



Stormwater Manual

City of Danville, Kentucky

February 1, 2006

CHAPTER 1
PURPOSE AND OVERVIEW

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PURPOSE AND OVERVIEW**

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1.1 INTRODUCTION

1.1.1 Introduction

Chapter 1 gives the purpose of this manual and an overview of the standards for stormwater management in the City of Danville. Three concepts; the public drainage system, the waters of Danville, and post-development floodplains; are important to the management of stormwater and are discussed in this chapter. The chapter also includes several general criteria required for the management of stormwater in new development and redevelopment. Finally, the chapter includes a summary of the specific criteria for managing water quantity and water quality. Many of the criteria presented in Chapter 1 are discussed in more detail in later chapters.

The manual is applicable to all stormwater infrastructure owned or regulated by the City of Danville. This includes infrastructure on commercial and industrial property. The only stormwater infrastructure not covered by the manual is farm facilities used for agricultural purposes.

1.1.2 Procedure for Revising the Manual

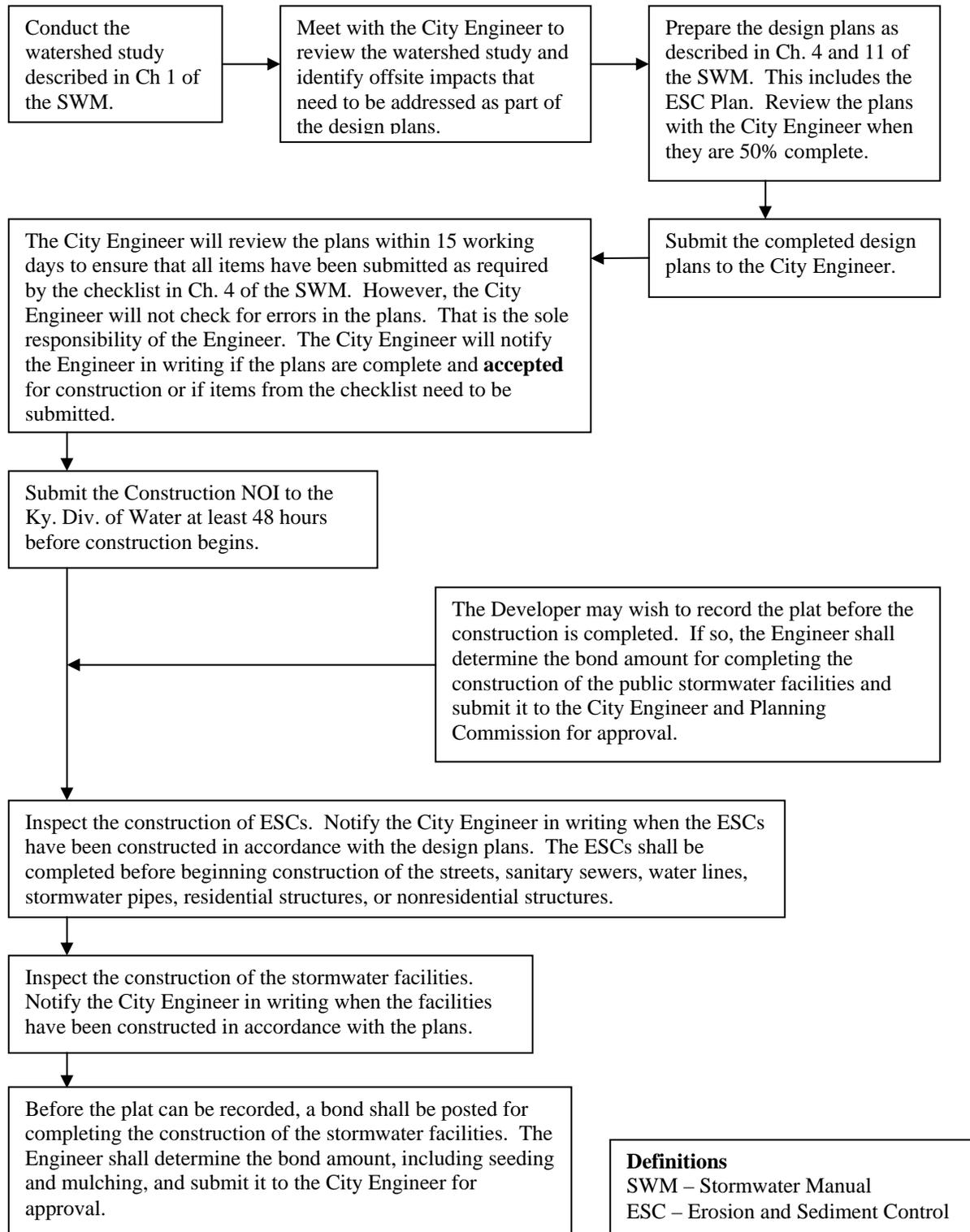
The City Engineer, Developers, Engineers, Homebuilders, Contractors, the Planning and Zoning Commission, and the public may propose amendments to the manual in accordance with the following procedures.

1. The applicant shall submit the proposed amendment in writing to the City Clerk to be included in the agenda for a City Commission meeting.
2. The City Commission shall review the proposed amendment and request comments from city staff, the City Engineer, and others as the City Commission deems appropriate.
3. Based on comments received, the City Commission may adopt or deny the proposed amendment. Factors considered by the City Commission shall include, but not be limited to, the following:
 - Cost
 - Impact on the plan review process
 - Effect on flooding
 - Effect on water quality
 - Effect on stormwater infrastructure such as pipes, inlets, and culverts
 - Compliance with the Stormwater Permit issued by the Ky. Division of Water

The manual shall be reviewed, updated, and republished every five years, or more often if needed, to incorporate the amendments that have been adopted by the City Commission.

1.1.3 Role of the Developer's Engineer

This flow chart describes the role of the Developer's Engineer for the design and construction of stormwater facilities in subdivision development.



1.2 PURPOSE

The regulated stormwater in the City of Danville lies on both public and private property. Portions of the stormwater infrastructure are constructed through the City of Danville's capital improvement projects and portions are constructed through private residential, commercial, and industrial development. In many cases, the City of Danville may ultimately become the owner of the stormwater infrastructure constructed by private development. To responsibly regulate the stormwater infrastructure, a consistent quality of construction is necessary regardless of the entity financing and managing the construction.

The purpose of this manual is to provide standards to assure quality in the design and construction of stormwater infrastructure that becomes a part of that owned or regulated by the City of Danville by providing standard design criteria to the engineers who design the infrastructure. The manual establishes uniformity in design assumptions and general methods of design. The manual also sets policy regarding design standards and specifications and provides for uniform interpretation of the specifications. Finally, the manual outlines the required calculations and design details applicable to all stormwater infrastructure.

This manual draws heavily on technical information and design criteria used in other city and state manuals and is thus similar in many instances to those manuals. However, this manual has been tailored to fit the City of Danville and contains important provisions that are unique to this area.

The manual includes requirements for the stormwater infrastructure that is routinely designed and constructed, including rational engineering principles and practices. However, more comprehensive methods of analysis and design and the installation of more extensive control practices may be required for unusual conditions not specifically covered in this manual, or where otherwise deemed necessary from an engineering or environmental standpoint to ensure public safety, environmental protection, public accommodation, or aesthetics.

1.3 DEFINITIONS

1.3.1 Public Drainage System in New Development

The public drainage system for subdivided property shall begin at the point where the water from more than two lots combine, or where water from one lot combines with water from a public road or other public facility. The public drainage system may be located on either public or private property.

The public drainage system is divided into two parts: the constructed part and the natural part. The constructed part includes those pipes, overland flow channels, swales, etc., which carry water from the beginning of the public drainage system to the portion of the drainage system that remains undisturbed, the natural portion. The natural portion of the public drainage system is referred to as the waters of Danville as defined below.

