Design Criteria

**Drainage area** - less than 2 acres

**Height** - 18 inches minimum

(measure from bottom of swale to top of dike)

**Bottom width of dike** - 2 feet minimum

**Width of swale** - 2 feet minimum

**Grade** - not to exceed 8%. Swale shall have positive drainage to a stabilized outlet.

### Construction Specifications

1. Stabilize the dike and swale within 48 hours of installation.
2. Install berm on the contour (along the slope).
3. Diverted runoff from a stabilized upland area shall outlet directly onto an undisturbed, stabilized area at a non-erosive velocity.
4. Diverted runoff from a disturbed upland area shall be conveyed to a sediment trapping device.

## Protecting Slopes to Prevent Gullies

Slopes—especially long ones—must be protected to prevent sheet, rill, and gully erosion. Slopes must be stabilized immediately after grading work is completed. The following practices can be used interchangeably to protect and stabilize slopes:

Interchangeable practices	Condition where practice applies			
	Slope Steepness			
	< 33%	33 - 50%	50 - 80%	> 80%
Erosion Control Blankets and Mats	x	x		
Hydraulic Mulch	x	x		
Rock Gabions			x	x
Riprap slope protection		x	x	

### Approximate slope conversions

Percent	Slope ratio	Degrees
100%	1:1	45°
50%	2:1	27°
33%	3:1	18°
25%	4:1	14°
10%	10:1	6°

The following practices are included in this section for informational purposes only. Consult the EPSC Plan designer or engineer for design and installation specifications.

Pipe Slope Drain • Subsurface Drain • Lined Waterway • Engineered Terracing • Surface Roughening • Retaining Wall • Fiber Roll

### Assessing slopes and soils

Steeper slopes (3:1 or steeper) require more protection than flatter slopes. Slopes with highly erodible soils (silty soils) need more protection than those with less erodible soils (sands and gravels). Also, long slopes (greater than 50 feet) are at greater risk for erosion than short slopes.

## Slope protection basics

Protecting slopes from erosion requires several actions that must be taken together. No single approach will be successful, especially if the slope is long, steep, or has highly erodible soils. Use one or more of the following actions to reduce erosion on slopes:

### Divert upland runoff

See Section 3 for information on how to install a berm or channel above the slope to divert upland rain runoff around the bare soil area.

### Control slope runoff

If slopes are broken up into benches or steps, runoff can be collected and diverted along berms or in channels to pipe or open channel slope drains with stable outlets.

### Till seedbed or condition the soil

Dozer tracks up and down slopes help hold soil in place and lengthen the runoff flow path down the slope. See Section 4 for information on how to condition of the soil surface.

### Seed and mulch

The best and cheapest protection by far. See Section 4 for details on seed types, application rates, and mulch, blanket, and mat products.

### Silt fence or other barrier

These should be installed at the toe of the slope or slightly away from the toe. Multiple fences should be installed on long slopes. Fiber rolls installed on the contour work very well in breaking up flows on long slopes.

### Retaining wall

Extremely steep slopes can be leveled out and shortened into two or more steps or benches by installing retaining walls of rock, brick, block, wood, logs, or other material. If rock layers are present along the slope, use these to establish firm benches in a stair-step pattern.

### Blankets, mats, or armoring

Slopes exceeding 3:1 with highly erodible soils must be protected with turf reinforcement mats or other products such as hydraulic soil binders or bonded fiber matrices. Rock mulch and lined down drain channels might be needed on steep slopes to control gullyng.

## Erosion Control Blankets and Mats

Steep slopes can be protected with erosion control mats and blankets. Erosion control matting and blankets are appropriate for slopes up to a 3:1 steepness. For slopes greater than 3:1, use turf reinforcement mats. (See Section 4 for installation details).



*Steep, long slopes need blankets or mats. Install blankets and mats up and down long slopes. For channels below slopes, install horizontally. Don't forget to apply seed, lime, and fertilizer (if used) before installing blanket.*



*Excellent slope protection with seeding and erosion control blanket. Blankets or mats are required on most projects if slopes are 3:1 or steeper.*

## Hydraulic mulch

Bonded fiber matrices and hydraulic mulch can be very effective in controlling erosion on slopes. Hydraulic mulch applied after seeding or with seed in the mix can provide permanent protection if mixed and applied properly. (See Section 4 for details)

## Rock Gabions

Rock Gabions are wire 'baskets' filled with rock used to permanently stabilize slopes. Gabion baskets should be filled with 4 - 8 inch stone and layered according to manufacturers recommendations.



*Good use of rock-filled, stacked gabion baskets to protect steep slope. Soil and bark mulch can be used in or over gabions and planted with live willow or hardwood cuttings to reduce “hardened” look.*



*Very poor slope protection. For best results, prepare soil and apply seed with mulch or blanket immediately after reaching final grade.*

## Riprap Slope Protection

Riprap is a layer of stone designed to protect and stabilize areas subject to erosion. Riprap is used in areas where vegetation cannot be established. Follow your EPSC Plan design specifications for installation.



*Good use of riprap on a steep roadside slope. Use the appropriate sized rock for the slope steepness to avoid rock slides.*

## Additional Practices for Protecting Slopes

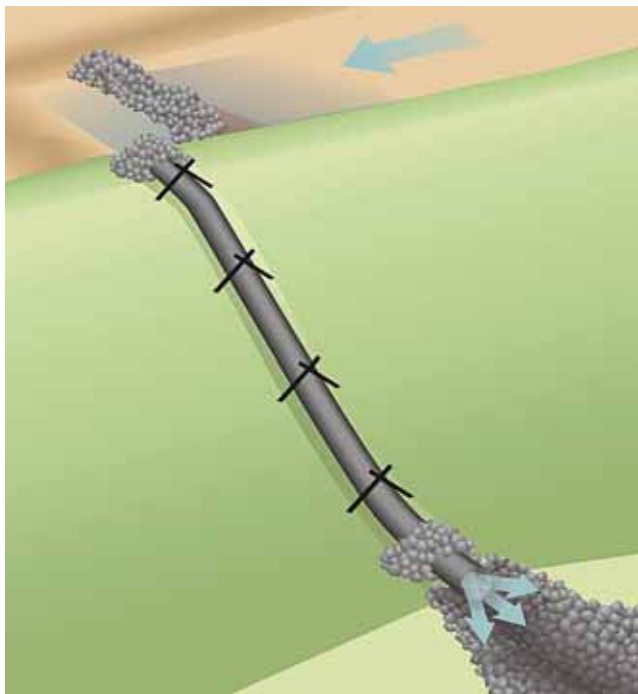
The following practices are included in this section for informational purposes only. Consult the EPSC Plan designer or engineer for design and installation specifications.

### Pipe Slope Drain

A pipe slope drain is a temporary structure placed from the top to the bottom of a slope to convey runoff down the slope without causing erosion.



*Good use of multiple pipe slope drains to prevent erosion while vegetation establishes.*



*Temporary downdrain using plastic pipe. Stake down securely, and install where heavy flows need to be transported down highly erodible slopes. Note silt check dam in front of inlet.*



*Very good use of 20-inch plastic slope drain pipes to convey water from roadway to lower channel. Note staking and rock anchoring at bottom of temporary slope drain pipes.*

## Subsurface Drain

A subsurface drain is a conduit, such as a tile, pipe, or tubing installed beneath the ground surface that intercepts, collects, and/or conveys drainage water.



*A subsurface drain safely conveys water down a slope to prevent erosion. Ensure to install the drain outlet to prevent scour and erosion.*

## Stone Lined Waterway

A stone lined waterway is a channel that carries water down a slope to prevent slope erosion or gully.



*Very good application of rock lined down drain channel to carry water down slope face. Use filter fabric under rock. Install multiple drains at appropriate spacing where flows are heavy. Install flow dissipaters at outlet to absorb energy of the discharge.*

## Engineered Terracing

Terracing is the reshaping of the existing land surface to control erosion and promote the establishment of vegetation.



*Good use of engineered terracing to reduce erosion on this steep roadside slope.*

## Surface Roughening

Roughening bare soil by creating horizontal grooves across a slope, stair-stepping, or tracking with construction equipment aids in seed establishment, reduces runoff velocity, increases infiltration, and reduces erosion by trapping water and sediment.



*Tread-track slopes up and down hill to improve stability.*

## Retaining Wall

A retaining wall is constructed against a slope to prevent soil movement. It retains soil in place and prevents slope failures and movement of material down steep slopes.

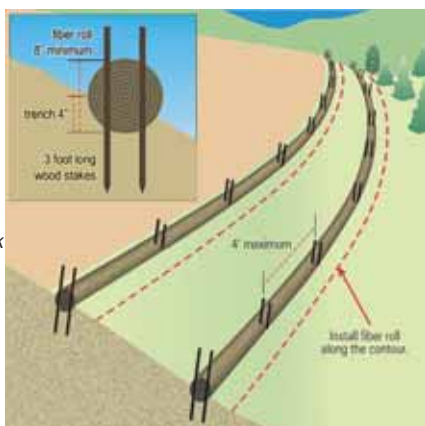
Retaining walls can be built from mortared block or stone, cast-in-place concrete, railroad ties, gabions, and precast, modular, segmented walls. The design of any retaining wall structure must address the aspects of foundation bearing capacity, sliding, overturning, drainage, and loading systems. These are complex systems and all but the smallest retaining walls should be designed by a licensed engineer.



*Good use of engineered retaining wall to break up slope. Development site and customer preferences will dictate type of materials used.*

## Fiber Roll

A fiber roll is a woven roll of coconut fiber, straw, or excelsior encased in a netting of jute, nylon, or burlap. Fiber rolls can be used to break up runoff flows on long slopes.



*Fiber rolls help to break up runoff flows on long slopes. They should be installed on the contour and according to manufacturer's specifications.*

# Protecting Culvert and Ditch Inlets and Outlets

Culverts and ditches are designed to carry moderate and large flows of storm water. They can transport a lot of sediment to streams, rivers, wetlands, and lakes if they are not properly protected. In addition, culvert and ditch outlets can become severely eroded if high velocity flows are not controlled.

## Culvert and storm drain ponding methods

Muddy runoff that flows toward a culvert, ditch, or storm drain inlet must be slowed down and pooled to settle out and remove sediment. This can be accomplished by placing rock, reinforced silt fencing, silt dikes, or other barrier in front of the inlet. The goal is to cause ponding of the inflow so sediment can settle out, and allow ponded water to enter the inlet only after sediment has been removed.

**Straw bales alone are not approved for inlet protection. The maximum drainage area above the inlet protection device is one acre.** For all inlet protection approaches, seeding and/or mulching upland areas promptly will greatly reduce incoming runoff volumes and sediment loads. **The drainage area for storm drain inlets shall not exceed one acre.** All inlet protection practices should be inspected after storm events and repaired as necessary. Accumulated sediment should be removed when 50% of ponding volume is lost.

The following are interchangeable practices for inlet protection:

Interchangeable Practices	Condition where practice applies		
	Drainage area ≤ 1 acre	Slope around inlet	
		< 1%	> 1%
Excavated drop inlet protection	x	x	x
Fabric drop inlet protection	x	x	
Stone & Block drop inlet protection	x	x	x
Curb drop inlet protection	x	x	x

## Excavated drop inlet protection

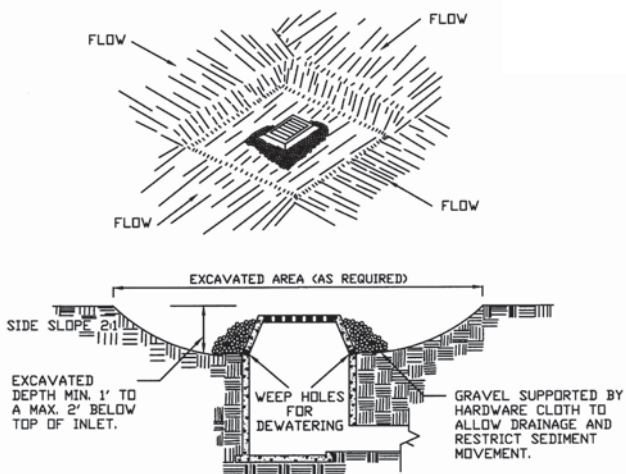
**Side slopes** - maximum steepness 2:1

**Depth** - minimum 1 foot; maximum 2 feet

Shape the excavated basin to fit conditions with the longest dimension oriented toward the longest inflow area to provide maximum trap efficiency. The capacity of the excavated basin, below the level of the grate, should be established to contain 900 cubic feet per acre of disturbed area. Weep holes, protected by fabric and stone, should be provided for draining the temporary pool.

Inspect and clean the excavated basin after every storm. Sediment should be removed when 50 percent of the storage volume is lost.

### Excavated drop inlet protection detail



Poor protection for drop inlet on concrete pad. Straw bales make good mulch but are not suited for inlet protection or silt check dams.

## Filter fabric drop inlet protection

**Slope around device** - Not to exceed 1%

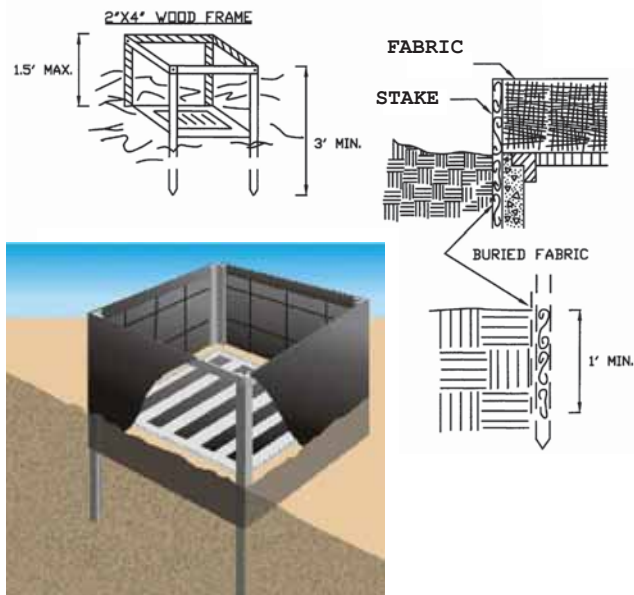
**Height of fabric** - 1.5 feet max., (unless reinforced).

The top of the barrier should be maintained to allow overflow to drop into the drop inlet and not bypass the inlet to unprotected lower areas.

**Support stakes** - 3 feet min., spaced max 3 feet apart; Stakes should be driven close to the inlet so overflow drops into the inlet and not on the unprotected soil.

1. Filter fabric shall have an equivalent opening size (EOS) of 40-85.
2. Cut fabric from a continuous roll to eliminate joints.
3. Stakes will be standard 2 x 4 inch wood or metal with a minimum length of 3 feet.
4. Space stakes evenly around inlet, 3 feet apart and 18 inches deep. Spans greater than 3 feet should be reinforced with wire mesh.
5. Fabric shall be embedded at least 1 foot in ground and backfilled. It should be secured to the stakes.
6. A 2 x 4 inch wood frame shall be completed around the crest of the fabric for overflow stability.

### Filter Fabric drop inlet protection detail



Use wire fence backing to reinforce frame, or diagonal bracing across top of stakes. Make sure fence is trenched in to prevent bypasses or undercutting. Inspect and remove sediment as necessary after each rain.

## Stone and block drop inlet protection

**Height** - 1 foot min., 2 feet max. Limit the height to prevent excess ponding and bypass flow.

**Block placement** - Recess the first row of blocks at least 2 inches below the top of the storm drain for lateral support. Blocks can also be supported by placing a 2x4 inch wood stud through the block openings perpendicular to the row. The bottom row should have a few blocks oriented so flow can drain through the block to dewater the basin area.

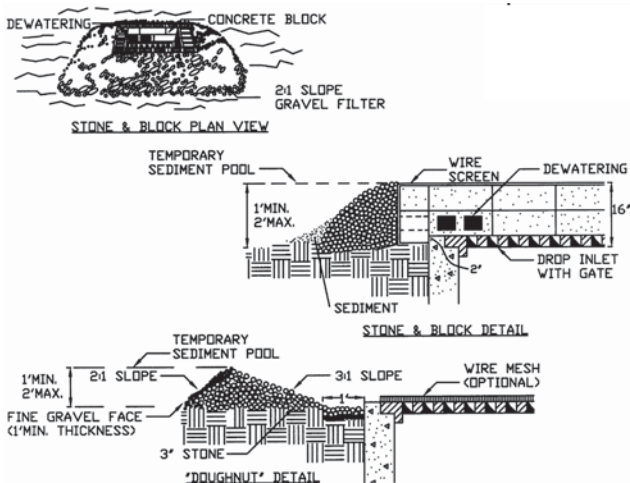
**Stone placement** - Place stone just below the top of the blocks on slopes of 2:1 or flatter. Place hardware cloth or wire mesh with  $\frac{1}{2}$  inch openings over all block openings to hold stone in place.

**Optional "doughnut" design** - The concrete blocks may be omitted and the entire structure constructed of stone, ringing the outlet. The stone should be kept at a 3:1 slope toward the inlet to keep it from being washed into the inlet. A level area 1 foot wide and four inches below the crest will further prevent wash.

**Stone size for "doughnut"** - At least 3 inches closest to the inlet, for stability; 1 inch or smaller around the larger rock to control flow rate.

**Elevation for "doughnut"** - The top of the stone should be 6 inches lower than the ground elevation down slope from the inlet to ensure that all storm flows pass over the stone into the storm drain and not past the structure. Temporary diking should be used as necessary to prevent bypass flow.

## Stone and Block drop inlet protection





Very good design and installation of inlet protection ponding dam using concrete blocks and rock. Outlet pipe in background has a rock apron to dissipate flows.



Very good application of mixed rock for culvert inlet ponding dam. Mixing rock promotes better ponding, drainage, and settling of sediment.



Straw bales have rotted and failed, with muddy runoff undercutting bales. Concrete apron and drop inlet grate are nearly covered in sediment. Use straw for mulch only.

Curb drop inlet protection

**Stone size** - 2 inches

**Wire mesh** - of sufficient strength to support the filter fabric and stone with the water fully impounded against it.

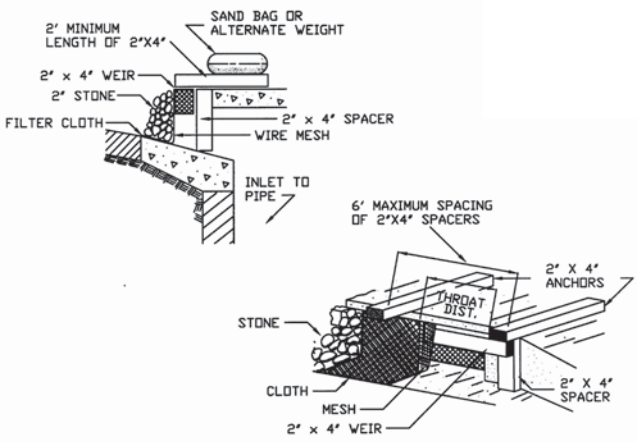
**Filter fabric** - type approved for this purpose with an equivalent opening size (EOS) of 40-85.

**Length of structure** - must extend beyond the inlet 2 feet in both directions.

Assure that storm flow does not bypass the inlet by installing temporary dikes (such as sand bags) directing flow into the inlet. Make sure that the overflow weir is stable. Traffic safety shall be integrated with the use of this practice.

The structure should be inspected after every storm event. Any sediment should be removed and disposed of on the site. Any stone missing should be replaced. Check materials for proper anchorage and secure as necessary.

Curb drop inlet protection detail





*Excellent use of concrete blocks and #57 rock for ponding dam to protect inlet. Note 2x4 inch board through blocks for stabilization. Note galvanized fencing and filter fabric between block and rocks.*



*Poor placement of stone bag inlet dam; poor education of construction site drivers. Bags work well if used properly and maintained. Bags must form a dam around the inlet with no large gaps.*



*Poor placement and poor maintenance of stone bag inlet ponding dam. Accumulated sediment must be removed and dam should be repaired after each half-inch rain.*

## Outlet protection methods

Outlets for storm drains, culverts, and paved channels that discharge into natural or constructed channels must be lined with rock or other armoring to prevent downstream bank and channel erosion when flow velocities are high.

The following practices are included in this section for informational purposes only. Consult the EPSC Plan designer or engineer for design and installation specifications.

- Rock Outlet Protection
- Paved Flume
- Level Spreader

## Rock outlet protection

Rock placed at the end of culvert reduces the depth, velocity, and energy of water, such that the flow will not erode the receiving downstream reach.



*Good placement and construction of rock apron at high-flow culvert outlet. If flow from culvert enters a channel, make sure channel is lined with grass, and blankets or mats, if necessary, to prevent erosion.*



## Paved Flume

A paved flume is a small concrete-lined channel designed to convey concentrated runoff safely down the face of a relatively steep slope without causing erosion.



## Level Spreader

A level spreader is a non-erosive outlet designed to convert concentrated flow to sheet flow and release it uniformly over a stabilized area.



Rick McLaughlin, NCSU



USACE-Chicago

SECTION

8

# Stabilizing Drainage Ditches

Stabilizing drainage ditches helps to provide for the safe transport of excess surface water from the construction sites and urban areas without damage from erosion.

This section is divided into 3 parts:

- Vegetating Low Grade Channels,
- Protecting Steep Channels, and
- Installing Check Dams

Interchangeable practices are provided for Vegetating Channels and Installing Check Dams. Practices for Protecting Steep Channels are included in this section for informational purposes only. Consult the EPSC Plan designer or engineer for design and installation specifications for steep channel protection.

## Vegetating Low Grade Channels

Vegetating drainage channels helps to reduce the velocity of the channelized runoff and limit the erosion potential. The following practices can be used interchangeably to vegetate low grade channels.

Interchangeable Practices	Condition where practice applies	
	Slope	
	≤ 10%	10 - 33%
Seed and Mulch	x	
Rolled Erosion Control Products	x	x
Sod	x	x

## Seed and Mulch

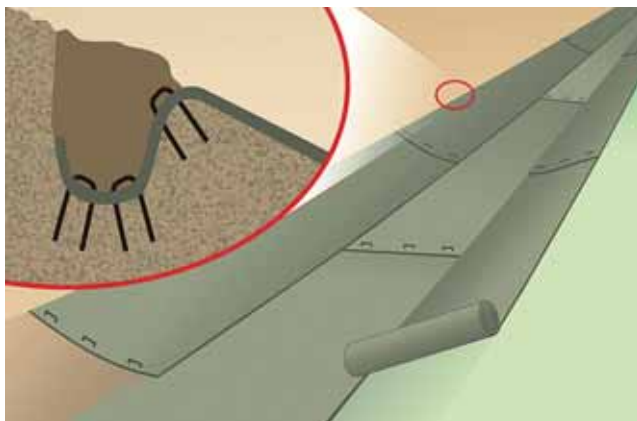
To establish vegetation in a channel, seed and mulch using the guidance in Section 4. Prepare the soil for seeding and ensure that vegetation is well established before water is diverted to the channel.

## Rolled Erosion Control Products (RECPs)

Rolled Erosion Control Products (RECPs) include erosion control mats, turf reinforcement mats, and jute and excelsior matting. RECPs should be used in channels with flow velocities up to 3.5 feet/sec. See Section 4 for installation instructions and seeding information.



*Good use of jute and excelsior matting to stabilize the channel. Rolled Erosion Control Products reduce erosive velocities and help vegetation establish.*



*Lay in ditch blankets similar to roof shingles; start at the lowest part of the ditch, then work your way up. Uphill pieces lap over downhill sections. Staple through both layers around edges. Trench, tuck, and tamp down ends at the top of the slope. Do not stretch blankets or mats.*

## Sodding

Sod can also be used in low grade channels to reduce runoff velocities and minimize erosion potential. See Section 4 for sod installation instructions and specifications.

## Protecting Steep Channels

Channels with grades steeper than 3:1 may need additional armoring to prevent downcutting and erosion.

The following practices are included in this section for informational purposes only. Consult the EPSC Plan designer or engineer for design and installation specifications.

- Rock Lining
- Grade Stabilization Structure

### Rock Lining

Riprap lined channels provide for the transport of concentrated runoff without damage from erosion, where vegetated channels would be inadequate due to high velocities.



### Grade Stabilization Structure

Grade stabilization structures control head cutting in natural or man made channels. They are designed to limit erosion by reducing velocities and grade in the watercourse.



Installing Check Dams

Drainage ditches need temporary check dams to capture sediment and reduce ditch bottom downcutting. The following are interchangeable types of check dams.