An adequate drainage right of way shall be required for all of the public drainage system not already in a street right of way. The right of way shall be of sufficient width to allow cleaning, widening, deepening, replacing, and generally maintaining the public drainage system. The minimum width of the drainage right of way shall be 20 feet.

The drainage right of way shall be treated the same as the street right of way. Like the area between the curb and the back of the sidewalk, property owners adjacent to the drainage right-of-way will have certain maintenance responsibilities such as mowing.

1.3.2 Waters of Danville

The waters of Danville are the natural portion of the public drainage system that shall remain undisturbed. These include:

- intermittent or perennial streams with a drainage area of at least 100 acres,
- wetlands with areas of more than ½ acre according to the current wetland delineation criteria used by the U. S. Army Corps of Engineers and a buffer area of 25 feet around the wetland,
- a vegetative buffer strip along streams extending 25 feet horizontally from the top of bank elevation,
- post-development floodplains

1.3.3 Post-Development Floodplain

The post-development floodplain shall be the portion of land adjacent to a stream (as defined above) covered with water during the 100-year 1-hour storm. It shall be determined using the procedures outlined in Chapter 3 of this manual. The post-development floodplain shall be based on a fully developed watershed and shall be used to determine the flood protection elevation for structures.

The floodplain shown on FEMA maps may be different than the post-development floodplain.

1.4 GENERAL CRITERIA FOR NEW DEVELOPMENT AND REDEVELOPMENT

1.4.1 Watershed Studies

Watershed studies are necessary to evaluate the impacts of a given development on the public drainage system and to define the post-development floodplain. The criteria for conducting watershed studies are given in Chapter 3. Watershed studies shall not be required for a development proposal less than 1 acre in size.

1.4.2 Regional Stormwater Management

The City of Danville shall require regional stormwater management facilities where feasible. This is more cost effective than requiring each small development project to construct its own stormwater facilities. In addition, the long-term maintenance requirements will be less because there will be fewer of these small facilities to maintain.

The City of Danville may require two or more developers to jointly fund the construction of a common water quality and/or water quantity practice by requiring cooperation between the developers or using a fee-in-lieu of stormwater management as defined later in this chapter.

The City of Danville may require a Developer to obtain offsite easements and construct offsite stormwater management practices.

1.4.3 Construction in the Waters of Danville

In general, construction activities shall not be allowed in the waters or post-development floodplains of the City of Danville. Filling the floodplain to allow more land to be developed shall be prohibited. Excavation in the floodplain to lower flood levels shall not be permitted. Only the following activities shall be undertaken in the waters or post-development floodplains

- temporary sediment ponds,
- roadways and utilities that cross at angles within 10 degrees of being perpendicular to the stream or floodplain,
- stormwater pipe outlets,
- regional flood control or water quality control ponds constructed by the City of Danville,
- other flood control practices that do not disturb below the normal top of bank of the stream,
- water quality practices that do not disturb below the normal top of bank of the stream, and
- pedestrian crossings and trails

1.4.4 Mitigation

Some impacts to streams are regulated by the U.S. Army Corps of Engineers (COE) and the Kentucky Division of Water (DOW) and require mitigation plans to be approved by those agencies.

1.4.5 Maintenance of Stormwater Best Management Practices

Stormwater best management practices (BMPs) for water quantity and water quality control are contained in Chapter 10.

Commercial and Industrial Property

The property owner shall be responsible for all maintenance. To ensure accountability, only one corporation or business shall own a BMP like a detention pond. A BMP shall not be subdivided into multiple lots.

Residential Areas

Property Owner

The property owner shall be responsible for the following:

- mowing (including the dam in detention ponds)
- removing all debris that accumulates in BMPs, including litter and tree limbs
- sodding or seeding bare areas, including areas on dams
- maintaining landscaped areas such as trees and shrubs

The property owner shall not plant trees on a dam because it may make the dam unstable. Trees may be planted in other areas of dry detention ponds. Since water may sometimes cover an entire dry detention pond, no structures shall be placed in the pond that could float and obstruct the outlet pipes. No fences, gazebos, swimming pools, trampolines, or buildings shall be placed in dry detention ponds. Questions about what may be allowed in ponds should be directed to the City of Danville.

The property owner shall ensure that a dry detention pond retains its original size (area and volume) and shape. Fill dirt shall not be placed in the pond unless approved in advance by the City of Danville.

Homeowners Association

Some BMPs like detention ponds may be on a separate lot owned by HOAs. In those cases, the HOA shall have the same maintenance responsibilities as the property owner above.

City of Danville

The City of Danville shall maintain the dam and structural items in all BMPs, including wet and dry ponds. This includes repairing concrete, pipe, gabions, stone, spillways, and headwalls. It also includes repairing eroded areas on dams that threaten the stability of embankments. The City of Danville shall repair paved ditches and inlet structures and remove large debris that obstructs the outlet pipes or spillways.

1.4.6 Lot Drainage in Residential Development

Constructed channels shall be provided for drainage areas greater than 1 acre in residential developments. The channel shall be designed to carry the 100-year storm to the stream. The drainage easement along the channel shall be 20 feet wide, or the width of the 100-year flow plus 5 feet on each side, whichever is wider. The Engineer shall design these channels as part of the construction plans. The design criteria are contained in Chapter 8.

Channels in back yards and side yards that receive runoff from a stormwater pipe or culvert shall have a paved (generally concrete) trickle channel designed to carry 50% of the 1 year storm. The design criteria for the trickle channel are contained in Chapter 8.

1.4.7 Maintenance of Drainage Easements

The City of Danville shall be responsible for maintaining the major structural items in the public drainage system easement. These items include pipes, paved channels, and headwalls. In residential areas, minor maintenance like mowing shall be the responsibility of the property owner. For commercial and industrial areas, the property owner shall be responsible for all maintenance.

Property owners shall not construct anything in the public drainage system, including the waters and post-development floodplains adjoining their property, that will impede the flow of water.

1.4.8 Class C Impoundments

Construction of Class C Impoundments as defined by the Kentucky Division of Water shall be prohibited. Proposed new impoundments shall be evaluated to determine the hazard classification. The evaluation shall be based on fully developed conditions downstream of the structure in accordance with the Comprehensive Plan.

1.4.9 Development Downstream of Existing Impoundments

Impoundments that are classified as Class A (Low Hazard) may sometimes become a Class B or C (Moderate or High Hazard) when vacant land below the impoundment is developed. Class B and Class C impoundments shall meet the design standards of the Kentucky Division of Water. These classifications apply to structures that temporarily or permanently hold water. More information on hazard classifications can be found in Chapter 2.

The Developer shall be responsible for making improvements to upstream structures, in accordance with the Kentucky Division of Water criteria, if the proposed development would cause the structure to be reclassified as a Class B or Class C impoundment. The appropriate agreements between the Developer and the owner of the impoundment shall be submitted to the City of Danville. Rather than improve the upstream structure, the Developer may choose to establish an easement to ensure that the impact area downstream of a failed impoundment is not developed.

1.4.10 Offsite Drainage Problems

Where offsite stormwater problems are known to exist, development projects shall consider these problems and integrate solutions determined through the Watershed Studies discussed above. Development projects shall help mitigate these existing problems.

1.4.11 National Flood Insurance Program

In general, construction within the FEMA floodplain is not allowed. However, it is appropriate and sometimes necessary to construct bridges, culverts, BMPs like detention ponds, and other stormwater facilities in the FEMA floodplain. In those cases, the construction is subject to the requirements of the National Flood Insurance Program.

A Letter of Map Revision (LOMR) shall be obtained from FEMA if there are changes to the FEMA floodplain. The LOMR shall be submitted to FEMA within 6 months of changes to the floodplain. The City of Danville shall review and approve the LOMR before it is submitted to FEMA.