	Condition where practice applies
Interchangeable Practices	Drainage area < 2 acres
Rock Check Dam	x
Fiber Rolls	x
Sand Bags	x

Silt fencing and hay bales are not approved for use as check dams, and must not be used in drainage ditches that carry flowing water. Also, do not place dams in creeks or streams. Sediment must be intercepted before it reaches streams, lakes, or wetlands.

Design Criteria

**Drainage Area:** Maximum 2 acres

**Height:** No greater than 2 feet. Center of dam should be 9 inches lower than the side elevation

**Side slopes:** 2:1 or flatter

**Spacing:** Space the dams so that the bottom (toe) of the upstream dam is at the elevation of the top (crest) of the downstream dam. This spacing is equal to the height of the check dam divided by the channel slope.

Spacing (in feet) = 
$$\frac{\text{Height of check dam (in feet)}}{\text{Slope in channel (ft/ft)}}$$

Check dams should be anchored in the channel by a cutoff trench 1.5 feet wide and 0.5 feet deep and lined with filter fabric to prevent soil migration.

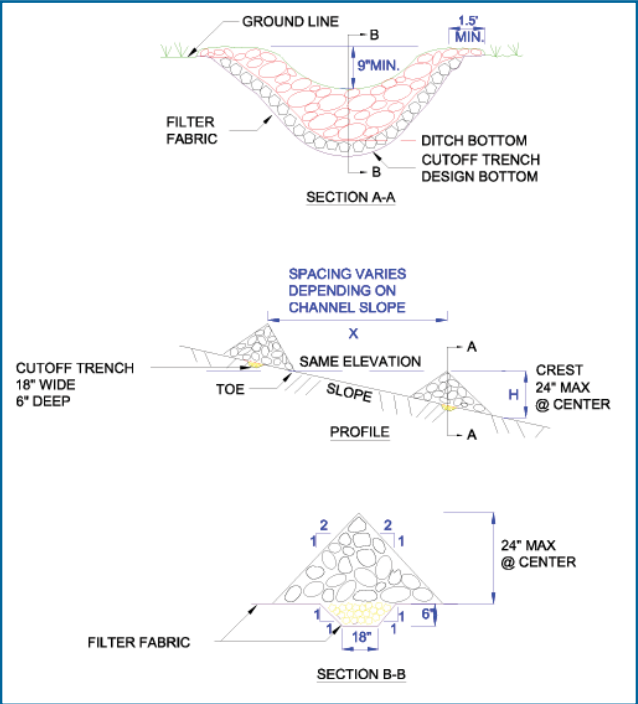
**Maintenance:** Check dams should be inspected after each runoff event. Correct all damage immediately. If significant erosion has occurred between structures, a liner of stone or other suitable material should be installed in that portion of the channel.

Remove sediment accumulated behind the dam as needed to allow channel to drain through the check dam and prevent large flows from carrying sediment over the dam. Replace stone, fiber roll, or sand bags as needed to maintain the design cross section of the structures.

Rock Check Dams

**Stone size:** Use a well graded matrix of 2 to 9 inch stone

$$X \text{ (spacing)} = \frac{\text{Height of check dam (in feet)}}{\text{Slope in channel (ft/ft)}}$$



Good installation of temporary rock silt checks. Remember to tie sides of silt check to upper banks. Middle section should be lower. Clean out sediment as it accumulates. Remove silt checks after site and channel are stabilized with vegetation.

## Fiber Rolls

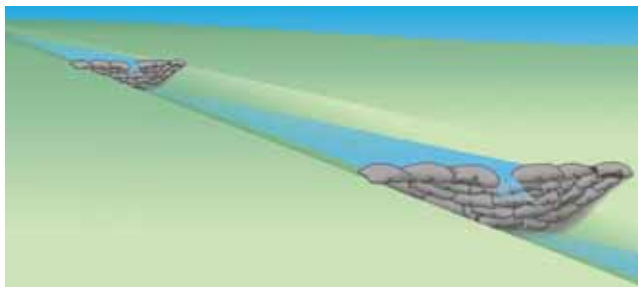
Fiber rolls may be used as check dams if they are keyed into the banks, securely fastened in the channel, and the centers are 9 inches lower than the side elevations. Follow the spacing and installation instructions for "Installing Check Dams".



*Good placement and spacing of fiber-roll silt checks. Coconut fiber rolls and other commercial products can be used where ditch slopes do not exceed three percent.*

## Sand Bag Check Dams

Sand bags may also be used to form check dams. Follow the installation and spacing instructions in "Installing Check Dams" at the beginning of this section.



*Check dams of rock, fiber roll, or stone-filled bags must be installed before uphill excavation or fill activities begin. See formula for correct check dam spacing. Tied end of bag goes on downstream side.*



*Hay bales must not be used as check dams due to their high failure rates.*



*Poor application of commercial check dam product. Commercial products are not approved for use as check dams.*



*Poor silt check installation. Straw bales are not approved as check dams for ditch or channel applications due to rotting, installation difficulties, and high failure potential.*

# Winter Requirements

Managing construction sites to minimize erosion and prevent sediment loading of waters is a year-round challenge. In Vermont, this challenge becomes even greater during the late fall, winter, and early spring months.

‘Winter construction’ as discussed here, describes the period between October 15 and April 15, where the erosion prevention and sediment control is significantly more difficult.

Rains in late fall, thaws throughout the winter, and spring melt and rains can produce significant flows over frozen and saturated ground, greatly increasing the potential for erosion. At the same time as the erosion risk increases, the “toolbox” available to the planner and on-site plan coordinator shrinks significantly.

In particular, establishing vigorous vegetation during winter construction is difficult if not impossible in most areas of the state. How a site addresses winter conditions depends upon the nature of the construction activities over this period.

## Effects of Winter on EPSC Practices

EPSC Measure	Effect of Winter Conditions
Vegetative Ground Cover	Cannot be established outside of growing season.
Hydroseeding	Stabilizers are poor in cold conditions, poor/no growth of seed cover.
Diversion Structures	Difficult or impossible to implement in frozen soils.
Sedimentation Basins	Must be installed pre-ground freezing. Can be overwhelmed by spring flows.
Silt Fence	Difficult to install in frozen ground. Often fail during spring melt.
Erosion Blankets	Cannot be installed correctly on frozen ground. Improper installations wash away in melt flows.
Grassed Lined Swales	Installation following ground freezing is difficult, leaving unprotected concentrated flows with significant erosion as a result.
Impervious Stabilization	Paving, other measures cannot be completed in winter.

## Requirements for Winter Shutdown

For those projects that will complete earth disturbance activities prior to the winter period (October 15), the following requirements must be adhered to:

1. For areas to be stabilized by vegetation, seeding shall be completed no later than September 15 to ensure adequate growth and cover.
2. All non-vegetative stabilization must be completed by October 15.
3. Where mulch is specified, apply roughly 3 inches with an 80-90% cover. Mulch should be tracked in or stabilized with netting in open areas vulnerable to wind.



*Stabilization and seeding of slopes before winter will reduce or eliminate erosion in the spring. The grass on this slope is holding the soil in place and promoting infiltration of the melting snow.*

## Requirements for Winter Construction

If construction activities involving earth disturbance continue past October 15 or begin before April 15, the following requirements must be adhered to:

1. Enlarged access points, stabilized to provide for snow stockpiling.
2. Limits of disturbance moved or replaced to reflect boundary of winter work.

3. A snow management plan prepared with adequate storage and control of meltwater, requiring cleared snow to be stored down slope of all areas of disturbance and out of stormwater treatment structures.
4. A minimum 25 foot buffer shall be maintained from perimeter controls such as silt fence.
5. In areas of disturbance that drain to a water body within 100 feet, silt fence shall be replaced with perimeter dikes, swales, or other practices resistant to the forces of snow loads.
6. Drainage structures must be kept open and free of snow and ice dams.
7. Silt fence and other practices requiring earth disturbance must be installed ahead of frozen ground.
8. Mulch used for temporary stabilization must be applied at double the standard rate, or a minimum of 3 inches with an 80-90% cover.
9. To ensure cover of disturbed soil in advance of a melt event, areas of disturbed soil must be stabilized at the end of each work day, with the following exceptions:
  - If no precipitation within 24 hours is forecast and work will resume in the same disturbed area within 24 hours, daily stabilization is not necessary.
  - Disturbed areas that collect and retain runoff, such as house foundations or open utility trenches.
10. Prior to stabilization, snow or ice must be removed to less than 1 inch thickness.
11. Use stone to stabilize areas such as the perimeter of buildings under construction or where construction vehicle traffic is anticipated. Stone paths should be 10–20 feet wide to accommodate vehicular traffic.

## Closing Out Your Construction Project

When construction is complete you must finish final grading and stabilize the site. Once the site is stabilized, clean out and remove all temporary sediment controls.

### Final site stabilization

Make sure all subcontractors have repaired their work areas prior to final closeout. Conduct a final inspection of all work areas, vegetation, stormwater flow structures, and downstream receiving waters to make sure no visible gullies or sediment movement is evident. Notify site owner or manager after all temporary erosion and sediment controls have been removed and final stabilization has been completed. If the site is one acre or larger and covered under a VT Storm Water Permit, submit a Notice of Termination to the VT Stormwater Section (see [dec.vermont.gov/watershed/stormwater](http://dec.vermont.gov/watershed/stormwater)).

### Vegetated cover considerations for close-out

No site is closed out properly until vegetation is established on all bare soil areas and ditches are stable. Check seeded areas, and reseed areas where vegetation is thin or absent. This is especially important for slopes, ditches, and channels.



*Seed and mulch or cover exposed soil with erosion control matting within 48 hours of establishing final grade.*

## Removing temporary sediment controls

When project is completed:

- Remove all silt fencing and stakes. Grade out and seed or remove accumulated sediment or broadcast over grassed areas or dispose of off-site, where sediment will not impact waters of the State.
- Culvert inlets should be stabilized, vegetated, and showing no visible gullies. Rock or soil that has been washed away by runoff or upstream flows should be replaced. Brush or other debris that could clog inlets should be removed.
- Check ditches and channels to make sure banks and ditch bottoms are well vegetated. Reseed bare areas and replace rock that has become dislodged.
- Check areas where erosion control blankets or matting was installed. Cut away and remove all loose, exposed material, especially in areas where walking or mowing will occur. Reseed all bare soil areas.
- Replace rock washouts near culvert and channel outlets. Fill, grade, and seed or riprap eroded areas around inlets and outlets. Make sure downstream ditches and channels are fully vegetated. Fill and seed any gullies along the banks or other slopes.
- Fill in, grade, and seed all temporary sediment traps and basins that have been removed. Double the seeding rate where runoff flows might converge or high velocity flows are expected.
- Remove temporary stream crossings and grade, seed, or re-plant vegetation removed during crossing installation.

## Acknowledgements

Design details and standards for erosion prevention and sediment control practices have been adapted from the New York State Standards and Specifications for Erosion and Sediment Control. August 2005.

This document is based on a similar Field Guide produced by the Tetra Tech Water Resources Division in Fairfax, VA for the Kentucky Division of Conservation and Division of Water. Inquiries regarding this publication should be directed to Barry Tinning, Tetra Tech, 1060 Eaton Place, Suite 340, Fairfax, VA 22030 (703.385.6000).

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VT Relay Service for the Hearing Impaired  
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For additional copies  
of this Field Guide, contact:

Vermont Department of Environmental Conservation  
Watershed Management Division - Stormwater Section  
One National Life Drive, Main Building - 2nd Floor  
Montpelier, VT 05620-3522

Tel: 802-828-1535

Fax: 802-828-1544

[dec.vermont.gov/watershed/stormwater](http://dec.vermont.gov/watershed/stormwater)

## **APPENDIX C**

### **STANDARD OPERATING PROCEDURES**



CREDERE ASSOCIATES, LLC

776 Main Street  
Westbrook, Maine 04092  
Phone: 207-828-1272  
Fax: 207-887-1051

# Standard Operating Procedure CA-1 Field Activity Documentation

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Effective Date: August 2, 2016  
Revision: 1

*Allison Drouin*

Allison Drouin, Author

8/2/2016

Date

*Theresa Patten*

Theresa Patten, Technical Review

8/2/2016

Date

Revision	Date	Reason for Revision
1	8-2-2016	EPA and Maine DEP Comments for SOP use with Generic Brownfields Quality Assurance Project Plan

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## **1. OBJECTIVE AND APPLICABILITY**

### **1.1 OBJECTIVE**

The purpose of this Standard Operating Procedure (SOP) is to provide a standard for the documentation of field activities by Credere Associates, LLC (Credere) employees. If followed correctly this SOP will allow for the following:

- Consistency in field reporting to better assimilate documentation between various field staff
- Better understanding by third party users of the documentation
- Defensibility of data collected for a project in the court of law

### **1.2 APPLICABILITY**

This SOP should be used for the documentation of all field activities including site reconnaissance, onsite meetings, sampling events, and oversight.



## **2. PROCEDURE**

### **2.1 REQUIRED EQUIPMENT**

The following is a list of required equipment for documenting field activities:

- Dedicated project bound field logbook with water resistant consecutively numbered pages
- Ink pen (all weather pens are best)
- Field sampling data forms
- Camera
- Backup battery(s)
- Task specific tools for measurement (see task specific SOP for appropriate tools)

### **2.2 INITIAL PROJECT DEDICATED LOGBOOK SETUP**

At the start of a project a dedicated logbook containing bound, consecutively numbered, water resistant pages will be started to be used for the duration of the project. Use of a project dedicated logbook facilitates locating field information and permits reference to prior field events while in the field. In the event that a project logbook is full, a second (or additional thereafter) will be started and each logbook will be consecutively number in order of chronology.

Each logbook will be labeled on the front cover with the following:

- Project name
- Project location and main address
- Credere project number and project manager
- Project (or respective logbook) start and end date

Additionally, the inside cover of the logbook and back of the logbook shall be labeled with the following in case of misplacement:

If lost, please return to:  
Credere Associates, LLC  
Attn: (project manager on cover)  
776 Main Street  
Westbrook, Maine 04092  
(207) 828-1272

Field books should be protected from the elements as best possible; pages should not be removed from a logbook; only factual and objective language shall be used.



### **Exception to Project Specific Logbook**

- A client specific logbook may be substituted for instances where numerous small projects are frequently conducted (i.e., brownfields program, environmental services contract, mini-bid program).
- Credere employees should keep a general logbook for short-term projects that are unlikely to result in long term work. For example, for a single site visit or single drilling job that are unlikely to result in additional project work. Individual entries in a general logbook will contain the project name, location, address, project number, and project manager.

## **2.3 LOGBOOK ENTRIES**

A logbook entry should contain enough detail to allow a third party to recreate the occurrences of a task. In addition to task specific information, the logbook entry should also note all modifications to a plan, health and safety precautions and upgrades, public concern, and visitors to the project site.

### **Daily Entry**

A daily entry shall begin at the top of a new page and printed legibly. Entries will be recorded using a 24-hour time clock and entered in the order that they occur. A new entry for each day will begin with the following:

- Date and project at the top of the page
- First and last name of Credere employee followed by initials and time of arrival onsite
- Full names and initials of additional team members and the time of their arrival onsite
- Scope of work for the day
- Weather (e.g., temperature, precipitation, wind directions)
- Subcontractors and duties (e.g., for drilling: drilling company, foreman, make and model of drill rig, type of drilling to be performed, etc.)
- Calibration details for field equipment (e.g., photoionization detector, water quality meter)

If field activities extend beyond one page, each successive page shall have the date, project and initial of person doing logbook entries written at the top. If the logbook changes hands during a daily entry, the initial writer shall sign after their last entry and the full name and initials of the new writer shall be entered consecutively.

The final page of a daily entry shall have open lines marked diagonally with a strike and shall be signed and dated.



## **Error Corrections**

All error corrections will be crossed out with a single line to maintain legibility of the original entry, and the correction will be entered, dated and initialed. At no time should an entry be blacked out or made illegible.

## **Partial List of Data to be Recorded**

The following is a partial list of information typically recorded during field tasks:

- Level of personal protective equipment (PPE)
- Changes to PPE
- Changes in personnel
- Sampling equipment serial numbers
- Equipment calibration details
- Decontamination procedures
- Field screening results
- Observations
- Unusual circumstances
- Problems encountered
- Problem resolutions
- Name and time onsite/offsite of anyone who enters the Site
- Correspondence with project managers
- Sample IDs
- Sample depths
- Method of collection
- Sample times
- Sample analysis requested
- Sample preservation
- Sample volume collected
- QA/QC samples
- Sample duplicate locations
- Site sketch
- Changes in weather

## **2.4 PHOTOGRAPHS**

Photographs are a useful tool in documenting field conditions and communicating observations to other staff. If photographs are of a subject that is indistinguishable (i.e., a soil macrocore, test pit sidewall, surface water sheen), the photograph number and a description of the photograph subject shall be included in the daily logbook entry. If the camera has a time and date stamp, make sure it is on and correct. When taking photographs consider including a frame of reference to indicate scale (e.g., a ruler, a person). Additionally, a wipe board appropriately labeled can aid in identifying photographs.



## **2.5 FIELD DATA FORMS**

Some field tasks have dedicated field forms to facilitate field data collection. If field forms are used these forms are also part of the legal record for the site and should be treated as such.

Field forms should be referenced in the daily logbook entry. Procedures for data entry and error correction should be followed when using field forms. Field forms should be thoroughly completed at the time of the field task to avoid missing information.



### **3. QUALITY ASSURANCE/QUALITY CONTROL**

Logbooks, field data forms, and chains of custody (COCs) shall be checked for consistency. (Note: see SOP CA-16 for specifics on preparation of a COC). In general, the following shall be checked at the close of a field task, sampling event, or project:

- Level of detail in notes is sufficient to recreate a sample, task, or method
- Completeness and accuracy of logbook entries, forms and COCs
- Consistency of data between logbook, field forms and COC
- Equipment calibration records
- Activity documentation compliance with this SOP



## 4. FIELD DATA MANAGEMENT

Copies of logbook entries, field forms, calibration forms, COCs, photographs, and any other field activity documentation shall be uploaded to the Credere server for easy access during report preparation. Originals of field activity documentation will be kept in the permanent project central file.





# CREDERE ASSOCIATES, LLC

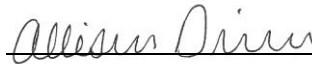
776 Main Street  
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## Standard Operating Procedure CA-2 Equipment Decontamination

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Effective Date: March 17, 2016

Revision: 0

 3/17/2016  
Allison Drouin, Author Date

 3/17/2016  
Theresa Patten, Technical Review Date

 3/17/2016  
Judd Newcomb, Technical Review Date

Revision	Date	Reason for Revision

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## **1. OBJECTIVE AND APPLICABILITY**

### **1.1 OBJECTIVE**

The purpose of this Standard Operating Procedure (SOP) is to provide guidance for the decontamination of equipment used for the collection of samples or during remedial activities. In circumstances where dedicated equipment is not available or cost effective, if followed correctly this SOP will allow for the following:

- Reduced cross contamination during sampling
- Reduction in incidental transfer of contaminated media to the support zone or other clean areas

A site-specific decontamination objective should be included in site investigation or remedial plans prior to implementation of the work. Preplanning facilitates implementation of decontamination procedures, creates safer working conditions, and assists in meeting the investigation objectives.

Credere Associates, LLC (Credere) SOPs are a guidance, and state requirements, site-specific plans, and special conditions may require alternative approaches.

### **1.2 APPLICABILITY**

This SOP should be used during the collection of samples from media where use of dedicated or disposable sampling equipment is not feasible. Decontamination includes both the removal of physical debris such as caked on soil, sediment or dust, and the removal of possible bonded compounds to sampling equipment through deactivation with a solvent or acid. At a minimum, decontamination should occur at the beginning and end of each sampling day to prevent transfer of contaminants to the support zone or clean storage areas, as well as between individual samples during the course of the day.



## 2. PROCEDURE

### 2.1 NECESSARY EQUIPMENT

The following is a list of required equipment for decontamination:

- Appropriate personal protection equipment (PPE)
- Decontaminant selected from Table 1
- Deionized (DI) water, or distilled when DI is unavailable
- 2 High volume spray bottles
- 2 Buckets
- Scrub brush
- Paper towels
- Aluminum foil
- Polyethylene sheeting
- Disposal container appropriate to level of contamination (drum, contractor bag)
- Steamer (optional)
- Pressure washer (optional)

Table 1: Chemical Specific Decontaminant Selection		
Chemical	Stage 1 Gross Contamination	Stage 2 Deactivation Rinse
Organics	Simple Green/Alconox/Liquinox	Methanol <sup>1</sup>
Inorganics	Alconox/Liquinox	10% Nitric Acid
Inorganic PCBs	ZEP Heavy Duty Citrus Degreaser	Thorough DI rinse

1 – methanol should not be used as a rinse if methanol is a contaminant of concern.

### 2.2 TRAINING AND HEALTH AND SAFETY

Credere employees should have received 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) training pursuant to 29 CFR 1910.120 and be current on their 8-hour refresher. Employees must have 24 hours of training specifically in decontamination procedures described herein and proven competence of the SOP in compliance with OSHA 29 CFR 1910.120(e)(4).

Employees will follow the Credere generic and/or Site-specific health and safety plan when implementing decontamination procedures.

### 2.3 GENERAL METHOD OF DECONTAMINATION

Bulk contamination is defined as caked on soil, sediment or dust present on sampling equipment that can be manually wiped, washed, or rinsed away. The following is the general procedure used for removal of bulk contamination:

1. Dry-brush item to remove bulk mud, chunks, and visible contamination from the tool
2. Rinse tool with water to remove additional bulk contamination



3. Scrub tool with scrub brush to remove additional bulk contamination
4. Wash tool with Stage 1 decontaminant selected from Table 1
5. Rinse tool with DI (or distilled) water
6. Rinse tool with Stage 2 rinse selected from Table 1
7. Rinse again with DI (or distilled water)
8. Dry with paper towels
9. Cover with aluminum foil or use immediately for next sample

This general method of decontamination may be modified based on site-specific requirements. The method of decontamination used, including the selected decontaminants, should be recorded in the field logbook.

More aggressive methods of bulk contamination removal such as air knifing, pressure washing and steam removal may be necessary for large equipment; however, these methods should be avoided where possible due to difficulty containing removed contamination.

Credeire employees are not responsible for decontaminating subcontractor's equipment (i.e., drilling equipment, excavator buckets); however, field staff should assure the subcontractor is appropriately decontaminating their equipment. In the event that decontamination procedures are not being followed by the subcontractor, field staff should consult with the project manager and a stop work order may be implemented.

At the end of a sampling day or close of a larger project, all sampling equipment should be decontaminated in a controlled indoor environment, inspected for damage, and made ready for subsequent use.

## **2.4 DECONTAMINATION WASTE DISPOSAL**

Decontamination waste should be disposed on a site specific basis. In general, wash water can be discharged onsite unless signs of contamination (odor, sheen) are observed. If wash water is observed to be contaminated, water will be containerized and stored onsite pending characterization. Solid materials such as paper towels, scrub brushed, and aluminum foil can be presumed household waste unless obvious signs of contamination (odor, oily residue, etc.) are present.



### **3. QUALITY ASSURANCE/QUALITY CONTROL**

Quality assurance will be obtained through collection of an equipment blank for laboratory analysis of the appropriate site-specific contaminants of concern (COC) that will indicate the efficacy of the decontamination process. The equipment blank should be collected by rinsing the respective equipment with DI water and collecting the rinsate as a sample. An equipment blank may not be required for all projects or COCs depending on the data quality objectives of a project.



## 4. DECONTAMINATION DOCUMENTATION

The method of decontamination, selected decontaminant solutions from Table 1, and the type of equipment used for sampling should be recorded in the field logbook. Additionally, the frequency of decontamination throughout a field day and documentation of decontamination prior to each sample and at the beginning/end of each field day should be properly documented in the field logbook in accordance with Credere SOP CA-1.



## 5. REFERENCES

Credere Associates, LLC, *Standard Operating Procedure CA-1 Field Activity Documentation*, Revision 0, dated August 4, 2015.

Maine Department of Environmental Protection, *Standard Operating Procedure, RWM-DR-017, Equipment Decontamination Protocol, Revision 03*: dated March 23, 2009.

New Hampshire Department of Environmental Services, *Decontamination Procedure, SOP No. HWRB-15, Revision 3*: dated January 2012.

U.S. DoD, *Environmental Field Sampling Handbook, Revision 1.0*, dated April 2013.

U.S. Environmental Protection Agency, *Compendium of Superfund Field Operations Methods*, dated December 1987.

U.S. Environmental Protection Agency Environmental Response Team, *Sampling Equipment Decontamination*, SOP#: 2006, dated August 11, 1994.

U.S. Environmental Protection Agency, Region 4, Science and Ecosystem Support Division, Operating Procedures, *Field Equipment Cleaning and Decontamination*, SESDPROC-205-R3, dated December 18, 2015.

Vermont Department of Environmental Conservation, *Investigation and Remediation of Contaminated Properties Rule*, dated July 27, 2017.





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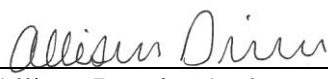
776 Main Street  
Westbrook, Maine 04092  
Phone: 207-828-1272  
Fax: 207-887-1051

## Standard Operating Procedure CA-5 Environmental Soil Sampling

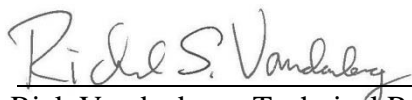
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Revision: 1

  
Allison Drouin, Author 3/9/2018  
Date

  
Theresa Patten, Technical Review 3/9/2018  
Date

  
Rick Vandenburg, Technical Review 3/9/2018  
Date

Revision	Date	Reason for Revision
1	March 9, 2018	Corrections based on VTDEC review of Generic Vermont QAPP

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## **1. OBJECTIVE AND APPLICABILITY**

### **1.1 OBJECTIVE**

The purpose of this Standard Operating Procedure (SOP) is to provide guidance for the collection of soil samples from surficial and subsurface soil. If followed correctly, this SOP will allow for the following:

- Safety of employees performing the sampling
- Collection of representative samples with reproducible results

Credere Associates, LLC (Credere) SOPs are guidance, and state requirements, site-specific plans, and special conditions may require alternative approaches.

### **1.2 APPLICABILITY**

This SOP should be used during soil sampling activities. This SOP does not cover procedures for field screening or description of soil, which are provided in Credere SOPs CA-7: Headspace Field Screening and CA-4: Soil Description, respectively. This SOP also does not cover the use of Encore<sup>®</sup> brand samplers.



## **2. PROCEDURE**

### **2.1 NECESSARY EQUIPMENT**

The following is a list of required equipment:

- Subcontractor drilling/excavation equipment or sample collection device (e.g., hand auger, shovel, etc.)
- Polyethylene sheeting
- Folding table (optional, for convenience)
- Sweeping brush
- Stainless steel spoons
- Stainless steel bowls
- Wooden stakes, marking paint, or pin flags
- Laboratory provided sample containers, cooler and ice
- Plastic syringes (if sampling for volatiles)
- Decontamination fluids
- Deionized or distilled water
- One 5-gallon buckets with water and detergent, one 5-gallon bucket with water, and scrub brush (if using shovel or hand auger)
- Paper towels
- Appropriate personal protection equipment (PPE)
- Site plan
- Field logbook
- Chain of custody
- Ink pens
- Digital camera

### **2.2 TRAINING AND HEALTH AND SAFETY**

Credere employees must have received 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) training pursuant to 29 CFR 1910.120 and be current on their 8-hour refresher. Employees must have 24 hours of training specifically in soil sampling procedures described herein and proven competence of the SOP in compliance with OSHA 29 CFR 1910.120(e)(4).

Employees will follow the Credere generic health and safety plan (HASP) and the site-specific HASP when collecting soil samples.

### **2.3 SOIL SAMPLE LOCATING AND TARGET DEPTHS**

Soil sample locating is highly site-specific. Additionally, sample locations laid out in a work plan may require field adjustment based on site conditions (e.g., bias toward obvious evidence of contamination or just beyond it depending on sample objectives). Typically, sample locations are selected based on the location of historical source areas, around previously detected



contamination for delineation purposes, or in areas presumed to be unimpacted for background comparison.

Sample target depths can be based on soil observations and field screening methods. Target depths are also selected based on sample objectives typically targeting the greatest area of contamination or beyond that area for delineation purposes. Some common sample target depths include the following:

- Surface soil (0 to 2 feet below ground surface [bgs])
- Depth of observed fill (anthropogenic material, non-native material)
- Depth of greatest field screening response
- Depth of groundwater interface
- Depth of a specific geologic feature (e.g., sand/gravel seam)
- Interval above confining layer or bedrock
- Contaminant saturated soil
- First encountered native soil (i.e., beyond contamination)
- A specific pre-designated depth for delineation purposes

Unless targeting a specific interval, non-volatile samples should consist of a 2-foot interval. Volatile samples will be collected from a specific exact depth due to the nature of the collection procedure.

## **2.4 SOIL SAMPLE COLLECTION PROCEDURES**

Soil samples can be collected from the surface (0 to 2 feet bgs) or subsurface via a number of methods. Hand tools such as shovels or hand augers can be used to collect samples from the surface. Drilling equipment such as a hollow stem auger with split spoon samples or direct-push drill rig with macrocore or other type of sampling device can be used to obtain samples from the subsurface. If cores of soil are collected using drilling equipment, soil should be continuously logged in accordance with Credere SOP CA-4 to observe the designated target depth features. Samples should generally be collected in order of increasing impacts where possible.

### **Sample Preparation**

1. Upon arrival at the Site, begin a field logbook entry recording the Credere staff, scope of work for the day, and weather conditions in accordance with Credere SOP CA-1. Also record the drilling contractor, foreman, drill rig make and model, and tooling details.
2. Calibrate field instruments according to Credere SOP CA-11 and product specifications. Keep record of calibration in the field logbook including instrument make and model, serial number, calibration gas and concentration, and span gas check.
3. Set up the sampling station with the optional folding table, truck tailgate, or on the ground surface by covering with clean polyethylene sheeting.



4. Prepare decontamination station. Note whether decontamination fluids must be containerized or can be discharged to the ground surface per the work plan.
5. Decontaminate sampling tools and cover with aluminum foil to keep clean until sampling or place on clean polyethylene sheeting.
6. Locate sample locations in accordance with the prepared work plan or project objectives. Mark the locations with stakes/paint/pin flags. Note any adjustments to sample locations based on field conditions in the log book.
7. Begin collecting soil samples with hand tools or drilling to target depth using standard techniques for the respective method. Describe soil in accordance with Credere SOP CA-4 and field screen soil, where applicable, in accordance with Credere SOP CA-7.

### **Grab Sample Collection**

A grab sample represents a single location or interval within the soil column or on a soil surface. Grab samples can represent any soil thickness; therefore, even though an interval may span 2+ feet it is still considered a grab sample. According to the work plan, samples will be collected in order of decreasing volatility.

1. Don clean nitrile gloves prior to collecting each sample.
2. Determine the representative soil to be sampled:
  - a. Direct measure to two feet below the ground surface (or other specified shallow interval) for surface soil samples.
  - b. Direct measure and collect representative soil from a test pit. Soil for sampling should be collected from the center of the mass not in contact with the excavator bucket.
  - c. In a direct push liner, determine the proportion of soil that represents the target depth based on the penetration and recovery of the core. (e.g., To collect a 6 to 8 foot sample from a 5 to 10 foot core with a penetration/recovery of 60/55, divide 55 by 60 and multiply by 12 inches (for the top) and 36 inches (for the bottom) [6 feet is 12 inches into the penetration and 8 feet is 36 inches into the penetration]. Directly measure and collect 11 to 33 inches from the recovery to represent 6 to 8 feet.). Use caution not to collect slough of caved in soil, which is generally present as loose soil in the top of the direct push liner.
  - d. Soil collected in split spoon samplers can be proportionally divided in half or quarters to represent an interval. It may be necessary to collect soil from multiple 24-inch split spoons to obtain soil for a target interval. (e.g., To collect soil for a 5 to 7 foot sample collect the bottom half of recovery from the 4 to 6 foot split spoon and top half of recovery from the 6 to 8 foot split spoon). Use caution not to collect slough of caved in soil, which is generally present as loose soil in the top of the split spoon sampler.
3. If sampling for volatiles, using a dedicated syringe obtain 10 grams of soil directly from the representative soil as determined per above and transfer to a 40 mL methanol



preserved VOA. Remove any sand grains from the cap threads and securely replace the VOA vial cap. Failure to remove soil from the cap threads can result in leaking of preservative out of or leaking of cooler ice melt into the container, which both may impact the data. **If sampling for only volatiles, also collect a syringe full of soil and cap the syringe for percent moisture analysis by the lab.** Place the filled syringe and VOA vial together in a bubble wrap sleeve. If other analyses are requested, this can be performed from other unpreserved soil volume.

4. Collect the remaining representative soil into a decontaminated stainless steel bowl using gloved hands or a decontaminated stainless steel spoon. Remove coarse gravel and organic detritus. If additional volume is needed due to poor recovery of many analyses, additional cores may be warranted. Homogenize the soil in the bowl, clayey or silty soil may require extra effort to homogenize well, and begin filling the remaining sample containers according to the following. If multiple sample containers are to be filled, alternate between containers adding a spoonful at a time to each.
  - a. SVOCs, PAHs, EPH, and PCBs: Fill an amber 4 to 8 oz. glass jar. Wipe away sand from the cap threads and replace cap. Failure to remove sand from the cap threads can result in leaking of cooler ice melt into the container, which may impact the data.
  - b. Metals: Fill a clear 4 to 8 oz. glass jar to the neck. Wipe away sand from the cap threads and replace cap. Failure to remove sand from the cap threads can result in leaking of cooler ice melt into the container, which may impact the data.
5. Label the sample container with the boring ID and depth as the sample ID: CA-SB-1 (0-2/1) where CA-SB-1 is the location, 0-2 is the interval for non-volatile analyses, and 1 is the grab depth for the volatile analysis.
6. Place samples immediately on ice. Record the sample time, ID, analyses, preservative, and sample volume in the field log book.

### **Composite Sample Collection**

Composite sampling involves collecting multiple grab samples, or aliquots, from multiple locations or discontinuous depths and combining them for a more generalized and average result. It should be noted that composite sampling other than for waste characterization purposes is not an accepted method for site characterization work in Vermont, particularly for VOCs. If composite sampling in Vermont is planned, prior Vermont Department of Environmental Protection (VTDEC) approval is required. Sampling procedures are generally consistent with above with the following modifications:

- Composite volatile samples can be collected in one of two ways:
  - Laboratory composite: Collect one 40 mL VOA vial from each location to be composited per the grab sample methodology. These grab samples will be submitted with one sample ID and laboratory composite will be requested on the chain of custody. The lab will extract from each vial and composite for one analysis under laboratory controlled conditions.



- Field composite: Depending on the number of aliquots, request a volatile container from the laboratory with a proportional amount of methanol to the number of aliquots required. Collect 5 grams of soil at each aliquot location into the one VOA vial provided by the laboratory. If three aliquots or less are required, 3 grams (or 5 grams for two aliquots) can be collected from each location for field compositing in a standard 40 mL VOA vial.
- Composite sampling for other analyses simply requires collection of soil from more than one grab location per the work plan into the same decontaminated stainless steel bowl. Soil from the multiple locations is then homogenized and placed in laboratory provided glassware the same as it would have been for a grab sample. The same volume of soil should be collected from each aliquot location for homogenization.

## 2.5 POST-SAMPLING PROCEDURE

The following procedure should be completed after collection of soil samples:

1. Complete the chain of custody using the notes recorded in the field logbook in accordance with Credere SOP CA-16.
2. Decontaminate non-dedicated equipment for use at the next sample location or for transport in accordance with Credere SOP CA-2. If using a shovel or hand auger to collect soil samples, using 5-gallon bucket of detergent and rinse water to remove bulk soil and perform subsequent decontamination with appropriately selected decontamination fluids, rinse, and dry method per Credere SOP CA-2.
3. Using the sweeping brush, brush away soil from the previously collected sample, and wipe polyethylene sheeting with a damp paper towel. If sampled soil was muddy, replace polyethylene sheeting or slide sheeting over the edge of the table to advance to a clean surface.
4. Store the sample containers on ice being sure to avoid pooled water in the cooler. Regularly replace ice and drain meltwater.



### 3. QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance (QA) and quality control (QC) will be obtained through collection of additional samples. The types of samples to be collected are dependent on the data quality objectives and should be defined in the project's proposal/scope of work, Site-Specific Quality Assurance Project Plan (SSQAPP), regulatory/client guidance, or similar. Types of QA/QC samples that may be collected include the following:

- Field duplicates (optional)
- Matrix spike/matrix spike duplicates (MS/MSD) (optional)
- Trip blanks (should be included with volatile analyses)
- Equipment blanks (e.g., after decontaminating an auger or sampler)
- Temperature blanks (laboratory specific, should be included in sample coolers for certain labs)

Additionally, field documentation will be reviewed to assure it is compliant with Credere SOP CA-1: Field Activity Documentation and methods used for sampling are compliant with the protocol herein.



## 4. FIELD DOCUMENTATION

The following information should be recorded in the field logbook in compliance with Credere SOP CA-1:

- Date of field activity
- Credere personnel
- Scope of work
- Weather (particularly precipitation)
- Health and safety precautions
- Contractor/foreman/equipment make and model (if applicable)
- Changes in scope or deviations from the work plan
- Correspondence with Project Managers and/or Clients
- Sketches of sample locations relative to Site features and measurements (i.e., “swing ties”) from permanent landmarks where location accuracy is required
- Sample details including IDs, time of collection, requested analyses, volume of sample collected, and preservatives
- Decontamination procedures
- General timeline of field activities



## 5. REFERENCES

- Credere Associates, LLC, *Standard Operating Procedure CA-1: Field Activity Documentation*, Revision 0, dated August 4, 2015.
- Credere Associates, LLC, *Standard Operating Procedure CA-2: Equipment Decontamination*, Revision 0, dated March 17, 2016.
- Credere Associates, LLC, *Standard Operating Procedure CA-4: Soil Description*, Draft, dated TBD.
- Credere Associates, LLC, *Standard Operating Procedure CA-7: Headspace Field Screening*, Draft, dated TBD.
- Credere Associates, LLC, *Standard Operating Procedure CA-16: Chain of Custody Preparation*, Draft, dated TBD.
- Maine Department of Environmental Protection, Standard Operating Procedure, *Protocol for Collecting Soil Samples*, SOP RMW-DR#006, April 3, 2009.
- New Hampshire Department of Environmental Services, *Soil Sampling Procedure*, SOP No. HWRB-11, Revision 1, January 2012
- U.S. DoD, *Environmental Field Sampling Handbook, Revision 1.0*, dated April 2013.
- U.S. Environmental Protection Agency Environmental Response Team, *Soil Sampling*, SOP#: 2012, dated February 18, 2000.
- U.S. Environmental Protection Agency, *Standard Operating Procedure for Soil, Sediment and Solid Waste Sampling*, SOP EIASOP\_SOILSAMPLING2, Revision 2, dated February 13, 2004.
- U.S. Environmental Protection Agency, Region 4, Science and Ecosystem Support Division, Operating Procedure, *Soil Sampling*, SESDPROC-300-R3, Revision 3, dated August 21, 2014.
- Vermont Department of Environmental Conservation, *Investigation and Remediation of Contaminated Properties Rule*, dated July 27, 2017.





# CREDERE ASSOCIATES, LLC

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## Standard Operating Procedure CA-16 Chain of Custody

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Effective Date: November 29, 2017

Revision: 0

*Allison Drouin*

Allison Drouin, Author

11/29/2017

Date

*Theresa Patten*

Theresa Patten, Technical Review

11/29/2017

Date

Revision	Date	Reason for Revision

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## ATTACHMENTS

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Attachment A .....	Example Completed Chain of Custody
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## **1. OBJECTIVE AND APPLICABILITY**

### **1.1 OBJECTIVE**

The purpose of this Standard Operating Procedure (SOP) is to provide a standard for the completion of chain of custody forms while collecting samples to be submitted to a laboratory by Credere Associates, LLC (Credere) employees. Sample custody begins immediately after a sample is collected. The sampler who collected the sample is responsible for the preservation and integrity of the sample(s) until that responsibility is transferred to someone else, and documented with the chain of custody form. The chain of custody form then travels with the sample(s) and is used to document any other transfers of custody. If followed correctly this SOP will allow for the following:

- Proper documentation of the custody of samples from collection to analysis and the maintenance of the integrity of the samples during the entire chain of custody
- Accurate communication of sample analysis requirements and sample details to the analytical laboratory
- Samples are protected from loss or damage
- Defensibility of data collected for a project in the court of law

### **1.2 APPLICABILITY**

This SOP should be used during collection of any samples to be submitted to an analytical laboratory. This SOP should be used in conjunction with the following sample collection SOPs:

- CA-3: Residential Well Sampling
- CA-5: Environmental Soil Sampling
- CA-12: Low-Flow Groundwater Sampling
- CA-13: Surface Water & Sediment Sampling
- CA-14: Sub-Slab Soil Gas and Indoor Air Sampling
- CA-15: Asbestos Containing Materials (ACM) Surveys and Asbestos Abatement Air Monitoring and Clearances
- CA-23: Collection of PCB-Containing Building Material and Substrate Samples
- CA-26: Incremental Sampling Methodology

Additionally, this SOP should be followed in conjunction with the procedures outlined in Credere SOP CA-1: Field Activity Documentation and custody elements of Credere SOP CA-17 Packaging and Shipping Samples.



## 2. PROCEDURE

### 2.1 REQUIRED EQUIPMENT

The following is a list of required equipment:

- Laboratory specific or generic chain of custody
- Ink pen (all weather pens are best)
- Field sampling data forms and field notes for associated samples
- Associated properly labeled samples

### 2.2 DEFINITIONS

- **Chain of Custody Form** – A document detailing who is legally responsible for samples at any point in time from collection until the sample is received by the laboratory.
- **Custody** – A sample is “in custody” when: 1) the sample is in the sampler's possession, or 2) the sample was in the sampler's possession and then secured by the sampler to prevent tampering, or 3) the sample is placed in a designated secure area.
- **Secure Area** – An area in which entry is limited by keyed lock to a designated population.

### 2.3 CHAIN OF CUSTODY FORM

Chain of custody forms should, in most cases, be carbon copy forms received directly from the laboratory where samples will be submitted. In certain instances, prepopulated generic chain of custody forms may be used (e.g., larger projects, FUDSCHEM set up projects). An example chain of custody form for reference is provided as **Attachment A**. The following outlines the steps for completing chain of custody forms:

- Complete the heading information (company, project, project required analyses/methods) prior to entering any sample information.
- At the time of sample collection, properly label the sample container according to the applicable sampling SOP (see **Section 1.2**). Immediately enter the sample details into the field logbook and/or field forms according to SOP CA-1 and enter the sample information onto the chain of custody form. Samples should be entered immediately in order of time collected. The chain of custody should not be completed at the end of a sampling day or anytime thereafter (e.g., the next day or at demobilization), otherwise the custody will not have been properly documented. In the event that multiple field samplers are submitting samples on a single chain of custody, communication should be maintained between samplers and the field manager (i.e., the person completing the chain of custody) to ensure no two samples have the same time and that the proper order of samples on the chain of custody can be maintained. Generally, laboratory provided chain of custody forms will provide fields for all required information. All fields must be populated prior to submittal to the laboratory.



The following is a list of required information on chain of custody forms:

- Credere name and address
- Project manager name and contact information
- Project number and project name
- Required level of reporting
- Sample IDs
- Preservatives
- Number of containers collected (include MS/MSD volume if collected)
- Date of sample collection
- Time of sample collection
- Type of sample
- Requested analyses
- Custody signatures documenting the timeline of custody from collection to analysis.
- Any notes for special handling or criteria for certain samples (e.g., MS/MSD for metals only, hold samples pending criteria)
- Ensure the chain of custody, field notes and sample container have matching field IDs, required analyses, and sample times. (This will be QC'ed again at the close of the field day per SOP CA-1 and other sampling SOPs.)
- It is not required to “sign over” samples from one Credere employee to another or into Credere cold storage within Credere’s office; as Credere’s is considered one entity, and the samples are still in Credere’s custody.

### **Error Corrections**

All error corrections will be crossed out with a single line to maintain legibility of the original entry, and the correction will be entered, dated and initialed. At no time should an entry be blacked out or made illegible.

## **2.4 STORAGE**

Samples should be stored in Credere’s possession or in a secure location accessible only to authorized Credere personnel (e.g., personal vehicles, Credere equipment room cold storage) until transferred to laboratory/courier custody. It is not necessary to sign away custody from the sampler to a storage location as long as the storage location meets the above criteria as the above storage is still considered to be in Credere’s custody.



## **2.5 COURIER SERVICE AND LAB DELIVERY**

At the time of transfer of custody to the lab or courier, signatures with the date and time of transfer will document the change in custody. If samples are being sent by mail, it will not be possible for the carrier to sign the chain and the receiver should be indicated to be “via carrier” (e.g., via Fedex, via USPS).



### 3. QUALITY ASSURANCE/QUALITY CONTROL

Logbooks, field data forms, and chains of custody will be checked for consistency. (Note: see SOP CA-1 for specifics on preparation of a field forms/logbook). In general, the following shall be checked at the close of a field task, sampling event, or project:

- Level of detail on COC is sufficient to communicate sample details and required analyses
- Completeness and accuracy of COCs
- Consistency of data between logbook, field forms and COC
- COC completion compliance with this SOP



## 4. FIELD DATA MANAGEMENT

Copies of COCs will be uploaded to the Credere server for easy access during report preparation and for reference prior to receipt of the laboratory reports. Carbon copies of COCs will be kept in the permanent project central file with the sampling field sheets.



## 5. REFERENCES

- Credere Associates, LLC, *Standard Operating Procedure CA-1: Field Activity Documentation*, Revision 1, dated August 2, 2016.
- Credere Associates, LLC, *Standard Operating Procedure CA-3: Residential Well Sampling*, Revision 1, dated March 17, 2016.
- Credere Associates, LLC, *Standard Operating Procedure CA-5: Environmental Soil Sampling*, revision 0, dated May 27, 2017.
- Credere Associates, LLC, *Standard Operating Procedure CA-12: Low-Flow Groundwater Sampling*, revision 2, dated May 2, 2017.
- Credere Associates, LLC, *Standard Operating Procedure CA-13: Surface Water & Sediment Sampling*, revision 0, dated September 9, 2016.
- Credere Associates, LLC, *Standard Operating Procedure CA-14: Sub-Slab Soil Gas and Indoor Air Sampling*, Draft, dated TBD.
- Credere Associates, LLC, *Standard Operating Procedure CA-15: Asbestos-Containing Materials (ACM) Surveys and Asbestos Abatement Air Monitoring and Clearances*, Draft, dated TBD.
- Credere Associates, LLC, *Standard Operating Procedure CA-17: Packaging and Shipping Samples*, revision 0, dated August 22, 2017.
- Credere Associates, LLC, *Standard Operating Procedure CA-23: Collection of PCB-Containing Building Material and Substrate Samples*, revision 0, dated October 25, 2017.
- Credere Associates, LLC, *Standard Operating Procedure CA-26: Incremental Sampling Methodology*, revision 0, dated October 31, 2017.
- Maine DEP, *Standard Operating Procedure Chain of Custody*, RWM-DR-012, Revision 05, dated April 3, 2009.
- US DoD, *Environmental Field Sampling Handbook*, Revision 1.0, dated April 2013.
- US Environmental Protection Agency, *Compendium of Superfund Field Operations Methods*, dated December 1987.