The official FEMA floodplain is shown on the Flood Insurance Rate Map. More information on FEMA can be found in Chapter 2 or by contacting the City of Danville FEMA coordinator.

1.4.12 Erosion Control Requirements

The erosion control requirements in Chapter 11 shall apply to all construction activities.

1.5 WATER QUANTITY CRITERIA FOR NEW DEVELOPMENT

1.5.1 Quantity Impacts

The runoff from impervious services created by development can result in impacts to property and the aquatic community caused by increases in the rate of flow and volume of water. Aquatic community impacts are addressed in the next section on water quality criteria. Impacts to property may occur because of

- flooding from loss of channel capacity caused by sediment deposition,
- flooding due to an increase in peak flow from the addition of less pervious areas,
- flooding due to the capacity of the drainage network being exceeded, and
- increases in the area subject to flooding.

1.5.2 Exemptions from Quantity Controls

Development sites that are part of a regional stormwater quantity master plan are exempted from quantity controls. Other sites are exempted as described below.

1. In general, runoff controls shall not be required if it can be shown by a detailed watershed study that any of the following exists:
 - The construction of detention ponds would have insignificant effects on reducing downstream flood levels, or
 - Detention ponds are not needed to protect downstream property and the downstream drainage system has sufficient capacity to receive any increase in runoff for the 100-year storm, or
 - Detention ponds are not necessary to control runoff at the exit of a proposed development and constructing such detention ponds would increase flood levels at some point downstream, or
 - The City of Danville determines that detention ponds are not needed to control runoff and installing such facilities would not be in the best interest of the city.

Therefore, detention shall not be required for a site if the effect of uncontrolled runoff for the 100-year 1-hour storm can be shown to have an insignificant effect on water levels on downstream properties.

To evaluate the effect on the receiving stream, the Engineer shall conduct a watershed study to determine the flood levels using the 100-year 1-hour storm. The study area shall extend downstream to a point where the drainage area is at least 10 times the area of the proposed development.

The study area shall be based on fully developed conditions assuming no detention on any of the remaining parcels of land within the study area. If the cumulative effect of the additional runoff from the undeveloped sites within the study area, without detention, increases the water level less than 0.1', then no detention shall be required on the development site in

question. If the cumulative effect increases the water level greater than 0.1' within the study area, no detention shall be required on the site in question if all of the following apply:

- The increase in water level at the downstream end of the study area is less than 0.1', and
 - The drainage system has sufficient capacity to carry the flow from the site in question to the receiving stream. Sufficient capacity for a pipe system shall be defined as no overflowing at inlets or manholes. Sufficient capacity for an open channel system shall be defined as a drainage easement wide enough to carry the flow.
2. Small “bathtub” detention ponds for small drainage areas are generally ineffective at reducing peak flows because they clog easily. Therefore, small projects shall not be required to have detention ponds to control peak flows if the drainage area is less than 1 acre in size and the pipe/open channel drainage system from the site to the stream has sufficient capacity, as defined above, to carry the 100-year storm.

1.5.3 Peak Flow Design Criteria

Stormwater BMPs shall be designed and constructed to reduce peak flows from new development projects to pre-development levels. The design storms used for this analysis are contained in Chapter 5. BMPs for controlling peak flows are contained in Chapter 10. The BMPs that can be used for residential and commercial/industrial development are shown in Table 1.1.

TABLE 1.1 - OPTIONS FOR STORMWATER MANAGEMENT

Best Management Practice	Residential Development		Commercial and Industrial Development	
	Quantity	Quality	Quantity	Quality
Bioretention Systems				•
Infiltration Systems				
Downspouts to Grass		•		•
Modular Pavement				•
Swales		•		•
Bermed Swales		•		•
Biofiltration Swales				•
Terraforming				•
Infiltration Basins		•		•
Vegetated Filter Strips				•
Riparian Buffers		•		•
Sand/Organic Filters				•
Prefabricated Treatment Devices				•
Detention Ponds	•		•	
Extended Detention Ponds	•	•	•	•
Wet Ponds	•	•	•	•
Constructed Wetlands	•	•	•	•

1.5.4 Downstream Study Limits

Stormwater facilities for future development shall be designed so that the capacity of the existing and proposed pipes, culverts, channels, and other components of the drainage system are not exceeded. The study limits for a proposed development site shall extend downstream to a point where the drainage area is 10 times the area of the proposed development.

The Engineer shall determine the existing flow capacity of the downstream drainage system impacted by the proposed development. Table 1.2 lists the flow criteria for these drainage system components.

1.5.5 Capacity of the Proposed Drainage System

Stormwater pipes, inlets, culverts, and constructed channels shall be designed to meet the design criteria in Table 1.2.

1.5.6 Flood Protection Elevation

All residential, commercial, and industrial structures shall be constructed at or above the Flood Protection Elevation. The Flood Protection Elevation (FPE) shall be determined by the Engineer and shall be all of the following

1. Two feet above the 100-year FEMA floodplain elevation or two feet above the calculated 100-year post development floodplain elevation, whichever is higher;
2. Two feet above the 100-year storm elevation in constructed channels;
3. Two feet above the 100-year storm elevation at low points of streets if there is no overflow channel;
4. Two feet above 100-year storm elevation upstream of culverts;
5. Two feet above the embankment crest of detention ponds and wet ponds.

For all new structures, the lowest floor elevation that is above ground level shall be at or above the FPE. Crawl space entrances, foundation vents, basement window sills, the top landing of outside stairways leading to basements, and other openings to the structure shall be at or above the FPE.

TABLE 1.2 - FLOW CRITERIA FOR STORMWATER FACILITIES

Stormwater Appurtenance	Criteria	Manual Reference Section
Road Inlets on Grade	Spread of water as listed below based on 4 inches/hour rainfall intensity: Local streets – $\frac{3}{4}$ of driving lane Collector streets – $\frac{1}{2}$ of driving lane Arterial Streets – 4 feet in driving lane	Chapter 6
Road Inlets in Sags	Top of curb at 4 inches/hour rainfall intensity Back of sidewalk for 100-year	Chapter 6
Stormwater Pipes	10-year and 100-year	Chapter 6
Culverts	100-year	Chapter 7
Constructed Channels	100-year	Chapter 8

1.5.7 Setback from Floodplain

Developments shall be designed so that the wall of any principal or accessory structure can be located a minimum of 10 feet from the 100-year 1-hour post-development floodplain.

1.6 WATER QUALITY CRITERIA FOR NEW DEVELOPMENT

1.6.1 Impairment of Uses

The runoff from impervious surfaces created by new development can result in impacts to the water quality of the waters of Danville. Impairment to aquatic life may occur because of the loss of aquatic habitat caused by

- the destruction of riparian vegetation,
- decreases in the base flow during non-runoff periods,
- increases in stream bank erosion from higher stages caused by additional runoff volume,
- bottom scour from higher velocities through culverts and other conveyance mechanisms,
- increased toxicity from the increased chemical content,
- the nuisance growth of algae and other aquatic plants resulting from the nutrients in runoff,
- decreased light penetration from suspended material, and
- increases in the sediment deposited on the stream bottom.

Impairment to secondary contact recreation uses results from

- increases in bacteriological content due to small animal wastes and
- increases in the presence of petroleum products.

Impairment to public water supply uses results from the

- growth of algae and other nuisance aquatic plants resulting from the nutrients in runoff,
- increases in bacteriological content due to small animal wastes,
- increases in the presence of petroleum products,
- increases in suspended solids resulting in an increased cost of water treatment, and
- decreases in reservoir water storage capacity resulting from sedimentation.

1.6.2 Exemptions from Quality Controls

Development projects that are part of a regional stormwater quality master plan are exempted from quality controls. In addition, residential development projects less than 1 acre are exempted from quality controls. Water quality controls are not required for sites that are less than 10% impervious.