**CHAIN-OF-CUSTODY RECORD  
AND ANALYSIS REQUEST**

Company Name: <b>Credere Associates, LLC</b>		Project Name:	
Company Address: <b>776 Main St, Westbrook, Maine</b>		Project #: <b>17001501</b>	
Report To: <b>Project Manager</b>		Project Location: NH MA <b>(ME)</b> VT NY Other	
Phone #: <b>207-828-1272 x 100</b>		Protocol: RCRA SDWA NPDES MCP NHDES OTHER	
Invoice to Email: <b>jenn@credereilc.com</b>		Reporting Limits: <b>QAPP</b> GW-1 S-1 EPA DW Other	
<input type="checkbox"/> Hard Copy Invoice Required		Quote # <b>Credere</b> <input type="checkbox"/> NH Reimbursement Pricing	
		PO #	

**ANALYSIS REQUEST**

Lab Sample ID (Lab Use Only)	Field ID	# CONTAINERS	Matrix			Preservation Method					Sampling			SAMPLER	Analysis																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
			WATER	SOLID	OTHER	HCl	HNO <sub>3</sub>	H <sub>2</sub> SO <sub>4</sub>	NaOH	MeOH	DATE	TIME	VOC 8260		VOC 824	VOC 8260	VOC 824	MPH MADEP	GRN	VOC 524.2	VOC 524.2	TPH	DRO 8015	8270PAH	8270	8082 POB	8081	O&G 1664	Mineral	pH	BOD	TSS	TDS	TS	RCRA Metals	PH	Total Metals-list	Dissolved Metals-list	Ammonia	COD	T-Phosphorus	PH	Cyanide	Sulfide	Nitrate	Nitrite	Corrosivity	React	TCL P Metals	TCL	Subcontract	Grain S	Composi																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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<input checked="" type="checkbox"/> VOC 8260	<input type="checkbox"/> VOC 8260 NHDES	<input type="checkbox"/> VOC 8260 MADP	<input type="checkbox"/> VOC 824	<input type="checkbox"/> VOC BTEX	<input type="checkbox"/> MIBE, only	<input type="checkbox"/> VOC 8015	<input type="checkbox"/> 1,4-Dioxane	<input type="checkbox"/> ALPH MADEP	<input type="checkbox"/> GRO 8015	<input type="checkbox"/> Gases-List:	<input type="checkbox"/> VOC 524.2	<input type="checkbox"/> NH List	<input type="checkbox"/> Gases-List:	<input type="checkbox"/> TPH	<input type="checkbox"/> DRD 8015	<input type="checkbox"/> EPH MADEP	<input type="checkbox"/> TPH Fingerprint	<input type="checkbox"/> 8270PAH	<input type="checkbox"/> 8270ABN	<input type="checkbox"/> 625	<input type="checkbox"/> EDB	<input type="checkbox"/> 8082 PCB	<input type="checkbox"/> 8081 Pesticides	<input type="checkbox"/> 608 Pest/PCB	<input type="checkbox"/> O&G 1664	<input type="checkbox"/> Mineral O&G SM5520F	<input type="checkbox"/> pH	<input type="checkbox"/> BOD	<input type="checkbox"/> Conductivity	<input type="checkbox"/> Turbidity	<input type="checkbox"/> TSS	<input type="checkbox"/> TDS	<input type="checkbox"/> TS	<input type="checkbox"/> TVS	<input type="checkbox"/> Alkalinity	<input checked="" type="checkbox"/> RCRA Metals	<input type="checkbox"/> Priority Pollutant Metals	<input type="checkbox"/> TAL Metals	<input type="checkbox"/> Hardness	<input type="checkbox"/> Total Metals-List:	<input type="checkbox"/> Dissolved Metals-List:	<input type="checkbox"/> Ammonia	<input type="checkbox"/> COD	<input type="checkbox"/> TKN	<input type="checkbox"/> TN	<input type="checkbox"/> TON	<input type="checkbox"/> TOC	<input type="checkbox"/> T-Phosphorus	<input type="checkbox"/> Phenols	<input type="checkbox"/> Bacteria P/A	<input type="checkbox"/> Bacteria MPN	<input type="checkbox"/> Cyanide	<input type="checkbox"/> Sulfide	<input type="checkbox"/> Nitrate + Nitrite	<input type="checkbox"/> Ortho P	<input type="checkbox"/> Nitrate	<input type="checkbox"/> Nitrite	<input type="checkbox"/> Chloride	<input type="checkbox"/> Sulfate	<input type="checkbox"/> Bromide	<input type="checkbox"/> Fluoride	<input type="checkbox"/> Corrosivity	<input type="checkbox"/> Reactive CN	<input type="checkbox"/> Reactive S-	<input type="checkbox"/> Ignitability/FP	<input type="checkbox"/> TCLP Metals	<input type="checkbox"/> TCLP VOC	<input type="checkbox"/> TCLP SVOC	<input type="checkbox"/> TCLP Pesticide	<input type="checkbox"/> Subcontract:	<input type="checkbox"/> Grain Size	<input type="checkbox"/> Herbicides	<input type="checkbox"/> Formaldehyde	<input checked="" type="checkbox"/> Grab (G)	<input type="checkbox"/> or	<input type="checkbox"/> Composite (C)
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<b>TAT REQUESTED</b> Priority (24 hr)* <input type="checkbox"/> Expedited (48 hr)* <input type="checkbox"/> Standard (10 Business Days) <input checked="" type="checkbox"/> *Date Needed <b>1/9/17</b>		See absoluteresourceassociates.com for sample acceptance policy and current accreditation lists.		<b>SPECIAL INSTRUCTIONS</b> MS/MSD for metals only, metals water samples are field filtered	
<b>REPORTING INSTRUCTIONS</b> <input checked="" type="checkbox"/> PDF (e-mail address) <b>pmanager@credereilc.com</b> <input type="checkbox"/> HARD COPY REQUIRED <input type="checkbox"/> FAX (FAX#)		RECEIVED ON ICE <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO TEMPERATURE <b>&lt; 6</b> °C			
<b>CUSTODY RECORD</b> QSD-01 Revision 1/27/16		Relinquished by Sampler: <b>Chris Sampler</b> <i>credere</i> Relinquished by: <b>Chris Labortory Carri</b> <i>corner</i> Relinquished by:		Date <b>1/2/17</b> Time <b>0900</b> Date <b>1/2/17</b> Time <b>1400</b> Date	
		Received by: <b>Chris Labortory Carri</b> <i>corner</i> Received by: <b>Labortory Carri</b> <i>check-in</i> Received by Laboratory:		Date <b>1/2/17</b> Time <b>0900</b> Date <b>1/2/17</b> Time <b>1400</b> Date	



# CREDERE ASSOCIATES, LLC


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## Standard Operating Procedure CA-18 Lead Paint Activities and XRF Safety

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Effective Date: July 2022

Revision: 1

 7/15/2022  
Moira Wentworth, Author Date

 7/15/2022  
Allison Drouin, Author Date

 7/15/2022  
Theresa Patten, Technical Review Date

Revision	Date	Reason for Revision
1	4/22/2022	Updates related to revised Maine Department of Environmental Protection (DEP) Chapter 424 regulation – 10/19/2021 New Hampshire Lead Paint Poisoning Prevention and Control, Chapter He-P 1600 – 06/04/2021

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## ATTACHMENTS

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Attachment A .....	Standard Building Components to Assess
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## 1. OBJECTIVE AND APPLICABILITY

### 1.1 OBJECTIVE

The purpose of this Standard Operating Procedure (SOP) is to provide guidance for lead paint activities, which include but are not limited to lead surveys, lead determinations, lead inspections, lead risk assessments, lead-safe evaluations, and for the collection of paint chip, wipe, soil, and water samples. If followed correctly, this SOP will allow for the following:

- Appropriate testing practices using an X-ray fluorescence (XRF) analyzer to allow documentation of lead paint conditions relative to the Clients' needs
- Safety of employees collecting XRF data, paint chip, wipe, soil, and water samples
- Collection of representative and reproducible sample results

Creder Associates, LLC (Creder) SOPs are a guidance, and state requirements, site-specific plans, and special conditions may require alternative approaches. This SOP is not a substitution for knowledge and implementation of state and/or federal requirements and procedures.

### 1.2 APPLICABILITY

This SOP should be used during lead paint activities such as lead surveys, lead determinations, lead inspections, lead risk assessments, lead-safe evaluations, and during the collection of paint chip, wipe, soil, and water samples from applicable painted building components or exterior areas believed to be contaminated. Building components include, but are not limited to, walls, ceilings, floors, windows, window frames, doors, door frames, stairs, railings, and exterior siding. **Attachment A** lists common interior and exterior building component types that should be tested with specific component names of a stairway, window, door, and roof detailed on a schematic.

This SOP does not cover direct screening of soil using an XRF. Calibration procedures and analytical ranges specific to Creder's XRF instruments should be reviewed to select the appropriate instrument relative to the Site location and applicable comparison criteria. U.S. Environmental Protection Agency Method 6200 Field Portable X-ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment should be reference for analysis of lead in soil using an XRF (see O:\Environmental Information\Lead)



## 2. PROCEDURE

### 2.1 NECESSARY EQUIPMENT

The following is a list of required equipment for lead surveys, lead determinations, lead inspections, lead hazard screenings, and lead risk assessments and for the collection of paint chip, wipe, soil, and water samples:

#### **Lead Surveys, Determinations/Inspection/Hazard Screening/Risk Assessment/-Safe Evaluation Equipment**

- Innov-x X-ray fluorescence (XRF) analyzer (Credere owned equipment)
- HP iPAQ
- HP iPAQ charger
- paper clip for resetting HP iPAQ
- NIST calibration cards
  - SRM 2570 White (0.00 mg/cm<sup>2</sup> calibration)
  - SRM 2573 Red (1.00 mg/cm<sup>2</sup> calibration)
- Minimum of three fully charged batteries
- Standardization clip

Or

- Heuresis XRF Analyzer (Credere owned equipment)
- 18 nickel metal hydride batteries
- Battery charger
- 3 battery holders
- NIST calibration wood block

And

- Keys or Site building access contact information
- Site plan
- Field log book
- Ink pens
- Nitrile disposable gloves
- Measuring tape
- Camera
- Ladder
- Flash light and/or headlamp
- Applicable State Lead Inspector license

#### **Paint Chip Sampling Equipment**

- Sharp stainless steel paint scraper
- Heat gun or other heat source operating below 1,100°F
- Sample collection device (piece of paper, aluminum container)



- Laboratory provided sample containers, labels and chain of custody
- Site plan
- Field log book
- Ink pens
- Nitrile disposable gloves
- Measuring tape
- Camera
- Ladder
- Flash light and/or headlamp
- Applicable State Lead Inspector license

### **Wipe Sampling Equipment**

- Disposable wipe that:
  - Contains low background lead levels
  - Is a single thickness
  - Durable
  - Contains no aloe
  - Can be digested in a lab
  - Can yield 80-120% recover rates from spiked samples
  - Remains moist during sampling
- Laboratory provided sample containers, labels, and chain of custody
- 1'x1' wipe template or other applicable/appropriate known size
- Site plan
- Field log book
- Ink pens
- Nitrile disposable gloves
- Measuring tape
- Camera
- Ladder
- Flash light and/or headlamp
- Applicable State Lead Inspector license

### **Soil Sampling Equipment**

- Bucket auger
- Laboratory provided sample container
- 5-gallon bucket with warm soapy water
- 5-gallon bucket with warm rinse water
- Scrub brushes
- Paper towels
- Laboratory provided sample containers, labels and chain of custody
- Site plan
- Field log book



- Ink pens
- Other decontamination supplies (see CA-2 Equipment Decontamination Procedures)
- Non-sterilized non-powdered disposable gloves
- Measuring tape
- Camera
- Ladder
- Flash light and/or headlamp
- Disposable wipes
- Applicable State Lead Inspector license

## 2.2 TRAINING AND HEALTHY AND SAFETY

Credere employees must have 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) training pursuant to 29 CFR 1910.120 and be current on their 8-hour refresher.

Toxic Substances Control Act (TSCA) Title IV, as amended through Residential Lead Based Paint Hazard Reduction Act of 1992, a.k.a. Title X, allows States the flexibility to develop accreditation and certification programs and work practice standards for lead-related inspection, risk assessment, renovation, and abatement that are at least as protective as existing Federal standards.

Additionally, the following state specific additional training for lead paint work must be completed:

- Maine
  - Maine lead inspectors must have completed the 32-Hour Initial Lead Inspector course and the 32-Hour Initial Lead Supervisor course (if initially licensed after 01/01/2022) in accordance with TSCA Title IV, HUD Title X, 24 CFR 35 and Maine DEP Chapter 424, section 5 (D), and be current on their 8-hour lead refresher.
  - Maine risk assessors must have completed the required lead inspector training (listed above), the 16-hour Lead Risk Assessor Initial course in accordance with TSCA Title IV, HUD Title X, 24 CFR 35, and Maine DEP Chapter 424, section 5(D), and be current on their 8-hour lead refresher.
- New Hampshire
  - New Hampshire lead inspectors must have completed the 24-Hour Initial Lead Inspector course in accordance with TSCA Title IV and X, 24 CFR 35 and New Hampshire Statutes Chapter 130, and be current on their 8-hour lead refresher.
  - New Hampshire Risk Assessors must have completed the 16-hour Lead Risk Assessor Initial course in accordance with TSCA Title IV and X, 24 CFR 35 and New Hampshire Statutes Chapter 130, and be current on their 8-hour refresher.



- Massachusetts
  - Massachusetts Inspectors must have satisfactorily completed the State Program or certified lead inspector training.
  - Massachusetts Risk Assessor's must be an Inspector and have completed a minimum of 25 inspections within two years. Additionally, documentation of training for use of an XRF and a license for its use with the Department of Public Health Radiation Control Program is required.
- Vermont
  - Vermont Inspectors must have 40 hours of training at least 8 of which must be hands-on.

Employees must prove competence of the SOP in compliance with OSHA 29 CFR 1910.120(e)(4). Employees are responsible for maintaining their licensing and training requirements

### **XRF Safety**

THE XRF SHOULD NOT BE POINTED AT ANYONE OR ANY BODY PART, ENERGIZED OR DE-ENERGIZED. The safe and proper operation of the XRF instruments is the highest priority. These instruments produce ionizing radiation and should ONLY be operated by individuals, who have been properly trained.

Radiation levels during testing are  $<0.1$  mR/hr on all surfaces of the analyzer except at or near the exit port for the radiation. This means that if an operator follows standard operating procedures and observes the following warnings, they will not obtain any detectable radiation dose above naturally occurring background radiation, on their hand while holding the analyzer, or on any area of their body:

- Do not service any Innov-X product yourself.
- Use the correct external power source.
- Do not hold samples in hand or on lap while analyzing.
- Use the analyzer in accordance with manufacturer instruction.
- Ensure leak testing and inspection of the instrument is performed on the required basis.

The XRF is licensed specifically for each state. Therefore, ensure the respective XRF is properly licensed and the case properly labeled for the state of intended use.

## **2.3 DETERMINING LEAD IN PAINT**

The method for determining the presence of lead in paint must be selected based on Site specific conditions and client requirements. The following table outlines the majority of Site specific situation and the corresponding method for determining the presence of lead in paint:



Situation	Appropriate Method
Brownfields (or otherwise) Site requiring initial information to estimate the extent of lead in paint. Often applicable in a commercial setting.	Lead Survey (not a term used by the State or EPA)
Residential dwelling or child-occupied facility requiring limited testing of selected surfaces or areas (not a full lead inspection). Sometimes targeted at areas for renovation.	Lead Determination
Residential dwelling or child-occupied facility where a surface by surface assessment of all applicable areas to determine the presence and condition of lead-based paint and the provision of a written report.	Lead Inspection
An assessment of a residential dwelling or child-occupied facility to determine the existence, nature, severity, and location of lead hazards, and the provision of a written report explaining the results of the assessment and the options for reducing lead hazards.	Lead Risk Assessment
Residential dwelling or child-occupied facility that is the subject of a real estate transaction in which an insurance company has requested a "Lead-Safe" certificate. Lead-safe means a residential dwelling or child-occupied facility that contains no lead hazards.	Lead-Safe Evaluation (ME)
Residential or child-occupied facility where the paint is in good condition and where the probability of finding lead-based paint hazards is low (a limited risk assessment).	Lead Hazard Screening

The following table summarizes the differences in these methods:

Method	Lead Survey	Lead Determination	Lead Inspection	Lead Risk Assessment	Lead Safe Evaluation	Lead Hazard Screening
XRF Testing of Limited Surfaces <sup>^</sup>	X	X				
XRF Confirmation testing of previous results*						X
Surface by Surface XRF Testing			X	X	X	
Soil/Wipe Sampling	(optional)	(optional)	(optional)	X	X	X
Identification of Surface Condition	X	X	X	X	X	X
Identification of Hazards		X	X	X	X	X
Issuance of Lead Safe Certificate					X	
Recommendations for Hazard Mitigation				X		

\*Friction, chewable, or in poor condition

<sup>^</sup>Limited to specific areas (e.g., targeted renovation areas)

Commercial buildings under the Brownfields program require only a lead survey. No lead determinations or lead inspections are required for commercial buildings that are not child-occupied. If a Brownfields Site is also a child-occupied facility, a lead determination will be performed to gather initial information, followed by a lead inspection, risk assessment, or hazard screening depending on the client requirements. Additionally, EPA's Lead Renovation, Repair



and Painting Rule (RRP Rule), 40 CFR 745, Subpart E, requires that firms performing renovation, repair, and painting projects on residential or child-occupied facilities built before 1978 that disturb lead-based paint (LBP) perform a lead determination or inspection prior to the start of work.

LBP is defined as paint or other surface coatings that contain lead equal to or in excess of 1.0 milligram per square centimeter or more than 0.5% by weight. Lead-containing paint (LCP) is paint or other surface coatings that contain any detection of lead. Paint is defined as any substance applied to a surface as a coating, including, but not limited to, household paints, varnishes, and stains. A testing combination is a unique combination of room equivalent, building component type, and substrate. Paint chip samples are only required during lead inspections without the use of an XRF analyzer.

A lead hazard is any condition that may cause exposure to lead from lead-contaminated dust, lead-contaminated soil, lead-contaminated water, or LBP that is in poor condition. Wipe, soil, and water sampling is used to determine the presence of a lead hazard in dust, soil, and water, respectively. Lead Inspectors are required to identify lead hazards; however, only Lead Risk Assessors are able to give recommendations regarding lead hazards to clients.

### **Lead Survey**

A lead survey is a non-state defined survey that is performed on a Site that requires initial information to estimate the extent of LBP/LCP within a commercial facility, but a lead determination or inspection is not required. A lead survey may also be performed for a homeowners own personal knowledge to identify areas of LBP generally with their home. The scope of a lead survey is flexible. The following procedures outline steps for preparation prior to a lead survey:

1. Upon arrival at the Site, begin a field log book entry recording the Credere staff, scope of work for the day, health and safety precautions, and weather conditions.
2. Take at least three calibration check readings for each calibration card and calibrate the XRF analyzer according to product specifications if necessary. Keep record of calibration in the field log book. Repeat every four hours throughout the survey.
3. Sketch the building layout in the field log book or obtain a copy of the building plans. Label the perimeter building sides A, B, C, and D. Side A for single-family housing is the street side for the address. Side A for multi-family housing is typically the apartment entry door, however this should be discussed with the Project Manager to ensure the designations make sense considering the building layout, orientation to the street, and intended use of data. Sides B, C, and D are identified clockwise from Side A. Each room requires a unique label (room equivalent) and number that should be included on the building sketch or building plans (numbering should always increase from left to right as one faces the building side). Numbering and letter designations should be clearly defined on all tables, figures, and within the body of the report.
4. Once the XRF analyzer is ready for use, XRF testing is required for at least one location per surface or components. **Attachment A** lists common interior and exterior building component types that should be tested. Each reading entry should include room equivalent,



building side, component, paint color, substrate, and condition. Alternatively, the determination can be biased to areas planned for renovation; however, this should be well defined prior to field mobilization and will require specific discussion of this limitation of the data during reporting.

5. Take at least three calibration check readings for each calibration card post lead survey. Keep record of calibration in the field log book.

### **Lead Determination**

A lead determination can be performed on a Site that is either a residential dwelling or child-occupied facility and is a limited inspection. The purpose of a lead determination is to identify the presence of LBP and/or lead hazards within a limited area, typically associated with an area planned for renovation. Lead determinations are required prior to any renovation or demolition of residential or child-occupied facilities by an outside company. If no renovations or demolition is planned, a lead determination can be used to estimate the extent of lead in paint throughout the building to gain a general idea of how much lead in paint is present, similar to a Lead Survey, but a Lead determinations also determines the presence of lead hazards in dust, soil, and water if there is reason to believe these interfaces are contaminated and if the client's needs require these media be sampled. The scope of a Lead Determination is flexible. The following procedures outline steps for preparation prior to a lead determination:

1. Upon arrival at the Site, begin a field log book entry recording the Credere staff, scope of work for the day, health and safety precautions, and weather conditions.
2. Take at least three calibration check readings for each calibration card and calibrate the XRF analyzer according to product specifications if necessary. Keep record of calibration in the field log book. Repeat every four hours throughout the determination.
3. Sketch the building layout in the field log book or obtain a copy of the building plans. Label the perimeter building sides A, B, C, and D. Side A for single-family housing is the street side for the address. Side A for multi-family housing is the apartment entry door. Sides B, C, and D are identified clockwise from Side A. Each room requires a unique label (room equivalent) and number that should be included on the building sketch or building plans (numbering should always increase from left to right as one faces the building side).
4. Once the XRF analyzer is ready for use, XRF testing is required for at least one location per surface or components, except for interior and exterior walls, where four readings should be taken, one on each wall (Wall A, B, C, and D). All painted surfaces within the area designation for the lead designation require XRF testing. **Attachment A** lists common interior and exterior building component types that should be tested. Each reading entry should include room equivalent, building side, component, paint color, substrate, and condition (intact, fair, poor). Alternatively, the determination can be biased to areas planned for renovation; however, this should be well defined prior to field mobilization and will require specific discussion of this limitation of the data during reporting.
5. Upon completion of XRF analyzer testing for all testing at the property, the Lead Inspector shall use a random number generator to generate (google search: random number generator and one should appear in the search) 10 random readings from the total X number of



readings taken. These 10 duplicate readings should be documented and then be retested using the XRF.

6. Take at least three calibration check readings for each calibration card post lead determination. Keep record of calibration in the field log book.
7. If results of the XRF testing suggest soil surrounding the building, interior dust as a result of lead paint in poor conditions, or drinking water are contaminated with lead, these media can be sampled at the Client's request. However, if renovations are planned, it may be pertinent for these media be sampled at the completion of renovations to avoid duplication unless results of this sampling would guide certain renovation practices/design. Sampling methodology for these media is provided in **Section 2.4**.

### **Lead Inspection**

A lead inspection is a **surface-by-surface** assessment to determine the presence and condition of LBP throughout an entire dwelling. Lead inspections are required prior to an outside company performing extensive construction work within a residential dwelling or child-occupied facility. Lead inspections also determine the presence of lead hazards in dust, soil, and water if there is reason to believe these interfaces are contaminated. A Lead Inspection has a well-defined scope with specific requirements defined by the state it is being performed in. This requirements must be met to be considered a Lead Inspection. The following procedures outline steps for a lead inspection:

1. Upon arrival at the Site, begin a field log book entry recording the Credere staff, scope of work for the day, health and safety precautions, and weather conditions.
2. Take at least three calibration check readings for each calibration card and calibrate the XRF analyzer according to product specifications if necessary. Keep record of calibration in the field log book. Repeat for every four hours during the lead inspection.
3. Sketch the building layout in the field log book or obtain a copy of the building plans. Label the perimeter building sides A, B, C, and D. Side A for single-family housing is the street side for the address. Side A for multi-family housing is the apartment entry door. Sides B, C, and D are identified clockwise from Side A. Each room requires a unique label (room equivalent) and number that should be included on the building sketch or building plans (numbering should always increase from left to right as one faces the building side).
4. Once the XRF analyzer is ready for use, XRF testing is required for each individual surface and/or component. **Attachment A** lists common interior and exterior building component types that should be tested and includes details with specific component names for a stairway, window, door, and roof. Each reading entry should include room equivalent, building side, component, paint color, substrate, and condition (intact, fair, poor).
5. Upon completion of XRF analyzer testing for all testing at the property, the Lead Inspector shall use a random number generator to generate (google search: random number generator and one should appear in the search) 10 random readings from the total X number of readings taken. These 10 duplicate readings should be documented and then be retested using the XRF.



6. Take a least three calibration check readings for each calibration card post lead inspection. Keep record of each calibration in the field log book.
7. If results of the XRF testing suggest soil surrounding the building, interior dust as a result of lead paint in poor conditions, or drinking water are contaminated with lead, these media are required to be sampled. Sampling methodology for these media is provided in **Section 2.4**.

### *Paint Chip Sampling*

Paint chip samples are used to determine the presence of lead in paint when an XRF analyzer is not available or is not appropriate to use on the surface. To avoid cross-sample contamination, dust must be cleared off the painted area to be sampled using a wet wipe. If the building of the lead inspection is occupied, the occupant must be notified when paint chip sampling is required because it is a destructive method.