1.6.3 Water Quality Volume Criteria

The impact of the increase in the volume of water that becomes runoff rather than infiltration from a development site shall be mitigated through the capture, storage, and release of a volume of water proportional to the amount of impervious area. This volume is referred to as the water quality volume. The procedures for calculating the water quality volume are contained in

Chapter 10. The water quality volume from development projects shall be treated using BMPs described in Chapter 10.

For residential areas, the practice of discharging downspouts to grass provides an infiltration volume credit. The use of swales also provides an infiltration credit. These credits are calculated as described in Chapter 10 and can be used to satisfy a portion of the water quality volume. The remaining water quality volume shall be provided in one or more of the BMPs shown in Table 1.1.

For commercial and industrial areas, at least 50% of the water quality volume shall be treated using bioretention or infiltration. In addition, all runoff from rooftops and parking lots shall pass through a bioretention or infiltration system, sand filter, or prefabricated treatment device before discharging to a pond or surface water.

1.6.4 Infiltration Credit for Floodplains

Proposed developments that contain a floodplain shall receive an infiltration credit equal to 6 inches times the area of the floodplain. The credit can be used against the required water quality volume.

1.6.5 Culvert Outlet Velocity Criteria

The design velocity at the culvert outlet shall be reduced to match the natural stream velocity in accordance with the BMPs in Chapter 11 and the design procedures in Chapter 7.

1.6.6 Erosion Controls

Non-structural and structural erosion and sediment control BMPs shall be designed and constructed in accordance with an approved erosion and sediment control plan, as described in Chapter 11.

1.7 WATER QUANTITY AND WATER QUALITY CRITERIA FOR REDEVELOPMENT PROJECTS

1.7.1 Background

A comprehensive approach to improving flooding conditions and water quality in the City of Danville includes controlling the impacts from new development, and reducing the impacts from existing development. To reduce the stormwater impacts from existing development, stormwater controls will be implemented as property is redeveloped. The goal of stormwater management on redevelopment sites will be to reduce the pollutant load and peak flows leaving the site to a level less than existing conditions.

Providing stormwater controls on redevelopment sites is typically more difficult and more expensive than on new development sites, possibly creating a disincentive for redevelopment. To encourage redevelopment and the resulting addition of stormwater BMPs to sites that currently have no BMPs, the water quantity and water quality requirements for redevelopment will be less stringent than those for new development.

1.7.2 Requirements

The term “redevelopment” shall refer to alterations of a property that change the “footprint” of a site or building in such a way that there is a disturbance of equal to or greater than 1 acre of land. The term does not include such activities as exterior remodeling.

Redevelopment projects shall not be required to install water quantity or water quality BMPs if the impervious area of the redeveloped site (RIA) is 80% or less of the original impervious area (OIA).

If the impervious area of the redeveloped site is more than 80% of the impervious area of the original site, then:

1. Stormwater quantity BMPs shall be designed and constructed to reduce peak flows, after redevelopment, to 80% of the peak flows before redevelopment. The design storms used to calculate peak flow are contained in Chapter 5.
2. Stormwater quality BMPs shall be designed and constructed to treat the Water Quality Volume (WQV) as calculated below:

$$\text{WQV} = 1.6 \text{ inches} \times (\text{RIA} - 0.8 \times \text{OIA})$$

To encourage redevelopment, the WQV determined above is equal to 20% of the WQV for a new development site.

1.8 ALLOWABLE USES IN THE FLOODPLAIN

Table 1.3, along with Figure 1-1, shows the allowable uses in floodplains.

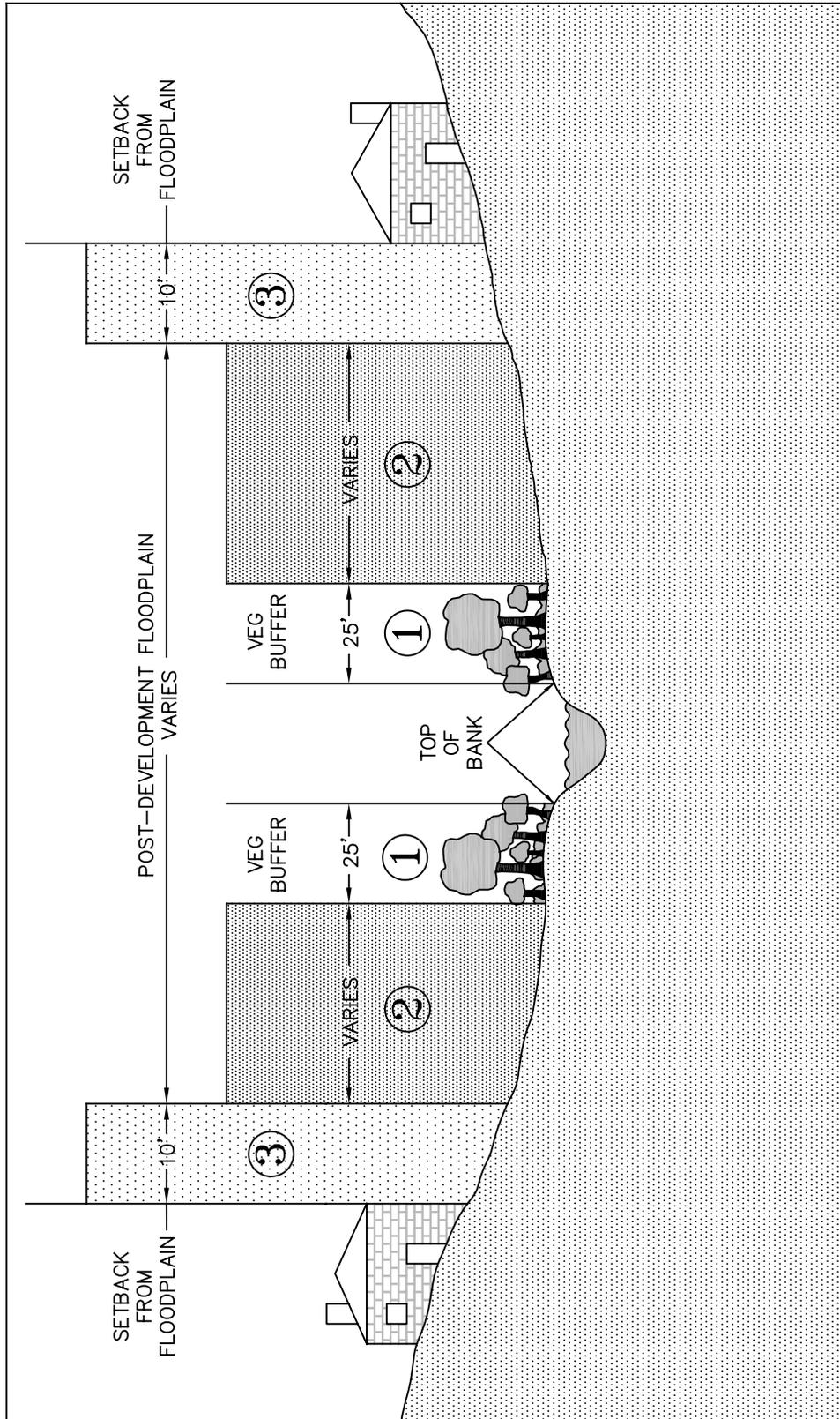
TABLE 1.3 - ALLOWABLE USES IN THE FLOODPLAIN

Activity or Use	Zone 1 Vegetative Buffer Strip	Zone 2 Floodplain	Zone 3 Floodplain Setback
Sediment Ponds	N	Y	Y
Detention Ponds along Perennial Streams	N	Y	Y
Detention Ponds along Intermittent Streams	Y	Y	Y
Constructed Wetlands	Y	Y	Y
Bank Stabilization	Y	Y	Y
Roads Parallel to Stream	N	N	Y
Road Crossing – Perpendicular	Y	Y	Y
Utility Crossing – Perpendicular	Y	Y	Y
Filling to Create Lots	N	N	Y
Excavation to Lower Flood Levels	N	N	N/A
Principal Structures (Homes, Businesses)	N	N	N
Swimming Pools	N	N	Y
Detached garages and storage buildings	N	N	N
Fences	N	Special Permit	Y
Lawns and gardens	N	Y	Y
Mowing	N	Y	Y
Large Tree removal (diam. > 4 inches)	N	N	Y
Shrub/Small Tree Removal (diam. < 4")	N	Y	Y
Shared Use Paths	N	Y	Y
Parking Lots with Temporary Parking	N	Special Permit	Y
Tennis Courts	N	Special Permit	Y
Park trails, baseball fields, soccer fields	N	Y	Y
Playground Equipment	N	Y	Y
Elevated Parking Garages	N	Special Permit	Y
Greenhouses	N	N	Y
Utilities Parallel to the Stream	N	Y	Y
Decks, Gazebos, and Shelters	N	Y	Y

1.9 FEE-IN-LIEU FOR NEW DEVELOPMENT OR REDEVELOPMENT

At its discretion, the City of Danville may charge a fee instead of requiring a new development or redevelopment to provide the water quantity and water quality practices listed above. This is called a fee-in-lieu program and may be used when

- the City of Danville or others have constructed or plan to construct water quantity or water quality practices providing an equivalent degree of protection or treatment
- situations exist in new development or redevelopment that have small drainage areas for which there are no applicable BMPs



See Table 1.3 for allowable uses in each zone.
The 10' setback shall be shown on the record plat.

CHAPTER 2

PERMITS

**CHAPTER 2
PERMITS**

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2.1 KENTUCKY DIVISION OF WATER FLOODPLAIN CONSTRUCTION PERMITS

2.1.1 Purpose

Pursuant to Kentucky law, dams or other improvements obstructing the movement of water in the floodplain are often regulated by the Kentucky Division of Water (KDOW). The purpose of the procedure described here is to require that the KDOW first review obstructions to the flow of water in floodplains. Implementation of the procedure should prevent a situation where the City of Danville would allow construction of and ultimately assume operation and maintenance of a structure that did not meet the standards of the KDOW.

A Floodplain Construction Permit is required from the KDOW of the Natural Resources and Environmental Protection Cabinet prior to the construction, reconstruction, relocation, or improvement of any dam, embankment, levee, dike, bridge, fill, or other obstructions across or along any stream or in the floodway of any stream. Permits are required for any such activity in designated 100-year floodplains or areas known to be flood prone. Exemptions exist that cover activities in watersheds of less than one square mile of drainage, activities covered under the Corps of Engineers General Permits, and some utility pipeline stream crossings. A permit from the KDOW is also required to deposit or cause to be deposited any matter that will in any way restrict or disturb the flow of water in the channel or in the floodway of any stream. In addition, a KDOW permit is required prior to the construction of structures qualifying as dams.

2.1.2 Procedure

In instances where KDOW permits are required, the City of Danville shall not approve the plans for construction until evidence of the Floodplain Construction Permit or a determination that no permit is required, is provided to the City of Danville by the Developer. In the case of dams where water will be impounded on a temporary basis, the City of Danville shall not approve the plans for construction of facilities dependent upon the structure until an approval by the KDOW to impound water has been obtained. The permitting requirements apply to dams constructed for sediment and erosion control, stormwater retention, or just aesthetic amenities. The requirements also apply to other flow obstructions like pump stations. The following procedure outlines the process for deciding whether a KDOW permit is required.

2.1.3 Determination of Need for Permit

This section describes the process for determining whether a KDOW Determination permit is required.

Step 1: Determine 100-year Post-Development Floodplain Boundaries

Post-development floodplain boundaries for the 100-year flood are as defined in Chapter 1 of this manual.

If the analysis described in the definition of post-development floodplains indicates that the construction is not in the floodplain, it can be submitted to the City of Danville as evidence of compliance with KDOW procedures.

Step 2: Determine the Hazard Classification of the Obstruction per DOW Criteria

Hazard Classification A – This classification may be applied for structures located such that failure would cause loss of the structure itself, but little or no additional damage to other property. Such structures will generally be located in rural or agricultural areas where failure may damage farm buildings other than residences, agricultural lands, or county roads.

Hazard Classification B – This classification may be applied for structures located such that failure may cause significant damage to property and project operation, but loss of human life is not envisioned. Such structures will generally be located in predominantly rural agricultural areas where failure may damage isolated homes, main highways or major railroads, or cause interruption of use or service of relatively important public utilities.

Hazard Classification C – This classification must be applied for structures located such that failure may cause loss of life, or serious damage to homes, industrial or commercial buildings, important public utilities, main highways or major railroads. This classification must be used if failure would cause probable loss of human life.

The City of Danville methodology for characterizing the hazard is based on the height of the structure. If the height is less than 15 feet, an A classification may be assumed if no roadways, walkways, residences, commercial buildings, or agricultural buildings are located, or could be located in the future, in the downstream floodplain within a distance from the structure defined by the equation given below, unless visual analysis indicates that a higher hazard classification is more appropriate.

Equation for calculating distance from the structure to a roadway, walkway, or building:

$$X=40Y$$

Where X is the downstream distance (ft) measured from the downstream toe of the structure and Y is the height (ft) of the structure measured vertically from the downstream toe to the top of the dam.

If the height of the structure is greater than 15 feet, the justification for the hazard classification shall be made based on a failure analysis. The analysis shall be conducted using the National Weather Service Dam Break Model or a similar model approved by the City of Danville. The results of the analysis shall be submitted to the City of Danville as documentation of the compliance with the KDOW procedures.

Step 3: Determine if the Structure is a Dam

A structure is defined by the KDOW as a dam if the distance from the downstream toe to the lowest point in the top of the dam is 25 feet or greater or if the structure has the potential for

impounding, either temporarily or permanently, 50 acre feet or more, measured to the crest of the embankment.

A KDOW Permit is required if:

1. From step 3, the obstruction is a dam
2. From step 2, the hazard classification is a C
3. From step 2, the hazard classification is an A or B and the drainage area above the obstruction is greater than 1 square mile

2.1.4 Fills

Fills not impounding water are a class of obstruction that is covered under this requirement. A KDOW Floodplain Construction Permit is not required for a fill if the drainage area above the fill is less than or equal to 1 square mile. However, in accordance with the requirements given in Chapter 1 of this manual, fill may only be placed in the floodplain if the fill is related to the construction of a stormwater management practice, roadway, or utility and the fill does not cause an increase in the 100-year post development flood level as calculated using the procedures given in Chapter 3 of this manual.

2.2 KENTUCKY DIVISION OF WATER KPDES STORMWATER PERMIT

2.2.1 Purpose

Erosion and Sediment Control on certain construction sites is controlled by Kentucky KPDES General Permit for Stormwater Point Sources (Construction) as well as by the City of Danville's Erosion and Sediment Control Ordinance. The KPDES General Permit requires, among other things.

1. The submission of a Notice of Intent to the Division of Water before construction begins,
2. The preparation of a stormwater best management practices plan, which includes an erosion and sediment control plan, to be kept on-site at all times,
3. A description of procedures to maintain erosion and sediment control measures during the period of construction,
4. The identification of each contractor or subcontractor who will install each erosion and sediment control measure,
5. The signing by each contractor or subcontractor of a statement certifying the awareness of the requirements of the KPDES Stormwater Permit for the site,
6. The inspection by qualified personnel, provided by the Developer, of the site at least once every seven calendar days and within 24 hours of the end of a storm of 0.5" or greater, and
7. The submission of a Notice of Termination to the Division of Water with a statement certifying that all storm water discharges associated with the construction activity have been eliminated.