1. Place a clean sheet of plastic measuring 4' x 4' under the area to be sampled to capture any paint chips that are not captured by the collection device. Any visible paint chips falling to the plastic should be included in the sample.
2. Scrape the paint directly off the substrate to remove all layers of paint equally. Take care not to scrape any of the substrate and include it in the sample. A heat gun can be used to soften the paint before removal and reduce the chances of including substrate with the sample.
  - a. The heat gun should be held no closer than six inches from the painted surface.
  - b. The heat gun should not exceed 1,100°F.
3. The sample should be between 2 to 4 square inches in size.
4. Place paint samples in appropriate baggies for transport to the laboratory.
5. Record the dimensions of the area sampled and include on the sampling form.
6. Clean up all settled dust with a wet wipe after sampling is completed.
7. Prepare the chain of custody in accordance with Credere SOP CA-16. Record the sample time, ID, analyses, and sample area in the field log book.

### **Lead Risk Assessment**

The objectives of a risk assessment are to identify and report on the existence, nature, severity, source, and location of lead hazards; and to identify and report on options for reducing or eliminating identified lead hazards, including interim controls or abatement measures, or both. A complete risk assessment is performed on the entire dwelling unit and all common areas; the scope of a targeted risk assessment is determined through contract. A Risk Assessment has a well-defined scope with specific requirements defined by the state it is being performed in. These requirements must be met to be considered a Risk Assessment. The following procedures outline steps for a risk assessment:



1. Upon arrival at the Site, begin a field log book entry recording the Credere staff, scope of work for the day, health and safety precautions, and weather conditions.
2. Perform a visual inspection of the Site to take note of chewable, friction, and impact surfaces. Record observations in the field log book.
3. Take at least three calibration check readings for each calibration card and calibrate the XRF analyzer according to product specifications if necessary. Keep record of calibration in the field log book. Repeat for every four hours during the risk assessment.
4. Sketch the building layout in the field log book or obtain a copy of the building plans. Label the perimeter building sides A, B, C, and D. Side A for single-family housing is the street side for the address. Side A for multi-family housing is the apartment entry door. Sides B, C, and D are identified clockwise from Side A. Each room requires a unique label (room equivalent) that should be included on the building sketch or building plans (numbering should always increase from left to right as one faces the building side).
5. Once the XRF analyzer is ready for use, XRF testing is required XRF testing is required for each individual surface and/or component, except for interior and exterior walls, where four readings should be taken, one on each wall. **Attachment A** lists common interior and exterior building component types that should be tested and includes details with specific component names for a stairway, window, door, and roof. Each reading entry should include room equivalent, building side, component, paint color, substrate, and condition (intact, fair, poor).
6. Upon completion of XRF analyzer testing for all testing combinations at the property, the Lead Inspector shall use a random number generator to generate (google search: random number generator and one should appear in the search) 10 random readings from the total X number of readings taken. These 10 duplicate readings should be documented and then be retested using the XRF.
7. To complete the risk assessment, dust and soil samples are required; water samples are optional. **Section 2.4** outlines sampling procedures for dust, soil, and water sampling.

### **Lead Hazard Screen (Maine)**

A lead hazard screen is a Maine defined term that means “a limited risk assessment that is appropriate for dwelling units in good condition where the probability of finding lead-based paint hazards are low”. For example, a residence or child-occupied facility with painted surfaces that are all in good condition. This methodology should be used only in Maine and is prescribed in Chapter 424 to comprise XRF testing limited to poor condition, friction, and chewable surfaces as well as confirmatory wipe samples. The following procedures outline typical steps for lead hazard screen:

1. Upon arrival at the Site, begin a field log book entry recording the Credere staff, scope of work for the day, health and safety precautions, and weather conditions.
2. Turn on the XRF and allow the unit to warm up. Take at least three calibration check readings for each calibration card prior to the hazard screen. Keep record of calibration in the field log book. Retest every 4 hours during the hazard screen.



3. Sketch the building layout in the field log book or obtain a copy of the building plans. Label the perimeter building sides A, B, C, and D. Side A for single-family housing is the street side for the address. Side A for multi-family housing is the apartment entry door. Sides B, C, and D are identified clockwise from Side A. Each room requires a unique label (room equivalent) that should be included on the building sketch or building plans (numbering should always increase from left to right as one faces the building side).
4. Completed a visual inspection to determine if any paint in poor condition is present and to locate at least two dust sampling locations.
5. Once the XRF analyzer is ready for use, XRF readings should be collected from paint in poor condition, friction surfaces, and chewable surfaces. **Attachment A** identifies surfaces that are typically considered to be chewable or friction. Poor paint condition will be based on field observation. Each reading entry should include room equivalent, building side, component, paint color, substrate, and condition.
6. Take a least three calibration check readings for each calibration card post hazard screen. Keep record of each calibration in the field log book.
7. Collect two composite dust wipe samples: one from the floor and one from window sills in locations where children under 6 are most likely to encounter lead dust. **Section 2.4** outlines sampling procedures for dust sampling.

### **Lead-Safe Evaluation**

A lead-safe evaluation is used to determine if any lead hazards are present and can be performed by a Lead Inspector or Risk Assessor. If no lead hazards are identified, a lead-safe certificate can be issued. In New Hampshire, only a Risk Assessor can issue a lead-safe certificate. Provided no lead hazards are identified, at the time a lead-safe certificate is issued, an Essential Maintenance Program must be implemented to manage any lead contamination identified.

1. A lead-safe evaluation follows the same steps as a lead inspection.
2. A Risk Assessor can provide recommendations on appropriate interim controls or abatement methods.

Unless the Site contains no lead in paint, dust, and soil above the applicable criteria, a reevaluation is required every six months to verify lead-safe status. A reevaluation is a modified lead inspection or risk assessment (a lead hazard screening) consisting of visual assessment of painted surfaces and prior lead hazard control or abatement work, limited dust and soil sampling, and a review of the implemented Essential Maintenance Program. It is recommended that consistent personnel perform reinspections for familiarity with prior conditions. A reevaluation will consist of the following procedure:

1. Review any prior reports relating to lead contamination at the Site.
2. Start with a visual assessment to identify painted surfaces in fair or poor condition with known lead-based paint, disruption of surfaces with LBP by renovation activities, deteriorated or failed interim controls of lead hazards or encapsulation or enclosure



treatments, lead-contaminated dust, and new bare soil with lead levels above applicable standards.

3. If all lead hazard control or abatement activities are in place, begin dust sampling procedures. All hazards must be controlled before dust sampling can begin according to **Section 2.4**.
4. If new areas of bare soil are observed, collect soil samples according to **Section 2.4**.

## **2.4 DETERMINING LEAD HAZARDS**

A lead hazard is any condition that may cause exposure to lead from lead-contaminated dust, lead-contaminated soil, lead-contaminated water, or LBP that is in poor condition. Wipe, soil, and water sampling is used to determine the presence of a lead hazard in dust, soil, and water. These samples are only collected during or after a lead inspection as a result of reason to believe these interfaces are contaminated. Visual assessment and XRF analysis are used to determine the presence of a lead hazard in LBP. Upon arrival at the Site, begin a field log book entry recording the Credere staff, scope of work for the day, health and safety precautions, and weather conditions.

### **Wipe Sampling Procedure**

Dust testing is conducted by a single-surface wipe sample. The primary objective of wipe sampling is to assess if dust from lead paint or lead-contaminated soil has been tracked through a building. Wipes used in dust testing must meet the requirements listed in Appendix A of Maine DEP Chapter 424: Lead Management Regulations. If a room had no detections of LBP during the lead inspection, dust wipe samples are not required for that room equivalent, unless in the Inspector's professional judgement tracking of lead dust/soil is a concern. One floor wipe sample may be required if lead is identified on the exterior of a building or in soil. Wipe samples should not be collected from surfaces with LBP in poor condition as these are already considered hazards.

1. Upon arrival at the Site, begin a field logbook entry recording the Credere staff, scope of work for the day, and weather conditions in accordance with Credere SOP CA-1.
2. Identify the areas to be wipe sampled including the youngest child's bedroom, the child principal play area, the entryway, kitchen window sill, and any other horizontal dust collecting surfaces (see Maine DEP Chapter 424 for guidance). If composite sampling for lead hazard screening, the floor, window sill, and window trough shall be sampled as well as a carpeted surface, if present.
3. Outline the wipe area by first identifying the area to be sampled. If composite sampling, the multiple areas to be composited should be set up before the first aliquot is collected.
  - a. Floors: Do not walk or touch the surface to be sampled. Apply masking tape or template to perimeter of the wipe area to form a 1-foot by 1-foot square or rectangle.
  - b. Window sills and other rectangular surfaces: Do not touch the wipe area. Apply two strips of masking tape across the sill to define a wipe area at least 0.1 square foot in size, but not more than 2 square feet.
4. Wearing new nitrile gloves, inspect the wipes to ensure they are moist. If composite sampling, use a separate wipe for each aliquot location.



5. Place the wipe at one corner of the surface to be wiped with the wipe fully opened and flat on the surface. Wipe side-to-side with as many “S”-like motions as are necessary to completely cover the entire wipe area. Exerting excessive pressure on the wipe will cause it to curl.
6. Fold the wipe in half using gloved hands, folding the wiping side inward. Complete a second wipe pass with the folded back side moving from top-to-bottom and wiping the area with “S”-like motions.
7. For a window sill, do not attempt to wipe the irregular edges presented by the contour of the window channel. Avoid touching other portions of the window with the wipe. If there are paint chips or gross debris in the window sill, attempt to include as much of it as possible on the wipe.
8. After wiping, fold the wipe again with the second wiping side facing inward, and insert into the centrifuge tube or other hard-shelled container. If composite sampling, put all wipes from up to four locations into the same tube.
9. After sampling, measure the surface area wiped to the nearest eighth of an inch. Floor areas should be laid out as 1 square foot; however, window sills will have irregular shapes and sizes. The area wiped must be at least 0.1 square feet.
10. Prepare the chain of custody in accordance with Credere SOP CA-16. Record the sample time, ID, analyses, and sample area in the field log book.
11. Submit the samples to the laboratory for analysis by method 7000B with hot block acid digestion by method 3050B.

### **Soil Sampling Procedure**

Soil samples are collected from bare soil totaling more than 9 square feet and from all foundation drip lines and play areas. One composite sample should be collected from each of the child’s principal play areas, one composite sample from any area of bare soil greater than 9 square feet that appears likely to pose a risk, and one composite samples from along the foundation drip line (separate discrete samples may be appropriate for drip line locations). It is not recommended to collect soil samples while the ground is frozen.

1. Upon arrival at the Site, begin a field logbook entry recording the Credere staff, scope of work for the day, and weather conditions in accordance with Credere SOP CA-1.
2. Prepare decontamination station.
3. Decontaminate sampling tools and cover with aluminum foil to keep clean until sampling or place on clean polyethylene sheeting.
4. For drip line sampling locations, collect five to ten 0 to 0.5 foot aliquots of surface soil from the building perimeter at least 2 feet from the foundation. The aliquots should be collected from each side of the building where bare soil is present and be biased to the highest locations of XRF results, if available (XRF soil screening should be conducted according to EPA Method 6200). If soil was not tested with the XRF, aliquots should be



biased to accumulation areas and areas of concentrated paint chips. Homogenize the soil in a decontaminated stainless steel bowl and transfer to laboratory provided 4 oz glass jars.

5. For play area or other bare soil sampling locations, collect three to ten 0 to 0.5 foot aliquots collected along an X-shaped grid in the child's principal play area. Each aliquot should be at least 1 foot distant from each other and collected from bare soil. Homogenize the soil in a decontaminated stainless steel bowl and transfer to laboratory provided 4 oz glass jars.
6. Decontaminate the core sampler between each composite sample collected (not between aliquots). Scrub the device in the 5-gallon bucket of warm soapy water, rinse, and dry completely with a paper towel. Repeat steps 4 or 5 for additional composites.
7. Prepare the chain of custody in accordance with Credere SOP CA-16. Record the sample time, ID, analyses, and sample volume in the field log book.
8. Submit samples to the laboratory for analysis of lead by EPA Method 6020A.

### **Water Sampling Procedure**

Water samples are used to identify lead-contaminated water. The sample(s) should be collected from the tap that serves as the primary source of cooking and drinking water.

1. First-Draw samples:
  - a. Collect a water sample into a 250 mL nitric acid preserved polyethylene bottle to the neck from the cold water tap after there has been no water used for at least six hours. The water sample should contain the first drops of water as the faucet is turned on and continue until the sample container is filled. Remove aerator from faucet before sampling.
2. Flushed samples:
  - a. Collect a water sample into a 250 mL nitric acid preserved polyethylene bottle to the neck from the same cold water tap as the first-draw sample. Allow the water to run for five minutes after collecting the first-draw sample before filling the sample container to be identified as the flush sample. Remove aerator from faucet before sampling.
3. Prepare the chain of custody in accordance with Credere SOP CA-16. Record the sample time, ID, analyses, and sample volume in the field log book.
4. Submit the samples to the laboratory for analysis by EPA Method 6020A.



### 3. QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance (QA) and quality control (QC) will be obtained through XRF calibration procedures, XRF randomized reading duplicates, and the collection of additional samples. The types of samples to be collected are dependent on the data quality objectives and should be defined in the project's proposal/scope of work, Site-Specific Quality Assurance Project Plan (SSQAPP), regulatory/client guidance, or similar. Types of QA/QC samples that may be collected include the following:

- XRF randomized replicates
- Field duplicates (optional)
- Wipe blanks to assess the wipe lead concentration
- Equipment blanks (e.g., after decontaminating an auger or sampler)
- Seven times replicate for soil XRF screening (See EPA Method 6200)

Additionally, field documentation will be reviewed to assure it is compliant with Credere SOP CA-1: Field Activity Documentation and methods used for sampling are compliant with the protocol herein.



## 4. FIELD DOCUMENTATION

The following information should be recorded in the field log book in compliance with Credere SOP CA-1:

- Date of sampling
- Credere personnel
- Scope of work
- Weather
- Equipment used
- Changes in scope
- Correspondence with Project Managers
- Sample depths and depths to bottom
- Sample location information (unless GPS is used)
- Sample IDs, time of collection, requested analyses, volume of sample collected, preservatives
- Decontamination procedures
- General timeline of field activities
- Sketch of the building interior and exterior indicating locations of building components. A, B, C, D side of the building and rooms must be labeled.
- If XRF cannot log sample test results, these must be recorded, along with sample location, color, substrate, condition, and if it is a chewable, friction or impact surface.
- XRF calibration results and frequency



## 5. REFERENCES

Credere Associates, LLC, *Standard Operating Procedure CA-1 Field Activity Documentation*, Revision 0, dated August 4, 2015.

Credere Associates, LLC, *Standard Operating Procedure CA-16 Chain of Custody Preparation*, Draft, dated TBD.

Maine Department of Environmental Protection, *Chapter 424: Lead Management Regulations*, dated October 19, 2021

Massachusetts Department of Public Health. *105 CMR 460 Lead Poisoning Prevention and Control*. December 1, 2017.

New Hampshire Code of Administrative Rule, Chapter He-P 1600, *Lead Poisoning Prevention and Control Rules*, June 4, 2021

New Hampshire Statute, *Chapter 130-A: Lead Paint Poisoning Prevention and Control*. September 11, 2015.

U.S. Department of Housing and Urban Development, *Guidelines for the Evaluation of Control of Lead-Based Paint Hazards in Housing*, Second Edition, dated July 2012

U.S. Department of Housing and Urban Development, *Lead Safe Housing Rule*, 24 CFR 35, June 21, 2004

U.S. Environmental Protection Agency, *Renovation, Repair, and Painting Rule*, dated April 22, 2008

U.S. Environmental Protection Agency, Title X, *Residential Lead-Based Paint Hazard Reduction Act of 1992*, as amended through April 21, 2005

U.S. Environmental Protection Agency, Toxic Substances Control Act, Title IV *Lead Exposure Reduction*, as amended through April 21, 2005

U.S. Environmental Protection Agency, *Method 6200 Field Portable X-ray Fluorescence Spectrometry for the Determination of Elemental Concentration in Soil and Sediment*. Revision 0, February 2007. <https://www.epa.gov/sites/default/files/2015-12/documents/6200.pdf>

Vermont Department of Health, *Vermont Regulations for Lead Control*, V.S.A. Title 18, Chapter 38, September 15, 2000.



**Attachment A \***  
**Examples of Interior and Exterior Building Component Types that Should be Tested**  
**CA-18 Lead Paint**

**Interior**

Air Conditioners	Counter Tops	Radiators
Balustrades	Crown Molding	Shelf Supports
Baseboards	Doors and Trims^	Shelves^
Bathroom Vanities	Electrical Fixtures, Painted	Stair Stringers
Beams	Fireplaces	Stair Risers and Treads^
Cabinets	Floors^	Stools and Aprons^
Ceilings	Handrails^	Walls
Chair Rails	Newel Posts	Window Sashes and Trim
Columns	Other Heating Units	

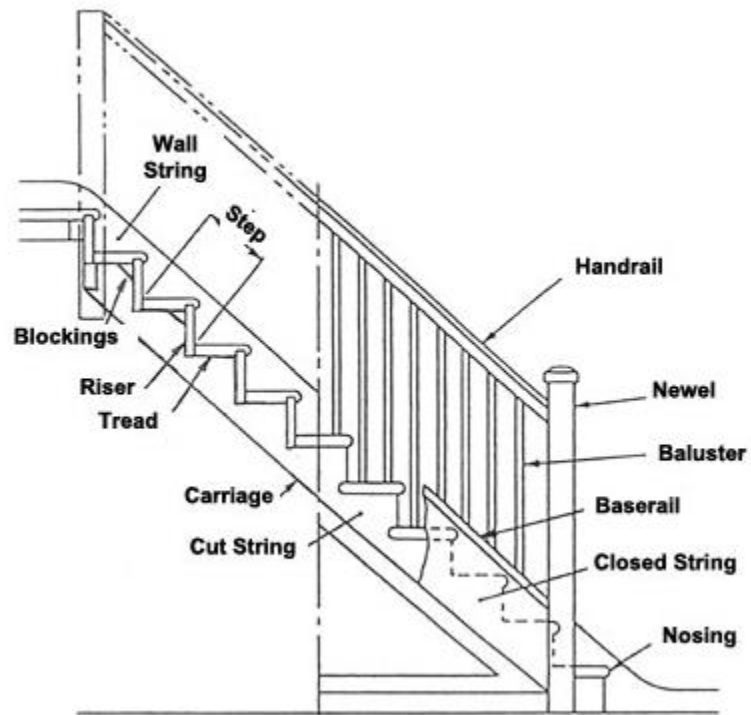
**Exterior**

Air Conditioners	Floors^	Sashes
Balustrades	Gutters and Downspouts^	Siding
Bulkheads	Joists	Soffits
Ceilings	Handrails^	Stair Risers and Treads^
Chimneys	Lattice Work	Stair Stringers
Columns	Laundry Line Posts	Window and Trim
Corner Boards	Mailboxes	Storage Sheds and Garages
Doors and Trim^	Painted Roofing	Swing Sets^
Facias	Railing caps	Other Play Equipment^
Fences	Rake Boards	

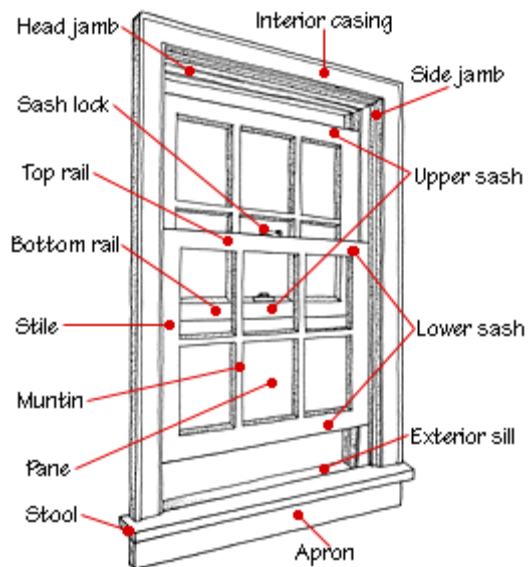
\*Referenced from Table 7.1 in Chapter 7, HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing, 1997 Revision

^Surface considered frictionable or chewable (if they are less than 4 feet above floor level) and should be screened as part of Hazard Screening

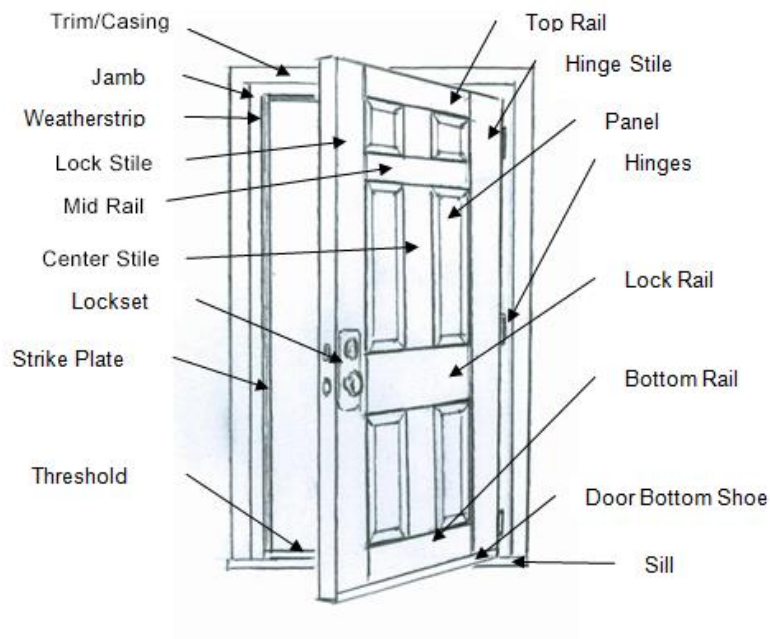
## Components of a Stairway



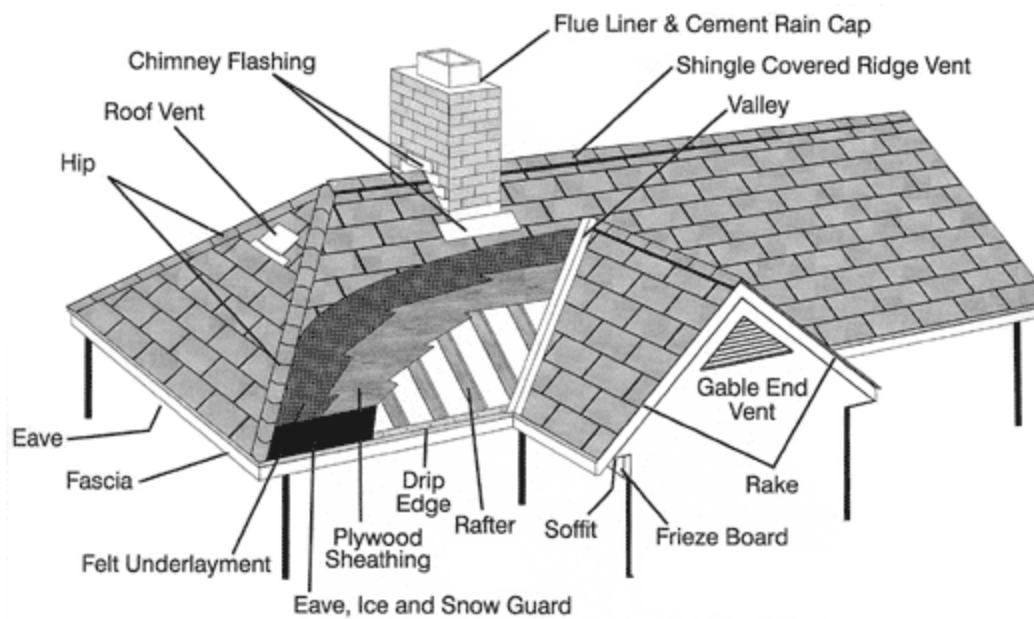
## Components of a Window



## Components of a Door



## Components of a Roof






CREDERE ASSOCIATES, LLC

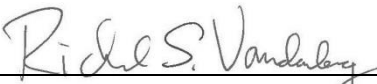
776 Main Street  
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# Standard Operating Procedure CA-20 Relative Elevation Survey & Trimble GNSS Basic Operation

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 3/6/2019  
Allison Drouin, Author Date

 3/6/2019  
Rick Vandenberg, Technical Review Date

 3/6/2019  
Theresa Patten, Technical Review Date

Revision	Date	Reason for Revision

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## ATTACHMENTS

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Attachment A .....	Relative Elevation Survey Form
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## **1. OBJECTIVE AND APPLICABILITY**

### **1.1 OBJECTIVE**

The purpose of this Standard Operating Procedure (SOP) is to provide guidance for performing relative elevation surveys and the basics of collecting field location data using a Trimble™ Global Navigation Satellite System (GNSS) unit. The general objective for these surveys is to collect elevation and location data for use in figure preparation and for identifying baseline elevations at a Site for comparison of other measurements (e.g., water levels, stratigraphic changes, surface topography, etc.). If followed correctly, this SOP will allow for the following:

- Safety of employees performing the data collection
- Collection of sufficiently precise location and elevation data for use during Site evaluation/assessment and/or remediation

Credere Associates, LLC (Credere) SOPs are guidance, and state requirements, site-specific plans, and special conditions may require alternative approaches.

### **1.2 APPLICABILITY**

This SOP should be used while collecting relative elevation data using a rod and level, and collection of location data with the Trimble GNSS. This SOP does not cover collection of vertical elevation data using the GNSS or procedures for data manipulation and post processing of GNSS collected data.



## 2. PROCEDURE

### 2.1 NECESSARY EQUIPMENT

The following is a list of required equipment for performing a relative elevation survey:

- Appropriate personal protection equipment (PPE)
  - Safety glasses
  - Reflective vest
- Well keys, sockets, hand tools as necessary to open monitoring wells (if surveying wells)
- Tripod
- Optical Level
- Extendable grade rod
- Site plan
- Well construction log(s)
- Field logbook
- Survey field form (**Attachment A**)
- Ink pens

The following is a list of required equipment for performing a location survey using the Trimble GNSS:

- Appropriate personal protection equipment (PPE)
  - Safety glasses
  - Reflective vest
- Trimble™ R2 antennae
- Backpack and antennae rod
- Trimble™ T10 tablet (fully charged)
- Trimble™ R2 batteries
- Digital pen (attached to T10 tablet)
- Field logbook
- Ink pens

### 2.2 TRAINING AND HEALTHY AND SAFETY

If working at a contaminated site, Credere employees must have 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) training pursuant to 29 CFR 1910.120 and be current on their 8-hour refresher. Employees will follow the Credere generic health and safety plan and any site-specific HASP for any project and employees must have 24 hours of training related to handling contaminated water and proven competence of the SOP and use of associated equipment in compliance with OSHA 29 CFR 1910.120(e)(4).

### 2.3 RELATIVE ELEVATION SURVEY PROCEDURES

Prior to mobilization to the Site, review the scope of work, well construction and local topographic information. It is important to know if the survey will be tying new features into an



existing survey, which will require some of the prior locations be used as a benchmark, or if the survey is new. The following procedures shall be used:

1. Upon arrival at the Site, begin a field logbook entry recording the Credere staff, scope of work for the day and weather conditions.
2. Complete a walkover of the Site and identify/plan sight lines between locations to identify the most efficient stations. Identify locations that will require turning points and stationary objects between setups that can serve as turning points (e.g., another well).
3. Setup the tripod on stable ground and attach the optical level. Set the unit so it is visually level.
4. Using the micro adjustments on the side of the optical levels, level the unit until the bubble is centered.
5. Setup the grade rod on the benchmark. The benchmark should be a stationary spot with easily identified point of reference, or a previously surveyed feature with a known elevation. For new surveys without existing wells, do not use other wells as a benchmark. After shooting the benchmark, set the angle on the optical level to 0.
6. Observe and record the measurements of the lower, mid, and upper crosshairs through the optical level. Record the angle on the optical level.
7. Proceed to continue recording the lower, mid and upper crosshair measurements and the angle at all necessary survey points with sightlines from this station. Record information on the form being sure to note each station for each surveyed location. If surveying monitoring wells, the following shots should be recorded for each well:
  - a. Top of casing (TOC) – top of the metal collar or road box
  - b. The top of well (TOW) – the measurement point of the PVC well riser. If no measuring point is marked, add the location where the survey elevation was collected. This is typically the highest point of an angled PVC riser, or a cut notch or marker point.
  - c. Ground surface (same as TOC for flush mount road boxes). This can alternatively be calculated by subtracting the stickup of the riser or standpipe/casing from the TOC elevation.
8. If all necessary survey points cannot be measured from this first station, turning points (aka, backshots) will be needed. Identify a second location where the remaining points can most efficiently be measured. Confirm at least two already surveyed features (one should be a monitoring well) can be seen from the new station. If needed, locate two arbitrary stationary turning points prior to moving the survey equipment from station 1 to station 2. **NOTE: you must shoot at least 1 turning point before moving the equipment from station 1 in order to carry elevation data to station 2.**
9. Setup the tripod and optical level at the new station 2 according to steps 3 and 4.
10. From station 2, remeasure the turning point(s).



11. Continue to measure the remaining new locations from station 2 being sure to label these points as measured from station 2.
12. If another turning point is needed, repeat steps 8 through 11.

### **Basic Post Processing**

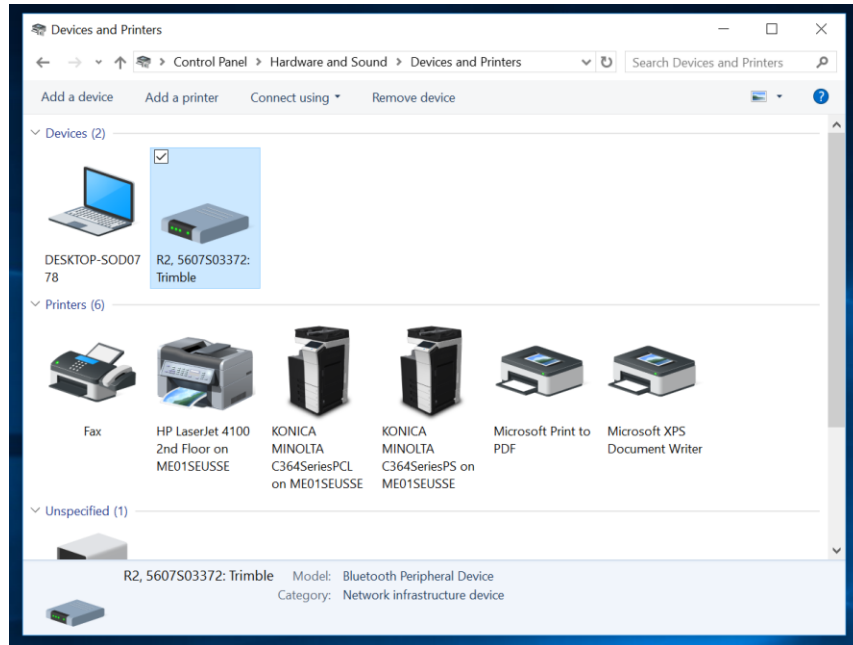
1. After collection of all the measurements, determine the instrument height at each station by adding the mid measurement to the known or an arbitrary benchmark or turning point elevation.
2. Using the instrument height at each station, subtract the mid measurement for all the measuring points associated with each respective station to determine the relative elevation of each point.

## **2.4 TRIMBLE™ GNSS BASIC FIELD POINT COLLECTION PROCEDURE**

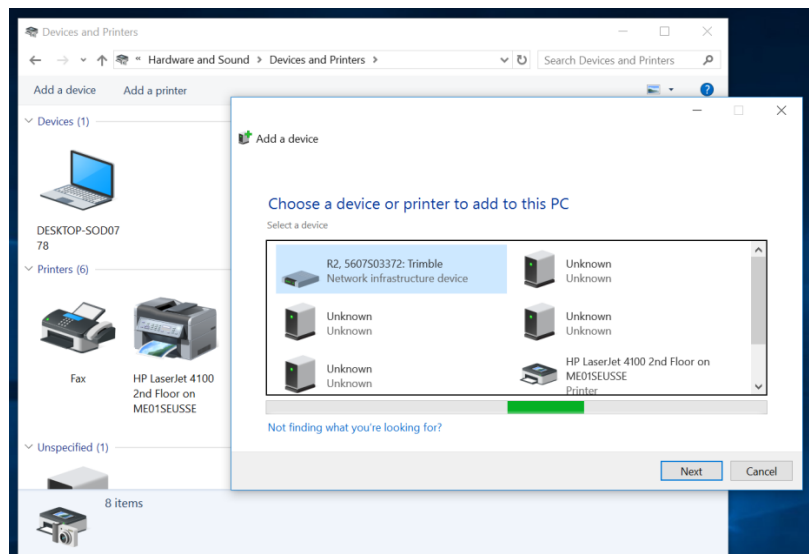
The following procedure is for use only with Credere's Trimble™ R2 antennae, T10 tablet and software package. This procedure covers only the basic collection of survey points and does not describe the more detailed project set, formatting, or troubleshooting.

1. Insert charged battery into Trimble™ R2 GNSS. The battery has been correctly inserted only if you hear two clicks (one from each of the two buttons).
2. Press the power button to turn on Trimble™ R2 GNSS. A green light should illuminate the power button. Once the R2 unit has connected to RTX (real-time corrections) the power button will blink green. It will usually take 5 to 10 minutes for the RTX corrections to be picked up by the R2.
3. On the tablet, make sure the R2 is connected to the T10 tablet via Bluetooth by going to: "Control Panel>Hardware and Sound>Device and Printers". This can be checked by ensuring the R2 is listed under "Devices". If the R2 is not listed under "Devices" follow these steps:



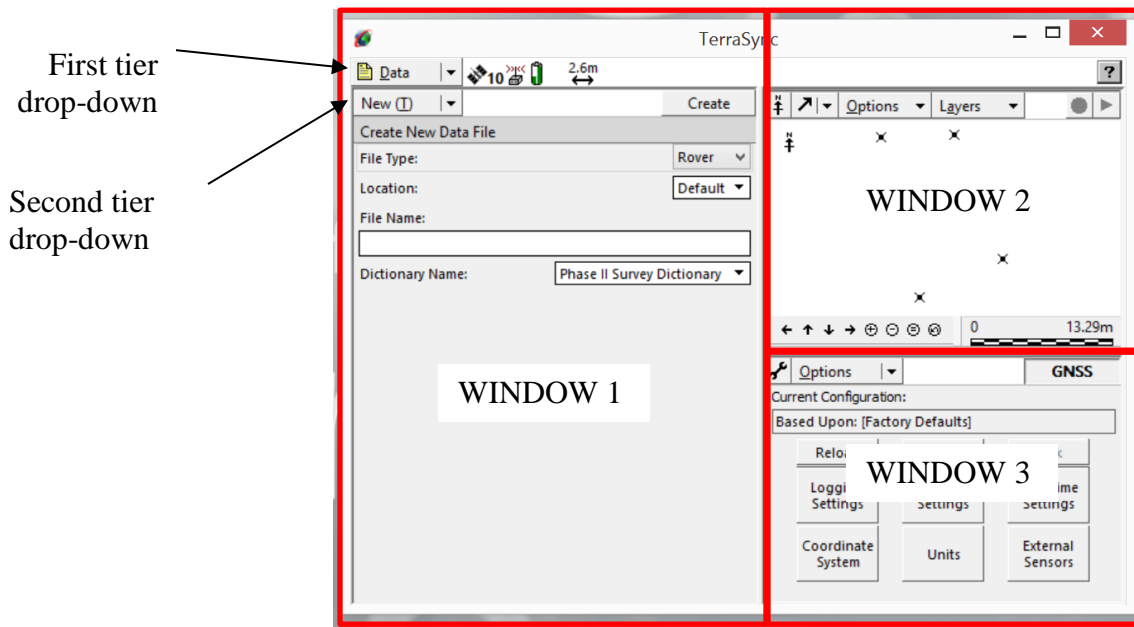


- a. Click the “Add a device” button at the top left of the window. A pop-up will show up and begin scanning for nearby devices.
- b. Once the Trimble™ R2 icon appears in the pop-up window, click on it and then select “Next”. This should pair the R2 with the tablet.

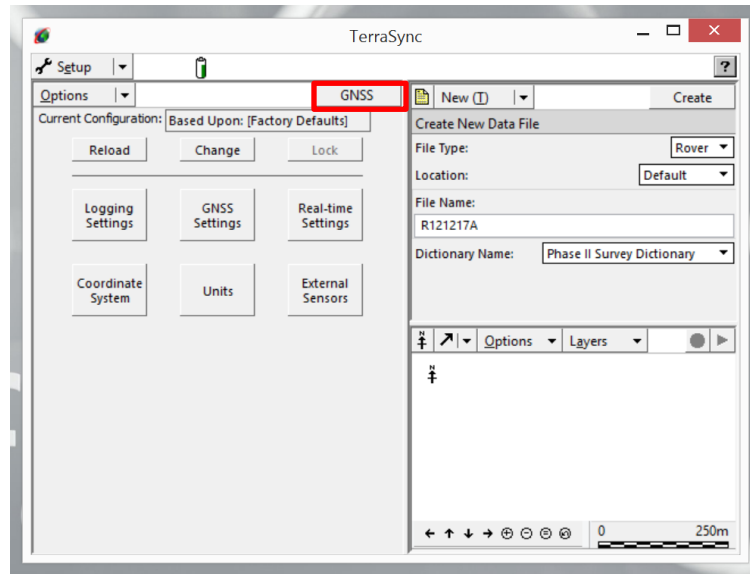


4. Open Trimble™ TerraSync software. Familiarize yourself with the two tiers of drop-down menus. The top drop-down (seen in the below screenshot with the “Data” window selected) will be referred to as the **first tier drop-down** in this SOP. The drop-down menu below that (seen in the below screenshot with the “New (T)” option selected) will be referred to as the **second tier drop-down** in this SOP. Additionally, there are three separate windows within the Terrasync software interface. One window takes up the entire left half of the interface, while the other two are split into two quadrants on the

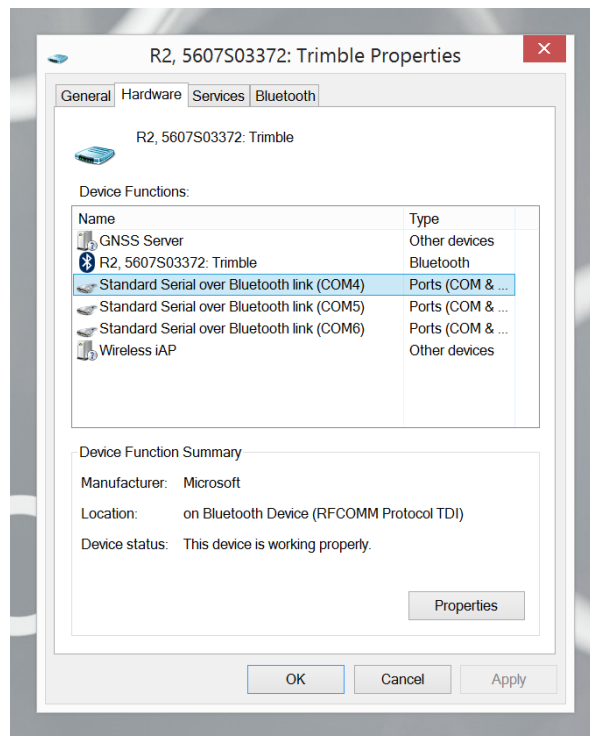
right side of the interface. These windows represent the different window options that you can select in the first tier drop-down (Map, Data, Navigation, Status, or Setup). You can customize the interface to display whichever combination of these window options you prefer.



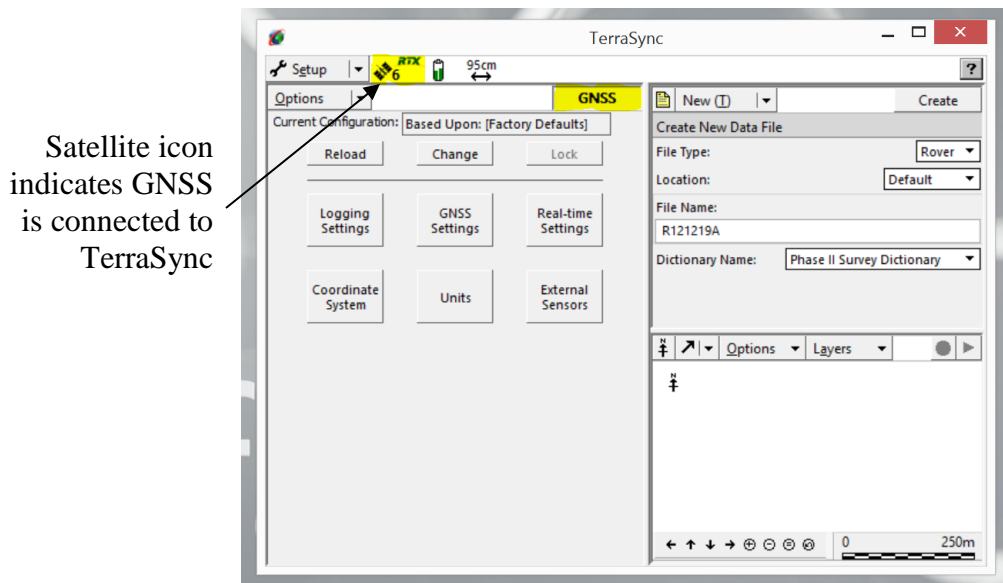
5. In most cases, the GNSS should automatically connect (you will hear a short ringing sound and a satellite icon will appear on the left side of the top taskbar with a corresponding number of connected satellites). If the GNSS does not connect automatically follow these steps:
  - a. In Terrasync, scroll to “Setup” in in the first tier drop-down.
  - b. Click the “GNSS” button in the top right portion of the “Setup” window.



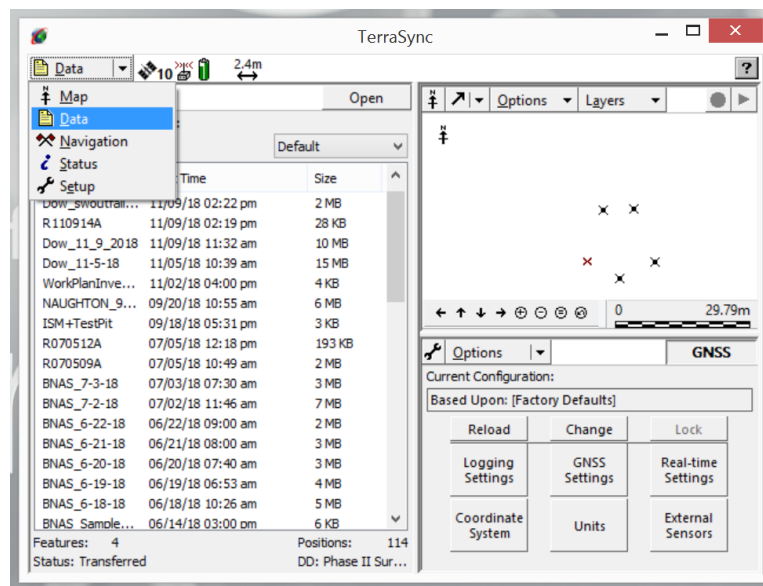
- c. If the GNSS still does not connect follow these steps:
- Go back to “Control Panel > Hardware and Sound > Device and Printers” and double click on the Trimble™ R2 icon.
  - A window titled “R2, 5607S03372: Trimble Properties” will pop up. Click on the “Hardware” tab at the top of the window.
  - In the column titled “Name”, take note of the numerically lowest COM port listed (in this case it is COM4).



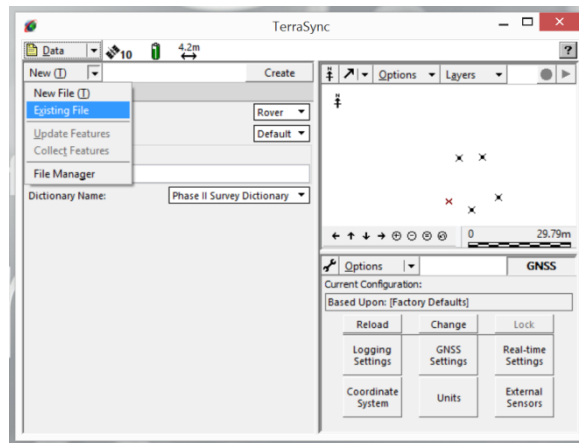
- iv. Go back to the TerraSync software, to the “Setup” window and click on the “GNSS Settings” button.
- v. In the “GNSS Settings” window scroll down on the drop-down menu labeled “GNSS Receiver Port” and make sure the selected port matches the COM port that was the numerically lowest listed in the “Name” column of the “Hardware” tab in the “R2, 5607S03372: Trimble Properties” window (in this case it is COM4).
- vi. Click the button “OK” at the top of the “GNSS Settings” window.
- vii. Click the “GNSS” button at the top of the “Setup” window. The GNSS should now connect to TerraSync.



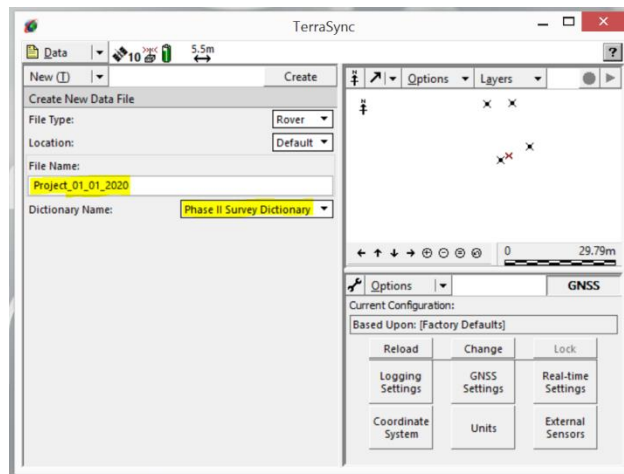
6. In TerraSync, scroll to “Data” in the first-tier drop down.



7. If you need to open up an existing file scroll to “Data” in the first-tier drop down, then scroll to “Existing File” in the second tier drop-down. Then scroll down the list of existing files, select the appropriate file, and click on the “Open” button in the top right of the “Data” window.



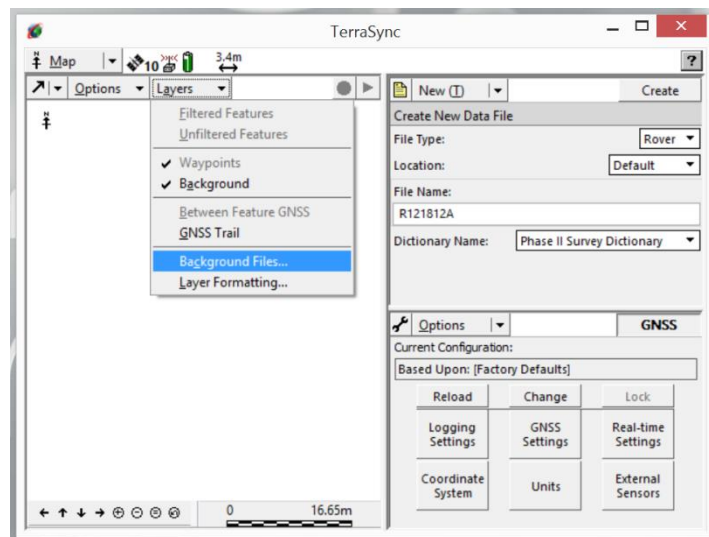
8. If you have not previously created file, follow these steps to create a new one:
  - a. Create a new file for your project by scrolling to “Data” in the first tier drop down and then “New File(T)” in the second-tier drop down.
  - b. Fill in the “File Name” text box with an identifying name (usually a combination of the project name and date).
  - c. Make sure the “Dictionary Name” is set to “Phase II Survey Dictionary”.
  - d. Click the “Create” button in the top right of the window to create the new file.



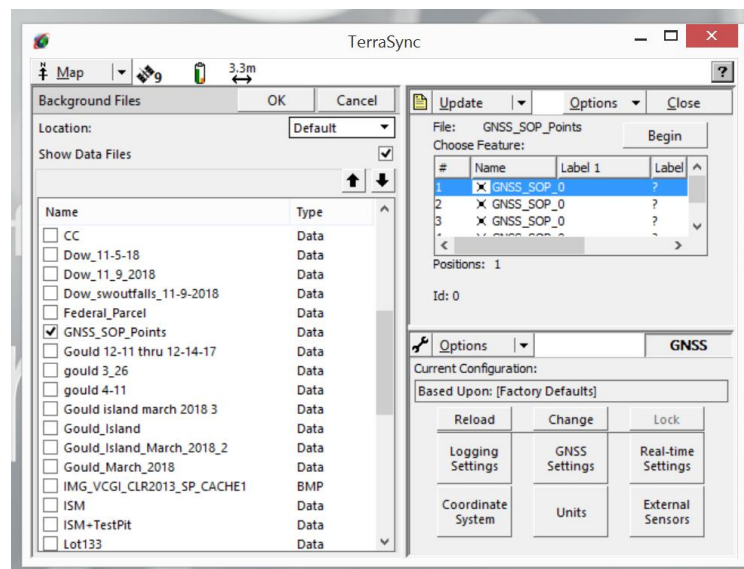
- e. A pop-up window will appear. The “Height” textbox should read “2.000 m”, the “Type” textbox should read “R2 internal”, and the “Measure To” textbox should read “Bottom of antenna mount”. Press the “OK” button to begin GNSS location data collection.