2.2.2 Procedure

The City of Danville shall not approve the erosion and sediment control plan until the Notice of Intent and items 2-5 above are provided to the Division of Water with a copy to the City of Danville. During the construction process, evidence of the inspection listed in item 6 above shall be submitted to the Division of Water with a copy to the City of Danville.

2.3 FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

2.3.1 Purpose

FEMA manages the National Flood Insurance Program (NFIP) based on maps showing floodplains and flood hazard areas. As part of the agreement for making flood insurance available in the City of Danville, the NFIP required the City of Danville to adopt floodplain management ordinances containing certain minimum requirements intended to reduce future flood losses. The City of Danville is also responsible for submitting data to FEMA reflecting revised flood hazard information so that the NFIP maps can be revised as appropriate. Up to date maps allow risk premium rates and floodplain management requirements to be based on current data.

In instances where construction in the floodplain changes the floodplain elevations shown on the NFIP maps, FEMA has a procedure for revising the maps. In general, construction in floodplains is not envisioned except for road and utility crossings and the construction of sanitary sewer and stormwater management facilities. In some instances, construction of these facilities may change the floodplain elevations, necessitating the filing of documents with FEMA to correct the floodplain maps. In other instances, the FEMA maps may incorrectly show the floodplains. Where a floodplain is shown incorrectly, the filing of documents with FEMA is required to correctly define the floodplains.

2.3.2 Procedure

Construction activities within the FEMA floodplain shall comply with the requirements of the City of Danville's Flood Damage Prevention and Control Ordinance.

For projects that change the FEMA floodplain, the Engineer shall submit the appropriate technical data to FEMA. The requirements for submitting the data can be obtained from the City of Danville.

2.4 401 AND 404 PERMITS – KENTUCKY DIVISION OF WATER AND U.S. ARMY CORP OF ENGINEERS

2.4.1 Purpose

The KDOW Floodplain Construction Permit addressed above only relates to the potential flooding from the construction of an obstruction to the flow of water in the stream or floodplain. The KDOW has another permitting program (401 permit) related to construction that impacts the stream channel and areas below the ordinary high water level. In general, construction below the ordinary high water level is not envisioned in the waters of Danville. However, if situations arise where construction is necessary below the ordinary high water level or in wetlands, the Kentucky Natural Resources and Environmental Protection Cabinet (MREPC), Department for Environmental Protection, Division of Water has requirements for projects that impact these waters. In addition, the U.S. Army Corps of Engineers (COE) has requirements for projects that impact waters of the United States, including wetlands. Where the KDOW 401 or COE 404 permits, including coverage under the COE nationwide permits, are required the City of Danville shall not approve the plans for construction until evidence of the 401 and/or 404 permits or a determination that no permit is required is provided to the City of Danville.

CHAPTER 3
WATERSHED STUDIES

**CHAPTER 3
WATERSHED STUDIES**

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3.1 INTRODUCTION

Watershed studies shall be conducted to:

- determine the effects of a proposed development on the public drainage system,
- establish the post-development 100-year floodplain,
- identify existing drainage problems,
- identify potential locations for regional stormwater facilities that address both flood control and water quality,
- establish design criteria over and above the design criteria specified elsewhere in this manual to correct or improve existing drainage problems, and
- develop a stormwater management plan for the watershed to minimize future drainage problems and reduce existing problems.

3.2 DATA COLLECTION

3.2.1 Data Sources

Appendix A lists numerous sources for obtaining mapping and other reference materials required as part of a watershed study.

3.2.2 Required Data

The following data shall be collected:

Watershed Characteristics

Determine the size of the contributing drainage area, expressed in acres, from the following:

- 2' contour map of the site with field checks to determine any significant changes in the contributing drainage area such as flood control structures and grade changes which have occurred since preparation of the map

Watershed Land Use

Document the existing and future land use. Information on existing land use can be obtained from:

- aerial photographs,
- zoning maps and the Comprehensive Plan from the Planning Commission,
- USGS and other maps,
- satellite images, and
- soil maps.

Existing land use data for small watersheds can best be determined or verified from a field survey. Use field surveys to update information on maps and aerial photographs, especially in basins that have experienced changes in development since the maps or photos were prepared.

Streams, Ponds, Lakes and Wetlands

At all streams, ponds, lakes, and wetlands that will affect or may be affected by future development, collect the following data:

- boundary (perimeter) and elevation of the water surface;
- water elevation for design storms specified in this manual;
- detailed description of any natural or manmade spillway or outlet works including dimensions, elevations, material, and operational characteristics;
- detailed description of any emergency spillway works including dimensions, materials, and elevations;
- profile along top of any dam and a typical cross section of the dam;
- use of the water resource (stock water, aquatic habitat, recreation, power, irrigation, municipal or industrial water supply, etc.);
- applicable water quality standards;

- existing data describing the physical, chemical, and biological water quality;
- boundaries of wetlands and sinkholes within the project boundaries or downstream of project in a location which may be impacted by storm water runoff.

Roughness Coefficients

Estimate roughness coefficients, in the form of Manning's n values, for the entire flood limits of the stream within the reach to be evaluated. A tabulation of Manning's n values with descriptions of their applications can be found in Chapter 8.

Stream Profile

Obtain streambed profile data to determine the average slope. Where there is a stream gage relatively close, obtain the discharge, with date and time of the reading corresponding to the stream level.

Stream Cross-Sections

Obtain stream cross-section data where stage-discharge-volume relationships will be necessary.

Existing Structures

- Investigate any structures that may cause backwater or retard stream flow.
- Evaluate the manner in which existing structures have been functioning with regard to such things as scour, overtopping, damage, and debris.
- For bridges, determine span lengths, height, type of piers, and substructure orientation.
- For culverts, determine the size, inlet and outlet geometry, slope, end treatment, culvert material, and flow line profile.
- Take photographs of high water debris lines.
- Determine outlet structure (principal and emergency spillway) dimensions, material, inlet condition, headwater and backwater conditions, slope, and invert elevations.
- Determine an elevation profile along the top of the embankment for simple outlet structures.
- For water quality calculations, determine the storage volume below permanent pools.
- Identify local sources of contamination, such as livestock, siltation, junk piles, and other point sources.
- Make a record of the condition of the structure concerning erosion, degradation, and damage.
- Take photographs of all structures to document their overall and detailed condition.
- Identify sinkholes and take photographs.

Acceptable Flood Levels

Determine the lowest opening elevation of structures where flooding is known to occur.

Flood History

Evaluate the history of past floods and their effect on existing structures. Information may be obtained from newspaper accounts, local residents, flood marks, or other evidence of the height of historical floods.

Obtain recorded flood data from the following agencies:

- U.S. Army Corps of Engineers,
- U.S.G.S.,
- Kentucky Division of Water, and
- City of Danville.

3.2.3 Documentation

Document the field review with dated field notes and photographs initialed by the reviewer. Include the documentation with the project plans and calculations submitted to the City of Danville. Collect field data in accordance with GIS requirements of the City of Danville.

An example field inventory form is contained in Appendix B.

3.3 RUNOFF MODELS

3.3.1 General

A watershed is a complicated unit of land, combining many hydrologic and hydraulic processes to produce a stream flow and water quality response. With the help of computers and their advanced computation capabilities, watershed models can be created to represent the characteristics of the watershed. Once created and calibrated, the model can be used to analyze the watershed. The HEC-1 or HEC-HMS model shall be used for the runoff model. More information is contained in Chapter 5.

3.3.2 Subbasin Data

Subbasin data shall be collected in accordance with the following requirements:

- Delineate watershed subbasins so that average subbasin size is 10-25 acres and maximum subbasin size does not exceed 50 acres.
- Determine existing percent imperviousness from Table 3-1.
- Calculate overland slope from an average of at least three slope measurements of the subbasin terrain.

TABLE 3.1 - LAND USE IMPERVIOUSNESS

Land Use	Percent Impervious
<i>Residential</i>	
1/8 acre lots	65
1/4 acre lots	38
1/3 acre lots	30
1/2 acre lots	25
1 acre lots	20
<i>Commercial</i>	85
<i>Industrial</i>	72

3.3.3 Structure Data

When assembling a watershed model, stage-area storage-discharge relationships shall be determined for all structures in the model.

- Calculate the stage-discharge curve for each structure.
- Using the 2-foot contour lines and field information, calculate a stage-area-storage relationship for each structure in the model. Include storage below the permanent pools.
- Combine the stage-discharge curve with the stage-area-storage curve to make one table.

3.4 POST-DEVELOPMENT FLOODPLAIN ANALYSIS

3.4.1 General

Once the runoff model is complete, post-development floodplains shall be determined with the United States Army Corps of Engineers' HEC-RAS computer program. This program will also provide results to indicate roadway and structure flooding. The design storm for floodplain analysis is contained in Chapter 5. This portion of the chapter details how to build the HEC-RAS input file for a watershed study based on the data collected in section 3.2.

3.4.2 Post-Development Floodplain

The post-development floodplain shall be determined for streams with a drainage area greater than 100 acres. The post-development watershed condition shall be based on future land use.

3.4.3 Cross-Sections

HEC-RAS determines floodplains based on cross-section data provided by the user. The following methodology shall be employed when developing cross sections.

- Starting at the most downstream end of the study area, locate a cross-section at least every 200 feet until the upstream end of the study area is reached.
- Orient the cross section so that it is perpendicular to the contour lines.
- Using a 2' contour map, determine stations and elevations along each cross-section from 500' to the left of the thalweg (facing downstream) to 500' to the right of the thalweg.
- Determine the station along the left side and the station along the right side of each cross-section that corresponds to the bank station (typically corresponds to a change in slope).
- Determine the downstream reach length from each cross-section to the preceding cross-section along the left bank, thalweg, and right bank.

The data outlined above are required for each cross-section. If a cross-section happens to fall where a tributary intersects the channel, then employ one of the following two options.

- If there are at least 50 other cross-sections, delete the tributary-impacted cross-section from the analysis.
- If there are less than 50 cross-sections, then copy the stations and elevations from the previous downstream cross-section to the tributary-impacted cross-section, but increase all the elevations along the tributary-impacted cross-section by the difference in elevation of the thalwegs of the two cross-sections.

If tributaries are to be modeled, treat them similarly to the main stem by working from downstream to upstream and spacing cross-sections at 200' intervals.

3.4.4 Roughness Values and Coefficients

Working from downstream to upstream, specify the following roughness values and coefficients:

- left bank = Manning's n from Chapter 8,
- right bank = Manning's n from Chapter 8,
- stream channel = Manning's n from Chapter 8,
- contraction coefficient = 0.10, and
- expansion coefficient = 0.30.

If the entire stream reach has the same set of roughness values from downstream to upstream, then only specify these values at the beginning of the input file.

3.4.5 Flow and Water Surface Elevations

The results from HEC-1 will provide the flows and surface elevations at flow control structures for each HEC-RAS run.

3.4.6 Rounding of Water Surface Elevations

The water surface elevations from HEC-RAS shall be rounded to the nearest 0.1'.

APPENDIX 3A – *Sources of Data*

APPENDIX 3A – Sources of Data

- Environmental Assessments
 - Kentucky Department of Fish and Wildlife Resources
Arnold L. Mitchell Building
#1 Game Farm Road
Frankfort, Kentucky 40601
(502) 564-4336
 - Kentucky Department for Natural Resources
Division of Conservation
663 Teton Trail
Frankfort, Kentucky 40601
(502) 564-3080
 - Kentucky Department for Natural Resources
Division of Forestry
627 Comanche Trail
Frankfort, Kentucky 40601
(502) 564-4496
 - Kentucky Nature Preserves Commission
801 Schenkel Lane
Frankfort, Kentucky 40601
(502) 573-2886
 - U.S. Fish and Wildlife Service
446 Neal Street
Cookeville, Tennessee 38501
www.fws.gov
- Flood Plain Delineations and Studies
 - Federal Emergency Management Agency
Flood Map Distribution Center
6930 (A-F) San Tomas Road
Baltimore, Maryland 21227-6227
www.fema.gov/msc/femahome.htm
 - U.S. Geological Survey, Water Resources Division
9818 Bluegrass Parkway
Louisville, Kentucky 40299-1906
(502) 493-1900
www.usgs.gov/public/data.html

APPENDIX 3A – Sources of Data (continued)

Kentucky Department for Environmental Protection
Division of Water
14 Reilly Road
Frankfort, Kentucky 40601
(502) 564-3410

- Hydraulic Studies
Federal Highway Administration
U.S. Department of Transportation
400 Seventh Street SW
Washington, D.C. 20590

Kentucky Transportation Cabinet
Department of Highways
State Office Building
Frankfort, Kentucky 40601
(502) 564-4890

U.S. Army Corps of Engineers
Louisville District
P.O. Box 59
Louisville, Kentucky 40201
(502) 582-5601

Kentucky Department for Environmental Protection
Division of Water
14 Reilly Road
Frankfort, Kentucky 40601
(502) 564-3410

- Mapping
Kentucky Geological Survey
228 Mining & Mineral Resource Building
University of Kentucky
Lexington, Kentucky 40506-0107
Water Resources Section
James S. Dinger
Publications Section
Carol L. Ruthven
(606) 257-5500

APPENDIX 3A – Sources of Data (continued)

- Meteorological Data
 - Midwestern Climate Center
2204 Griffith Drive
Champaign, Illinois 61820-7493
(217) 244-8226
mcc.sws.uiuc.edu
 - National Oceanography and Atmospheric Agency (NOAA)
Climate Data Center
Asheville, North Carolina 28801
www.crh.noaa.gov/lmk/climate.htm
 - U.S. Geological Survey, Water Resources Division
9818 Bluegrass Parkway
Louisville, Kentucky 40299-1906
(502) 493-1900
www.usgs.gov/public/data.html
- Water Quality Data
 - Kentucky Department for Environmental Protection
Division of Water
14 Reilly Road
Frankfort, Kentucky 40601
(502) 564-3410
 - STORET User Assistance
Mail Stop 4503-F
U.S. EPA
401 Main Street, S.W.
Washington, DC 20460
(800) 424-9067
STORET@epamail.epa.gov
www.epa.gov/OWOW/STORET
 - U.S. Geological Survey, Water Resources Division
9818 Bluegrass Parkway
Louisville, Kentucky 40299-1906
(502) 493-1900
www.usgs.gov/public/data.html

APPENDIX 3B – *Example Field Inventory Form*

CHAPTER 4
DESIGN DOCUMENTATION

**CHAPTER 4
DESIGN DOCUMENTATION**

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4.1 OVERVIEW

4.1.1 Introduction

An important part of the design or analysis of any hydraulic facility is the documentation. Appropriate documentation of the design of any hydraulic facility is essential because of:

- the importance of public safety,
- future reference by engineers (when improvements, changes, or rehabilitations are made to the drainage facilities),
- information leading to the development of defense in matter of litigation, and
- public information.

Frequently, it is necessary to refer to plans, specifications and analysis long after the actual construction has been completed. Documentation permits evaluation of the performance as anticipated or to establish the cause of unexpected behavior, if such is the case. In the event of a failure, it is essential that contributing factors be identified in order that recurring damage can be avoided.

4.1.2 Definition

The definition of hydrologic and hydraulic documentation as used in this chapter is the compilation and preservation of the design and related details as well as all pertinent information on which the design and decisions were based. This includes maps, field survey information, source references, photographs, engineering calculations and analyses, measured and other data, and flood history including narratives from newspapers and individuals such as highway maintenance personnel and local residents who witnessed or had knowledge of an unusual event.