*NOTE: You DO NOT need to save the file before you close the program. TerraSync automatically saves all the files during GNSS data collection.*

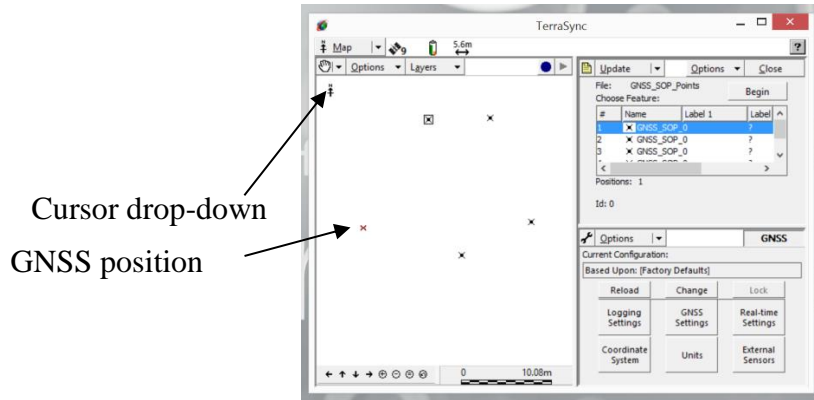
9. If you need to navigate to a specific point within a file that has already been uploaded to TerraSync (i.e., a proposed sample location), scroll to “Map” in the in the first-tier drop down:
  - a. In the second-tier drop-down menu titled “Layers” scroll down and click on “Background Files” option.



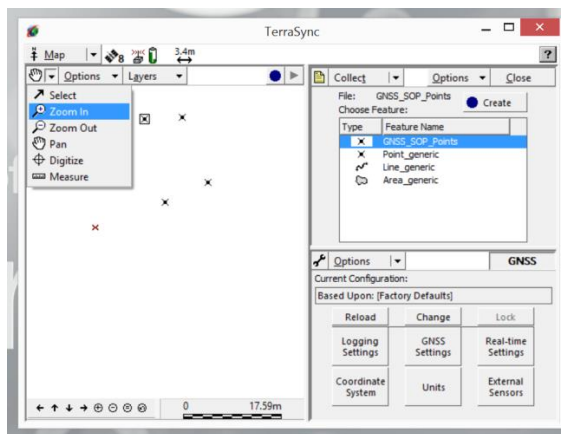
- b. Make sure the box for “Show Data Files” is checked.
  - c. Scroll down to the appropriate background files you would like to display in the “Map” window and make sure the box to the left of the file name is checked (in this example the file is titled “GNSS\_SOP\_Points”). Click the “OK” button at the top of the window to save your changes.



- d. Now you will see the GNSS position displayed as a red “X” within the map window. The black “X”s are the points from the file “GNSS\_SOP\_Points”. You can now walk the GNSS over to the black “X”s and when the red “X” overlaps the appropriate black “X” you will be ready to mark the proposed sample location in the field.

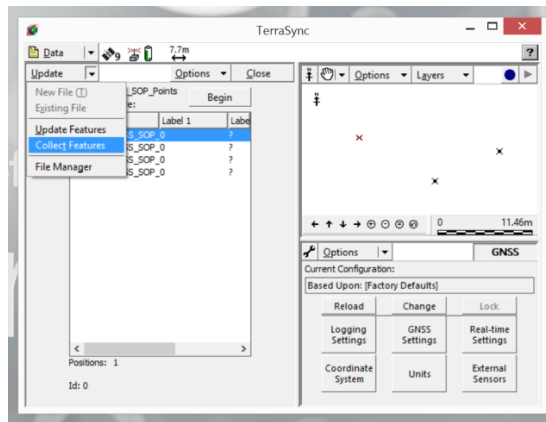


- e. To zoom in or out, pan, etc. within the “Map” window, use the second-tier cursor drop-down menu and select the preferred cursor to manipulate the “Map” window.

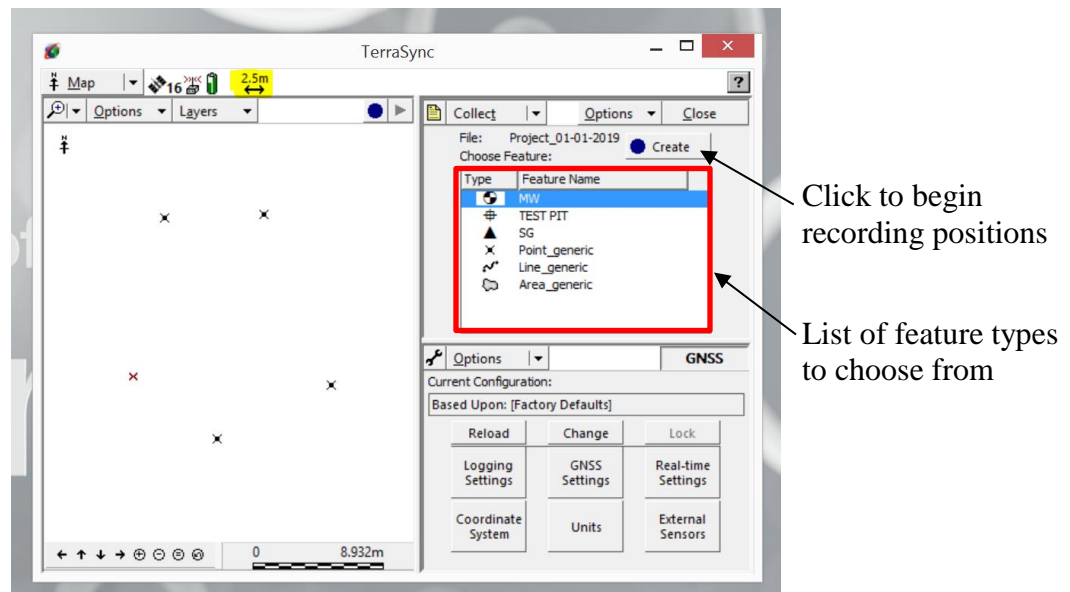


10. To collect a GNSS position, scroll to “Data” in the first tier drop-down and follow these steps:

- a. Scroll down and click “Collect Features” within the second tier drop-down.

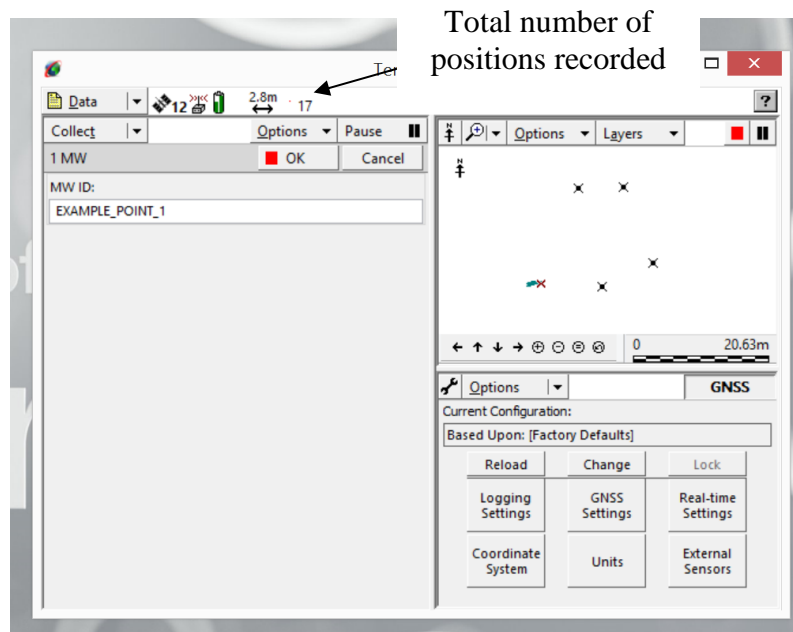


- b. Once you have moved to the appropriate location where you want to collect a GNSS position, check the accuracy range found at the top of the TerraSync window. It is represented by a line with arrows pointing in both directions and the accuracy range in millimeters or meters shown above it (in the below example the accuracy range is 2.5 meters). The accuracy range is influenced by the number of satellites within range of the GNSS, the weather (GNSS is most accurate on a clear day), the canopy above the GNSS. If the accuracy range is shifting a lot, wait for it to stabilize at numerically lowest accuracy range.

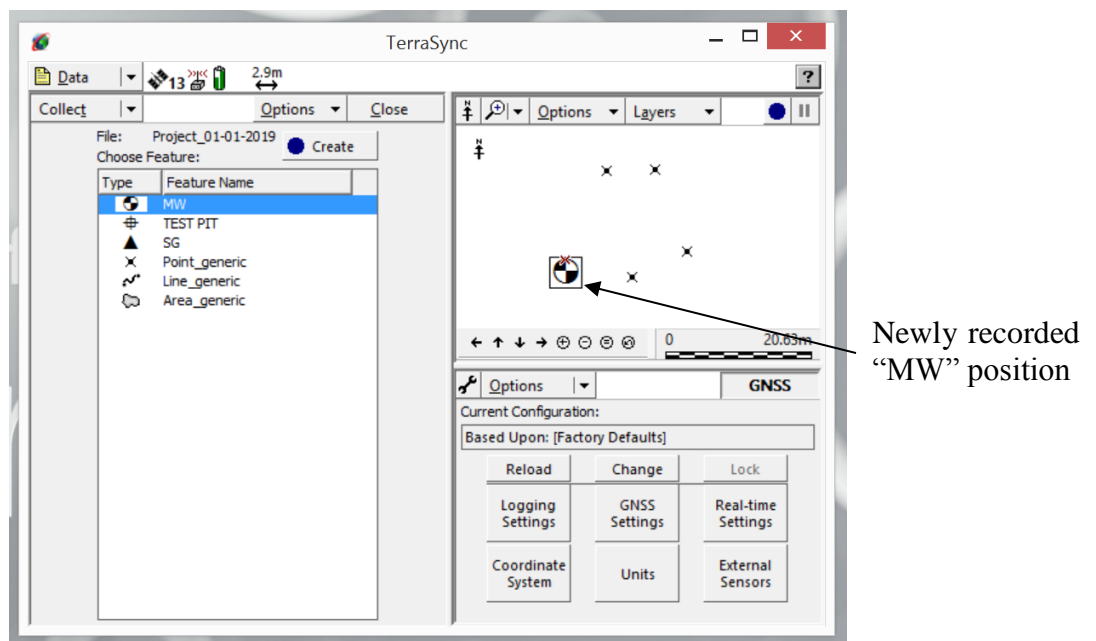


- c. Click on the appropriate Feature type (MW, TEST PIT, SG, etc) for the GNSS position you are about to record.
- d. Click the “Create” button to begin recording the GNSS position. A count of the total positions recorded will begin next to a flashing red target icon along the top

of the window. As the positions are recorded, name the point you are collected (EXAMPLE\_POINT\_1 in this case) in the ID textbox. Once you record 15 – 20 positions, click the “OK” button near the top of the window to finish the GNSS position collection.



- e. The location of the position recorded will now be displayed in the “Map” window. In this case represented by the large monitoring well icon.



11. Once all the required positions have been recorded, you can close TerraSync without saving (it automatically saves as you record).

12. Turn off the Trimble™ R2 antenna by holding the power button until the light turns to an orange color. Let go of the power button and the antenna will turn off.



### 3. QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance (QA) and quality control (QC) will be maintained through review of field note completeness prior to dismantling equipment. Reading precisions will also be checked after each point by comparing the difference between the upper and mid crosshairs, and the lower and mid crosshairs. The difference between these numbers should be less than 0.1 inches. If greater, that point should be remeasured prior to moving the station.

For the GNSS, quality control will be measured at Sites with previously surveyed locations by attempting to locate a prior well or marked sample locations. If the known point and the GNSS point do not align, this should be noted in the field notebook as a potential lack of precision that is typically due to the configuration of satellites at the time of the survey. For sites without prior survey data, a similar procedure will be attempted using a known site feature that can be loaded to the GNSS such as a building corner, utility pole, or other surficial feature observable from an aerial photograph through georeferencing. However, this evaluation will not be considered as reflective of the instrument precision due to the potential variance due to aerial photo angular skewing and inaccuracies during georeferencing.

Additionally, field documentation will be reviewed to assure it is compliant with Credere SOP CA-1: Field Activity Documentation and methods used for sampling are compliant with the protocol herein.



## 4. FIELD DOCUMENTATION

The following information should be recorded in the field logbook in compliance with Credere SOP CA-1:

- Date of surveys
- Credere personnel
- Scope of work
- Weather
- Equipment used
- Changes in scope
- Correspondence with Project Managers
- Station setup location
- Description of benchmark locations to allow for relocation in the future
- Turning point locations
- Measuring point data (lower, mid and upper and the angle)
- Associations of measuring point and station numbers
- Well stickup measurements
- Satellite details affecting precision
- General timeline of field activities



## 5. REFERENCES

Credere Associates, LLC, *Standard Operating Procedure CA-1 Field Activity Documentation*, Revision 0, dated August 4, 2015.



**RELATIVE ELEVATION SURVEY LOG**  
**Credere Associates, LLC, 776 Main Street, Westbrook, ME 04092**



PROJECT NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

PROJECT NUMBER: \_\_\_\_\_

FIELD STAFF COMPLETING SURVEY: \_\_\_\_\_

**BENCHMARK STATION 1** (be sure to shoot benchmark and turning point from Station 1 if turning point is needed)

Benchmark description: \_\_\_\_\_

Arbitrary datum (feet AMSL): \_\_\_\_\_

Instrument Height (ft): \_\_\_\_\_

Station No.	Shot/Well ID	Lower	Mid	Upper	Angle	Stickup (inches)
	Benchmark					NA

**Station #2**

Turning Point Description: \_\_\_\_\_

Turning Point Elevation (feet AMSL): \_\_\_\_\_

Instrument Height (ft): \_\_\_\_\_

Station	Shot/Well ID	Lower	Mid	Upper	Angle	Stickup (inches)
	Turning Point #1					NA

**Station #3**

Turning Point Description: \_\_\_\_\_

Turning Point Elevation (feet AMSL): \_\_\_\_\_

Instrument Height (ft): \_\_\_\_\_

Station	Shot/Well ID	Lower	Mid	Upper	Angle	Stickup (inches)
	Turning Point #2					NA

**SURVEYOR SIGNATURE**

Signature \_\_\_\_\_

\* Attach sketch of station positions, wells, benchmark, and turning points.



# CREDERE ASSOCIATES, LLC

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## Standard Operating Procedure CA-26 Incremental Sampling Methodology

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Effective Date: April 13, 2021  
Revision: 2

4/13/2021

Richard S. Vandenberg, Author

Date

4/13/2021

Allison Drouin, Technical Review

Date

4/13/2021

Theresa Patten, Technical Review

Date

Revision	Date	Reason for Revision
1	5/16/2019	Consideration of mass reduction in sampling procedures
2	4/13/2021	Updates for October 2020 ITRC ISM-2 update

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## 1. OBJECTIVE AND APPLICABILITY

### 1.1 OBJECTIVE

The primary objective of this Standard Operating Procedure (SOP) is to detail the methods to be employed for the collection of soil samples using incremental sampling methodology (ISM). Successful implementation of ISM in the field requires execution of several planning elements and sample preparation procedures with the analytical laboratory prior to entering the field. As a result, this document does provide some general background/guidance in these areas. If followed correctly, this SOP will allow for the following:

- Collection of representative samples with reproducible results that represent a predefined decision unit.

Credere Associates, LLC (Credere) SOPs are guidance for field staff to utilize to ensure proper methods are being employed. However, specific state and federal requirements, site-specific plans, and special conditions may require alternative approaches or amendments to this SOP.

### 1.2 APPLICABILITY

This SOP shall be used during soil sampling activities employing ISM. ISM will be implemented at sites where a structured composite methodology is needed to provide reasonably unbiased, reproducible estimates of the mean concentration of analytes in the specified volume of soil. ISM can also be used for the sampling of shallow and deep soil, though deeper soil has added challenges. As such, this SOP is only applicable for projects that employ this method of surface and subsurface soil sampling. This SOP is not applicable for sampling other environmental media such as groundwater or soil vapor. This SOP does not cover field processing of ISM samples as this process is to be avoided where possible and this SOP assumes all ISM process (drying, sieving, grinding, segmenting) is done in a controlled laboratory setting. Procedures for field processing will be included in Site-specific work plans when applicable.

Grab and standard composite sampling are summarized in SOP CA-5. This SOP does not cover procedures for description of soil or field screening, which are provided in Credere SOPs CA-4: Soil Description and CA-7: Headspace Field Screening, respectively.

Portions of this SOP have been taken directly from the Interstate Technology Regulatory Council (ITRC) Technical and Regulatory Guidance for ISM dated October 2020 (ITRC Guidance).



## 2. BACKGROUND, DEFINING INCREMENTAL SAMPLING METHODOLOGY & OTHER TERMS

Incremental sampling methodology (ISM) is a structured composite sampling and processing protocol that reduces data variability and provides a reasonably unbiased estimate of mean contaminant concentrations in a volume of soil targeted for sampling. ISM provides representative samples of specific soil volumes defined as decision units (DUs) by collecting numerous increments of soil (typically 30–100 increments) that are combined, processed, and subsampled according to specific protocols. More information on ISM can be obtained through ITRC's website at <https://ism-2.itrcweb.org/>.

Variability in measured contaminant concentrations between discrete soil samples has been determined to be primarily due to the particulate nature of soil and heterogeneous distribution of contaminants resulting from releases or filling. The elements of ISM that control data variability are incorporated into (a) the field collection of soil samples and (b) laboratory processing and subsampling procedures. If used correctly, a single replicate is obtained from each defined area/volume of soil. This sample theoretically has all constituents in the same proportions. Properly executed, the methodology provides reasonably unbiased, reproducible estimates of the mean concentration of analytes in the specified volume of soil.

Like all sampling approaches, ISM should be applied within a systematic planning framework. One of the first steps in such a framework is to have the investigation project team establish a working conceptual site model (CSM). Once the CSM has been agreed to, the project team defines the data quality objectives (DQOs) and determines the appropriate decision unit (DU) size(s) and location(s). DUs are based on project-specific needs and site-specific DQOs; both considerations specify and constrain the appropriate end use of the data. The size of a DU is site-specific and represents the smallest volume of soil about which a decision is to be made based upon ISM sampling (ITRC, 2020). In some cases, a DU is composed of smaller units known as sampling units (SUs), which can be used to understand nature and extent while still assessing the mean concentration of a larger DU. The requirement to explicitly and appropriately define the DU that each incremental sample represents is a key component of ISM.

It is important to understand the meaning of the following terms. The definitions of these terms were taken directly from the 2020 ISM ITRC guidance.

*Composite sample* – A sample composed of two or more increments, which generally undergoes some preparation procedures designed to reduce the errors associated with obtaining a measurement from the combined sample. An ISM sample is a type of composite sample whose collection and preparation steps are designed using the general suggestions of Gy's theory of sampling. Traditional composite samples generally do not consist of a large volume or a large number of increments and do not undergo the same preparation and subsampling steps suggested by Gy's theory. The mean for the area covered by a composite sample is not expected to be as accurate as a mean produced by an incremental sample.



*Decision unit (DU)* – The smallest volume (i.e., plan area and depth) of soil (or other media) for which a decision will be made based upon ISM sampling. A DU may consist of one or more sampling units. It is an incorrect use of the term DU when used to represent all ISM sample results, regardless of decision type or intended use.

*Exposure point concentration (EPC)* – An estimate of the concentration of a constituent in an environmental medium to which a receptor will be exposed. The EPC can be determined for an entire site or for an individual exposure unit. The EPC is based on a statistical derivation of either measured data or modeled data. In risk assessment, an EPC is typically based on a 95% upper confidence limit so that that risk-based decisions are protective of human health and the environment.

*Exposure unit (or exposure area)* – A decision unit that is used to make decisions about risk or a volume of an environmental medium (for example, soil) over which a receptor is reasonably assumed to move randomly and is therefore equally likely to contact all locations.

*Field replicate samples* – Two or more incremental samples independently collected from the same decision unit or sampling unit using the same number of increments but from offset increment collection locations. Field replicates are not splits but are independently collected *incremental samples*.

*Increment* - a volume of soil collected from a single point within a decision unit (DU) or sampling unit (SU) that is collected with a single operation of a sampling device. Multiple increments (typically 30 or more) are collected from a DU or SU and combined to form an incremental sample. This term should be used instead of the term aliquot, which actually has the opposite meaning. An increment is something added in or added together, an aliquot is something taken out, like a portion of extract taken from a flask to inject into an analytical instrument.

*Incremental Sample* - a sample formed from multiple increments collected from a defined volume of soil, the decision unit (DU) or sampling unit (SU), which are combined, processed, and analyzed to estimate the mean concentration in that DU or SU.

*Laboratory replicate sample* – two or more subsamples taken from a single field sample. Synonymous with subsample replicate. Not to be confused with a laboratory instrument replicate (or lab duplicate), which is repeated measurement of a sample to determine precision for the instrument.

*Sampling unit (SU)* – the volume of soil from which increments are collected to determine an estimated mean concentration of analytes of interest for that volume of soil.



### 3. SYSTEMATIC PLANNING AND DEVELOPING DECISION UNITS

ISM is useful when practical constraints limit the number of discrete samples that can be collected and, therefore, limit the precision with which the mean concentration in heterogeneous matrices may be estimated. Most action levels are derived from risk-based receptor models that assume a specific exposure scenario in a given area. In these cases, estimates of mean concentrations in volumes of media are generally the appropriate statistic to compare to action levels.

It is important to match the project objectives with the type of sampling employed. For some objectives, discrete sampling is appropriate (when sufficient numbers of discrete samples are used); for other's ISM sampling may be the best/most appropriate option. In certain situations, a hybrid of the discrete and ISM may be the most advantageous. For example, discrete samples might be used to make decisions on obviously contaminated volumes of soil in which contaminant concentrations are very likely to exceed action levels. Even though contaminant concentrations in this situation may be highly variable, this variation would not result in decision errors since any possible sample collected from the volume will likely have contaminant concentrations above the action level. Discrete samples may also be used to estimate the variability within a DU prior to ISM sampling. When field analytical methods (or other cost-saving analytical approaches) are available, sufficient numbers of discrete samples may be used to characterize some contaminants or DUs, while ISM may be appropriate for those contaminants for which these analytical approaches are not available.

ISM is most applicable when an average exposure assessment for a given area of common historical use or current exposure area, large or small, is desired. The larger the DU, the more reliable and economical ISM becomes. Simply put, collecting 30 increments throughout a 1-acre DU that provides one mean concentration for comparison to criteria is faster to implement, more reliable and cheaper than collecting the discrete samples using conventional spacing and layout, which would typically look like only fraction of discrete samples compared to the number of increment.

#### 3.1 ISM PLANNING

The use of ISM to characterize the soil within a DU can provide higher-quality data and fewer decision errors than conventional discrete or composite sampling designs. In combination with well-conceived investigation objectives and DU and SU designations, incremental samples will reduce the need for additional sample collection, will increase the certainty of decisions, and will reduce the time and money required to complete environmental projects. Although a project team may have an ISM strategy in mind during initial planning, a number of sampling and analysis options should still be considered, and the sampling strategy selected should be an outcome of the systematic planning process.

A systematic planning process will serve to identify the objectives of the site investigation and establish the type of information needed to make environmental decisions. The level of detail needed to adequately incorporate a systematic planning approach into a data collection effort



varies from project to project; larger or more complex projects usually warrant more detailed planning than smaller, simpler projects. The nature of the ISM process is such that many decisions have to be made and detailed plans established in advance of sample collection. For these reasons, the principles of the systematic planning approach should be applied on every ISM project. The specifics of the systematic planning approach will be detailed in the project work plan.

### **3.2 USE OF THE CONCEPTUAL SITE MODEL (CSM) IN ISM**

CSMs are essential elements of the systematic ISM planning process. A comprehensive CSM serves to conceptualize the relationship between contaminant sources and receptors through consideration of migration and exposure pathways (potential and actual). The CSM also presents the current understanding of the site, helping to identify data gaps, and focus the data collection needs. The CSM should be maintained and updated as additional information is collected throughout the project. A Credere CSM describes site conditions, identifies the sources areas and contaminants of potential concern (COPCs), estimates the extent of contamination, and seeks to describe the exposure and migration pathways for current and reasonable future site conditions. The sampling strategy should reflect the assumptions about the transport phenomena and exposure scenarios articulated in the CSM.

### **3.3 DEFINING DECISION UNITS**

A clear understanding of the study objectives is important with all sampling strategies, but particularly so with ISM sampling. Different objectives will dictate the type, location, dimensions of DUs, and number of aliquots per decision unit. For example, small source-area DUs are important for highly mobile chemicals that can pose significant vapor intrusion or leaching risks. Larger exposure-area DUs or subsurface DUs can be appropriate to evaluate risks to specified receptors. The decision for additional investigation or remedial action might be made based on a comparison of ISM sample results to published screening levels. In other investigations the estimate of the mean contaminant concentration provided by ISM samples might be used to estimate the risk to human or ecological receptors. ISM results may also be used to estimate background concentrations, to assess sources, or to evaluate various stages of remedial activities and confirmatory sampling.

There are various approaches to defining DUs. The approach selected should be consistent with the understanding of the site and support the objectives of the investigation. According to ITRC, DUs can be defined in regularly spaced and equal volumes as established by exposure areas, or they can be based on irregular features of the site that define contaminant transport or receptor exposure.

DUs may be based on the understanding of the known or suspected distribution of contaminants. This can be used in and around source areas. Volumes of soil known or suspected to be contaminated are generally good candidates for designation as DUs because the decision over these volumes is best made separately from less-contaminated surrounding volumes. Human health or ecological exposure areas may also provide the basis for the designation of DUs. This



approach has the advantage of being supported by the exposure assumptions that are used to develop most risk-based action levels.

DUs developed and based on the needs of remediation or excavation are appropriate. Examples include, using sidewalls and excavation floors as DUs to determine whether soil removal was sufficient.

Selection of DUs need to also consider geologic aspects of the Site defined in the CSM. If boundaries between different geologic formations are important for contaminant transport or exposure, they may provide a logical demarcation of the DU. However, a DU can extend across more than one geologic formation or soil type.

Two primary types of DUs according to ITRC include:

1. Those based on the known or suspected locations and dimensions of source areas, called “source area DUs”
2. Those based on the size assumptions of risk assessment, called “exposure area DUs”

A source area is defined here as a discernible volume of soil (or waste or other media) containing elevated or potentially elevated concentrations of contaminant in comparison to the surrounding soil. Source areas include the following:

- Areas with stained soil, known contaminations, obvious releases/filling
- Areas where contaminants were suspected to be stored, handled, or disposed
- Areas where sufficient sampling evidence indicates elevated concentrations relative to the surrounding soil over a significant volume of contaminated media

Exposure area DU’s are a fundamental part of many environmental investigations and are an essential tool in risk assessments and risk-based decision making. An “exposure area” is defined as an area where human or ecological receptors could come into contact with contaminants in soil on a regular basis. ITRC defines the following example exposure area DU’s: residential yards, schoolyards, playgrounds, gardens, areas of commercial/industrial properties, or areas designated as exposure areas through other means (e.g., state laws).

This definition highlights the difference between types of DUs. Source area DUs are differentiated from exposure area DUs in that the boundaries of source area DUs and the scale of sampling are based on the known or hypothesized extent of the contamination, while the boundaries of exposure area DUs are determined through the exposure assumptions of the risk scenario. It is important to differentiate between these two types of DUs so that concerns regarding the dilution of source area will be eliminated and to reiterate that the action levels derived from risk assessment scenarios are based on exposure assumptions that include a specified areal extent of contamination within which a mean concentration is of interest.

The October 2020 ITRC Guidance provides additional background on the specifics of defining DU’s for a several of scenarios including: residential exposure, commercial/industrial exposure,



ecological exposure, source areas, subsurface, stockpile, and excavation. The DU's defined at a site where ISM is employed will be tailored to the site and the CSM.



## 4. FIELD PROCEDURE

### 4.1 NECESSARY EQUIPMENT

The following is a list of required equipment:

- GPS
- Field measuring tape
- Wooden stakes, marking paint, pin flags, string
- Sampling tool
  - Compacted soil sampler (bucket assembly, gas powered drill head, fuel, bucket liners)
  - Open slot probe<sup>1</sup>/<sub>2</sub>-inch or 1-inch corer and ejector
  - alligator probe sampler
- Stainless steel bowl, new polyethylene resealable bags, 5-gallon plastic containers, or other appropriate large container for placing the increments; the size of the container should be adequate to hold the total increments
- Field scale
- If ISM sampling is used for volatile organic compound analysis, EnCore® sampler and laboratory container partially filled with sufficient methanol for the planned number of increments (1:1).
- Subcontractor drilling/excavation equipment or sample collection device (e.g., hand auger, shovel, etc.) if sampling subsurface DUs
- Polyethylene sheeting
- Folding table (optional, for convenience)
- Sweeping brush
- Laboratory provided sample containers, cooler and ice
- Decontamination fluids
- Pipe brush or brush specific to sampling tool
- Deionized or distilled water
- One 5-gallon buckets with water and detergent, one 5-gallon bucket with water, and scrub brush
- Paper towels
- Appropriate personal protection equipment (PPE) as required by the Site-specific Health & Safety Plan
- Site plan
- Field logbook
- Chain of custody
- Ink pens
- Digital camera

### 4.2 TRAINING AND HEALTHY AND SAFETY

Credere employees must have received 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) training

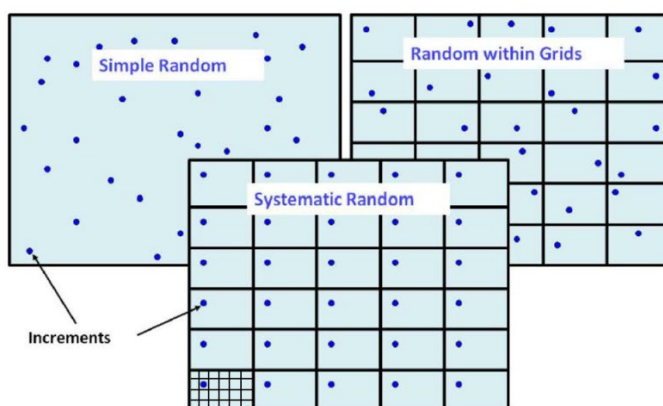


pursuant to 29 CFR 1910.120 and be current on their 8-hour refresher. Employees must have 24 hours of training specifically in soil sampling procedures, described herein, and proven competence of the SOP in compliance with OSHA 29 CFR 1910.120(e)(4). This SOP assumes the samplers will have training and background understanding of typical environmental soil sampling procedures outline in Credere SOP CA-5: Environmental Soil Sampling.

Employees will follow the Credere Corporate Health and Safety (CHASP) and the site-specific HASP when collecting soil samples.

### 4.3 DECISION UNIT FIELD LAYOUT

Depending on the areal and vertical contaminant distribution profile, ISM sampling and processing is used to minimize these sources of error, resulting in an average concentration that is a much more precise and accurate estimate of the mean for the DU when compared to conventional means calculated with discrete samples. The sample grid dimensions, number of increments, and number of replicates will be predetermined during the systemic planning stages. The relative location of any replicate increments within each **SU/DU** cell will be established in a random manner to remove potential bias. The cell may be divided in turn into sub-grids and a sub-cell may be selected randomly to select the relative increment location for a replicate increment. The following figure visually defines the different increment collection patterns:



*ITRC ISM-2, Oct 2020*

The increment locations can be located in the field through field measuring a pre-determined sample grid, which is best suited to large open level spaces, or through GPS located points. In either case, the SU/DU will be marked in the field using pin flags, spray paint (when not sampling for VOCs), or rope/string and fixed with a GPS.

#### **GPS Located Points**

GPS located points will be located with a GPS with sub-foot accuracy. The points will be loaded into the GPS after overlaying the predetermined grid in GIS. Replicate increments can be collected from locations measured from a certain distance in a certain direction from the point (e.g., replicate DU1-1 aliquots will be collected from 6 inches north of the center point and replicate DU1-2 aliquots will be collected from 2 feet east of the center point) or an approximate

radius around each point can represent the grid spacing and the increments will be collected randomly with the radius from each point. Alternatively, if the sampling pattern is simple random, only the DU or SU boundaries will require markout and the increments can be randomly collected from anywhere within the DU/SU.

### **Field Measured Grid**

The field measured grid will be laid out on a pre-determined grid size or such that equally sized grid units fill the SU/DU. The grid will be marked with pin flags, spray paint and or string so that each grid unit is distinguishable. The grid's ends and corners will be located with a GPS with sub-foot accuracy.

Grids can also be laid out on sidewalls. As the sidewalls represent a 3-D grid, the top of the sidewall will be marked with the horizontal spacing and the vertical extent of the grid will be measured down the sidewall.

## **4.4 SOIL SAMPLE COLLECTION PROCEDURES**

Equal core shaped increments of soil will be collected within each cell of the above located SU/DU. It is important that soil increments be the same weight/mass; however, recognizing the infeasibility of weighing each increment, similarly sized increments collected with the same tool will be considered the same.

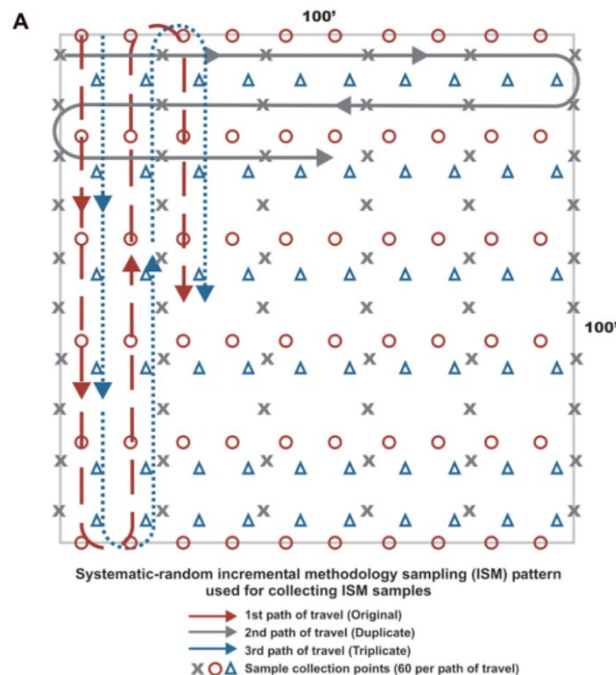
Depending on the sample design, samples can be collected from the surface to a desired depth or from a subsurface plane bound by a pre-determined criteria (e.g., depth, geological feature). The following sections describe the step-by-step procedure for sample collection for both these scenarios.

### **Surface Sampling Procedure**

1. Upon arrival at the Site, begin a field logbook entry recording the Credere staff, scope of work for the day, and weather conditions in accordance with Credere SOP CA-1.
2. Calibrate field instruments according to Credere SOP CA-11 and product specifications. Keep record of calibration in the field logbook including instrument make and model, serial number, calibration gas and concentration, and span gas check.
3. Set up the sampling station with the optional folding table, truck tailgate, or on the ground surface by covering with clean polyethylene sheeting.
4. Prepare decontamination station. Note whether decontamination fluids must be containerized or can be discharged to the ground surface per the work plan.
5. Decontaminate sampler and collection container (or obtain a new bag) according to Credere SOP CA-2: Equipment Decontamination.
6. Begin collecting the first replicate by advancing the sampler to the desired depth. Collect the soil increment directly into a large re-sealable bag, 5-gallon bucket, or alternative large container.



- a. If sampling for VOCs, an individual VOA vial can be collected at each increment location to be composited by the laboratory. VOC increments will be collected directly from in situ soil and not from combined soil container. Alternatively, a large volume methanol preserved container can be prepared by the laboratory with sufficient methanol to meet the 1:1 ratio considering the planned number of increments (typically this is a 1-liter amber glass container with 15 mL of methanol for 30 5-gram increments [150 grams]).
7. Repeat step 6 for each increment location until the desired number of increments have been collected. It is not necessary to decontaminate the sampling tool between the increments within a SU/DU.
8. Describe the combined soil type according to Credere SOP CA-4: Soil Description, and transfer the entire soil volume to a laboratory provided or approved container (typically a 1-gallon resealable bag or 1-gallon plastic container).
9. Label the sample container with the ID and DU as the sample ID: CA-DU1-1 (0-1) where CA-DU1 is the location, -1 is the replicate and 0-1 is the interval. If more than one SU has been defined for a DU, the SU designation should be added to the sample ID [e.g., CA-DU1-SU1-1 (0-1)]. (*Sample nomenclature may vary and should comply with the Site-Specific Work Plan nomenclature.*)
10. Double bag the sample to prevent melted ice from entering the sample.
11. Place samples immediately on ice. Record the sample time, ID, analyses, preservative, and sample volume in the field log book.
12. For each additional replicate repeat steps 5 through 10. Any replicate samples from the same SU/DU will be collected following a different path, as shown in the figure below (which was obtained from ITRC, 2020).



## **Subsurface Sampling Procedure**

1. Upon arrival at the Site, begin a field logbook entry recording the Credere staff, scope of work for the day, and weather conditions in accordance with Credere SOP CA-1. Also record the drilling contractor, foreman, drill rig make and model, and tooling details.
2. Calibrate field instruments according to Credere SOP CA-11 and product specifications. Keep record of calibration in the field logbook including instrument make and model, serial number, calibration gas and concentration, and span gas check.
3. Set up the sampling station with the optional folding table, truck tailgate, or on the ground surface by covering with clean polyethylene sheeting.
4. Prepare decontamination station. Note whether decontamination fluids must be containerized or can be discharged to the ground surface per the work plan.
5. Decontaminate sampling tools and collection container (or obtain a new bag) according to Credere SOP CA-2: Equipment Decontamination.
6. Begin advancing soil borings to the desired subsurface increment according to Credere SOP CA-5: Environmental Soil Sampling.
7. Collect the desired increment as a wedge from the sampled core and place in the large resealable bag, 5-gallon bucket, or alternative large container. If multiple depth increments are to be collected, prepare a dedicated container and label with the depth to ensure they are not mixed up during subsequent borings<sup>1</sup>.
  - a. If sampling for VOCs, an individual VOA vial will be collected at each increment location to be composited by the laboratory. VOC increments will be collected directly from in situ soil and not from combined soil container. Alternatively, a large volume methanol preserved container can be prepared by the laboratory with sufficient methanol to meet the 1:1 ratio considering the planned number of increments (typically this is a 1-liter amber glass container with 15 mL of methanol for 30 5-gram increments [150 grams]).
8. Repeat step 7 for each additional boring/increments until the desired number of increments have been collected. It is not necessary to decontaminate the sampling tool between the increments within a DU or SU.
9. Describe the combined soil type according to Credere SOP CA-4: Soil Description, and transfer the entire soil volume to a laboratory provided or approved container (typically a 1-gallon resealable bag or 1-gallon plastic container).
10. Label the sample container with the ID and DU as the sample ID: CA-DU1-1 (2-3) where CA-DU1 is the location, -1 is the replicate and 2-3 is the depth interval. If more than one SU has been defined for a DU, the SU designation should be added to the sample ID [e.g., CA-DU1-SU1-1 (2-3)]. *(Sample nomenclature may vary and should comply with the Site-Specific Work Plan nomenclature.)*

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<sup>1</sup> Alternative mass reduction techniques besides wedge are acceptable but the wedge approach is Credere's recommended approach for most application. See ITRC, 2020 for additional mass reduction techniques.



11. Double bag the sample to prevent melted ice from entering the sample.
12. Place samples immediately on ice. Record the sample time, ID, analyses, preservative, and sample volume in the field log book.
13. For each additional replicate repeat steps 5 through 11. Any replicate samples from the same SU/DU will be collected following a different path, as shown in the figure above (which was obtained from ITRC, 2020).
14. Holes left by sampling will be filled using surrounding soil or sand may be used to bring the subsurface sampling areas back to original grade.

### **Sidewall Sampling Procedure**

Sidewall samples are often collected as confirmatory samples or from test pits. These samples are unique from subsurface sampling as the sidewall is an exposed surface allowing from greater increment access. The following procedure offers a slight variation in methods to the subsurface sampling approach.

1. Upon arrival at the Site, begin a field logbook entry recording the Credere staff, scope of work for the day, and weather conditions in accordance with Credere SOP CA-1. Also record the excavation contractor, foreman, excavator rig make and model, and bucket details.
2. Calibrate field instruments according to Credere SOP CA-11 and product specifications. Keep record of calibration in the field logbook including instrument make and model, serial number, calibration gas and concentration, and span gas check.
3. Set up the sampling station with the optional folding table, truck tailgate, or on the ground surface by covering with clean polyethylene sheeting.
4. Prepare decontamination station. Note whether decontamination fluids must be containerized or can be discharged to the ground surface per the work plan.
5. Decontaminate sampling tools and collection container (or obtain a new bag and dedicated syringe) according to Credere SOP CA-2: Equipment Decontamination.
6. Excavate the test pit or soil removal area as required by the plans or in accordance with Credere SOP CA-6 for Test Pitting.
7. Once the target sidewall is exposed or the targeted extent of excavation is complete, mark out the grid or identify the target DU depth.
8. From the sidewall, collect the desired increment with a dedicated syringe or approved sampler and place in the large re-sealable bag, 5-gallon bucket, or alternative large container.
  - a. If sampling for VOCs, an individual VOA vial will be collected at each increment location to be composited by the laboratory. VOC increments will be collected directly from in situ soil and not from combined soil container. Alternatively, a large volume methanol preserved container can be prepared by the laboratory with sufficient methanol to meet the 1:1 ratio considering the planned number of



increments (typically this is a 1-liter amber glass container with 15 mL of methanol for 30 5-gram increments [150 grams]).

9. Repeat step 7 for each additional boring/increments until the desired number of increments have been collected. It is not necessary to decontaminate the sampling tool between the increments within a DU or SU.
10. Describe the combined soil type according to Credere SOP CA-4: Soil Description, and transfer the entire soil volume to a laboratory provided or approved container (typically a 1-gallon resealable bag or 1-gallon plastic container). As sidewall DUs are often much smaller than larger surface DUs representing a historical use, smaller sample volumes may be applicable for this application and an 8 oz glass jar may be appropriate.
11. Label the sample container with the ID and DU as the sample ID: CA-DU1-1 (0-4) where CA-DU1 is the location, -1 is the replicate and 0-4 is the interval. *(Sample nomenclature may vary and should comply with the Site-Specific Work Plan nomenclature.)*
12. Double bag the sample to prevent melted ice from entering the sample.
13. Place samples immediately on ice. Record the sample time, ID, analyses, preservative, and sample volume in the field log book.
14. For each additional replicate repeat steps 5 through 11. Any replicate samples from the same SU/DU will be collected following a different path, as shown in the figure above (which was obtained from ITRC, 2012).
15. Proceed with backfilling as appropriate.

#### 4.5 POST-SAMPLING PROCEDURE

The following procedure should be completed after collection of soil samples:

1. Complete the chain-of-custody using the notes recorded in the field logbook in accordance with Credere SOP CA-16. Ensure the ISM processing steps that are requested of the laboratory are clearly identified. It is pertinent to notify the laboratory that ISM are coming so they can be prepared.
  - a. Not all laboratories perform ISM processing. Ensure the selected laboratory for the project has ISM processing capabilities.
2. Decontaminate non-dedicated equipment for use at the next sample location or for transport in accordance with Credere SOP CA-2. If using an incremental sampling tool, shovel, or hand auger to collect soil samples, using 5-gallon bucket of detergent and rinse water to remove bulk soil and perform subsequent decontamination with appropriately selected decontamination fluids, rinse, and dry method per Credere SOP CA-2.
3. Store the sample containers on ice being sure to avoid pooled water in the cooler and ensure bagged samples are double bagged. Regularly replace ice and drain meltwater.

## 5. QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance (QA) and quality control (QC) will be obtained through collection of additional samples. The types of samples to be collected are dependent on the data quality objectives and should be defined in the project's proposal/scope of work, Site-Specific Quality Assurance Project Plan (SSQAPP), regulatory/client guidance, or similar. Types of QA/QC samples that may be collected include the following:

- Field replicates (typically 3)
- Laboratory replicates collected as an extra subsample from the slabcake in the lab to assess the precision of the lab processing
- Matrix spike/matrix spike duplicates (MS/MSD; as needed or required), extra volume is not typically needed as the added volume for the spikes is taken from the slabcake during subsampling
- Trip blanks (should be included with volatile analyses)
- Equipment blanks (e.g., after decontaminating an auger or sampler)
- Temperature blanks (laboratory specific; should be included in sample coolers for certain labs). These are typically not needed as ISM samples are left at room temperature for several days during ISM processing.

Field quality control will also be evaluated through comparison of replicate results. However, comparison of these results may speak to the heterogeneity of the soil and Site rather than the sampling procedures so all factors should be considered when evaluating these results.

Additionally, field documentation will be reviewed to assure it is compliant with Credere SOP CA-1: Field Activity Documentation and methods used for sampling are compliant with the protocol herein.



## 6. FIELD DOCUMENTATION

The following information should be recorded in the field logbook in compliance with Credere SOP CA-1:

- Date of field activity
- Credere personnel
- Scope of work
- Weather (particularly precipitation)
- Health and safety precautions
- Contractor/foreman/equipment make and model (if applicable)
- Changes in scope or deviations from the work plan
- Correspondence with Project Managers and/or Clients
- Sketches of sample locations relative to Site features and measurements (i.e., “swing ties”) from permanent landmarks where location accuracy is required. GPS will be used to define the limits of each SU/DU in the field and notes regarding the sampling path will be included.
- Sample details including IDs, number of increments per replicate, time of collection, requested analyses, volume of ISM sample collected, and preservatives.
- Requested laboratory processing details and any field processing details, if applicable
- Decontamination procedures
- General timeline of field activities



## 7. REFERENCES

Credere Associates, LLC, *Standard Operating Procedure CA-1: Field Activity Documentation*, Revision 1, dated August 2, 2016.

Credere Associates, LLC, *Standard Operating Procedure CA-2: Equipment Decontamination*, Revision 0, dated March 17, 2016.

Credere Associates, LLC, *Standard Operating Procedure CA-4: Soil Description*, Revision 0, dated March 17, 2016.

Credere Associates, LLC, *Standard Operating Procedure CA-7: Headspace Field Screening*, Revision 0, dated May 20, 2016.

Credere Associates, LLC, *Standard Operating Procedure CA-16: Chain of Custody Preparation*, Revision 0, dated November 29, 2017.

Interstate Technology Regulatory Council (ITRC), *Technical & Regulatory Guidance, Incremental Sampling Methodology*, Prepared by ITRC Incremental Sampling Methodology Team, October 2020.

U.S. DoD, *Environmental Field Sampling Handbook, Revision 1.0*, dated April 2013.

U.S. Environmental Protection Agency Environmental Response Team, *Soil Sampling*, SOP#: 2012, dated February 18, 2000.

U.S. Environmental Protection Agency, *Standard Operating Procedure for Soil, Sediment and Solid Waste Sampling*, SOP EIASOP\_SOILSAMPLING2, Revision 2, dated February 13, 2004.

U.S. Environmental Protection Agency, Region 4, Laboratory Services and Applied Science Division, Operating Procedure, *Soil Sampling*, LSASPROC-300-R4, Revision 4, dated June 11, 2020.



## **APPENDIX D**

### **GEOPHYSICAL DOCUMENTATION**

# Locate Field Report

Lighthouse Point Rd Isle La Motte, VT 05463 United States

Wednesday, June 7, 2023

Prepared For Credere Associates

A handwritten signature in black ink, appearing to be 'Jm' or similar, written in a cursive style.

# **BUTTON**

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**UNDERGROUND  
LOCATING**

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VERMONT'S PREMIER LOCATING SERVICE

**802-338-1105**

## Locate Summary

BUL located the following utilities in the area of proposed borings:

- UST
- Fuel Line
- Phone Line

Equipment used to identify and mark utilities include:

- GSSI Sir 4000 GPR w/400 mhz antenna
- Rigid Sr24 receiver
- Ridgid ST-510 transmitter
- Schonsted magnetic locator GA-72c



**Fuel Line**



**Fuel Line**



**Possible Small Line Located With GPR**



**Phone Line**



**Phone Line And UST**



**Phone Line**



**UST, Fuel Line, And Phone Line**



**UST, Fuel Line, And Phone Line**