4.2 PURPOSE

The purpose of this chapter is to present the documentation that will be included in the design files and on the construction plans for new developments. This chapter focuses on the documentation of the findings obtained in using the other chapters of this manual. This chapter identifies the system for organizing the documentation of hydraulic designs and reviews so as to provide as complete a history of the design process as is practical.

The major purpose of providing good documentation is to define the design procedure that was used and decisions that were made to arrive at the final design. Documentation should be viewed as the record of reasonable and prudent design analysis based on the best available technology. Thus, good documentation can provide the following:

- identification of the situation at the time of design which might be very important if legal action occurs in the future;
- protection for the engineer by proving that reasonable and prudent actions were, in fact, taken (such proof should certainly not increase a potential court award and may decrease it by disproving claims of negligence by the plaintiff);
- documentation that generally accepted procedures and analysis were used at the time of the design which were commensurate with the perceived site complexity and flood hazard (this should further disprove negligence claims);
- a continuous site history to facilitate future reconstruction;
- the file data necessary to quickly evaluate future site problems that might occur during the facility's service life; and
- expedited plan development by clearly providing the reasons and rationale for specific design decisions.

4.3 50 PERCENT DESIGN PLANS

The Engineer shall meet with the City Engineer to review the plans when they are approximately 50% complete. The following information shall be provided.

4.3.1 General Plan Sheet Information

1. Name of development; name, address, and telephone number of developer in lower right-hand corner of plans
2. Names of existing utilities and telephone numbers
3. Sheet index
4. Legend
5. Minimum 24" x 36" sheet
6. Title block
7. Name, address, and telephone number of developer
8. Name, address and telephone number of engineer
9. Professional engineer seal and signature
10. Sheet number
11. North arrow
12. Scale (1" = 50' preferred, a scale showing greater detail may be used)
13. Contour Interval of 2 feet , a smaller interval may be used where appropriate
14. Date
15. Addresses
16. Building line setbacks
17. Boundary lines
18. Back of curb
19. Buildings footprints, existing
20. Building footprints, new
21. Centerlines, roadway
22. Connection to existing lines, detail
23. Contours, existing
24. Contours, proposed
25. Easements, existing
26. Easements, proposed
27. Lot lines
28. Lot numbers
29. Match lines with station number reference
30. Monuments
31. Pipe, proposed; size, type and class
32. Property owners, deed book and page numbers of recorded plat
33. Roadway right of way (designate city, county or state)
34. Street names
35. Utilities in project area, existing
36. Utilities in project area, proposed
37. Standard details

4.3.2 Stormwater Information

The following general information shall be submitted:

- a map showing all drainage areas and sub-areas used to size hydraulic structures at a scale of 1:24,000 (a scale showing a greater level of detail may be used)
- proposed inlets, stormwater pipes, culverts, manholes and their sizing calculations
- proposed stormwater best management practices
- proposed constructed channels and their sizing calculations
- 100-year post development floodplain
- FEMA floodplain
- sinkholes
- caves
- springs
- ponds
- streams
- wetlands
- tree stands,
- steep slopes greater than 12%
- existing and proposed underground utilities

4.4 FINAL DESIGN

Final design drawings shall include the same information as the 50% submittal plans except they shall be complete in all respects. In addition, the final submission for stormwater shall include the following information:

4.4.1 Hydrology

Submit the following items:

- watershed area size
- peak discharge and hydrographs for design storms
- expected level of development in upstream watershed over the anticipated life of the facility (include sources of basis for these development projections)

4.4.2 Inlets, Stormwater Pipes, and Manholes

Submit the following items:

- computations for inlets and pipes, including hydraulic grade lines
- a complete drainage area map
- a schematic indicating storm drain system layout
- pipe lengths, slopes, diameters, and material
- structure types, labels
- grate elevations
- existing and proposed 2' contours
- separate sheets for details

Plan View

- street layout, lot lines
- catch basins - type, designation (station and number), invert elevation, and station offset or coordinates (NAD 83)
- pipes - sizes, type, class, slope, and designation
- manholes - size and type, station and offset or coordinates (NAD 83)
- headwalls - type and invert elevation
- sanitary sewer crossings
- culvert size and shape
- other utility line crossings

Profile View

- underground utility crossings
- existing and proposed ground surfaces
- curb inlets - elevations and type
- manholes - elevations and type
- pipes with size, grade, type, class, length

- headwall type and elevation
- all crossings (with elevations) of sanitary sewers and underground utilities
- all street sections at crossings and all regrade contours
- capacity and proposed flows in pipes
- hydraulic grade lines
- manholes
- inlet and outlet elevations of pipes
- copies of all computer analyses, with input data listed and output clearly identified

4.4.3 Culverts and Bridges

Submit the following items:

- culvert performance curves
- allowable headwater elevation and basis for its selection
- cross-section(s) used in the design highwater determinations
- roughness coefficient assignments (n values)
- stage discharge curves
- performance curves showing the calculated backwater elevations and outlet velocities for the design storms
- type of culvert entrance condition
- culvert outlet appurtenances and energy dissipation calculations and designs
- copies of all computer analyses, with input data listed and output clearly identified
- roadway geometry (plan and profile)
- headwall locations and details

4.4.4 Constructed Channels

Submit the following items:

- profiles
- cross-section(s) used in the design water surface determinations and their locations
- roughness coefficient assignments (n values)
- channel velocities
- water surface profiles through the reach for the design 100-year storm
- design analysis of materials proposed for the channel bed and banks
- energy dissipation calculations and designs
- copies of all computer analyses, with input data listed and output clearly identified

4.4.5 Stormwater Quantity and Quality Best Management Practices

Submit the following items:

- design calculations and schematics
- complete drainage area map, delineating area draining to each practice and denoting total area and impervious area draining to each device
- separate detail sheet for detention/retention basins
- detail sheets for water quality treatment devices

- water quality treatment practice (designate type of device, total area and impervious area draining to device, and volume used to size device)
- embankment elevation
- peak stages
- emergency spillway details
- plan view of detention volume (1' contours)
- other utilities

4.4.6 Floodplains

Submit the following items:

- FEMA floodplain,
- post-development floodplain,
- profiles,
- cross-section(s) used in the design water surface determinations and their locations;
- roughness coefficient assignments (n values),
- water surface profiles through the reach for the 100-year storm,
- copies of all computer analyses, with input data listed and output clearly identified.

4.4.7 Erosion and Sediment Control Plan

Submit the Erosion and Sediment Control Plan described in Chapter 11.

4.5 COMPOSITE DRAINAGE PLAN

This plan is intended to aid home builders and commercial/industrial builders in preparing their application for a building permit. The following information shall be shown on the Composite Drainage Plan.

- surface drainage easements on each lot,
- flow arrows that indicate the direction of surface drainage through each surface drainage easement,
- sanitary sewers and manholes,
- stormwater pipes and manholes,
- surface inlets, curb inlets, constructed channels, and detention ponds,
- Flood Protection Elevation for each lot.

CHAPTER 5
HYDROLOGY

**CHAPTER 5
HYDROLOGY**

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5.1 INTRODUCTION

5.1.1 Purpose

The analysis of the peak flow, volume of runoff, and time distribution of flow is fundamental to the design of storm water drainage facilities. Errors in the estimates can result in a structure that is either undersized and causes drainage problems or oversized and costs more than necessary. On the other hand, it must be realized that any hydrologic analysis is only an approximation. The relationship between the amount of precipitation on a drainage basin and the amount of runoff from the basin is complex, and too little data are available on the factors influencing the rural and urban rainfall-runoff relationship to expect exact solutions.

The purpose of this chapter is to describe approved methods of hydrological analysis for watershed studies and for the design of sediment ponds, stormwater best management practices, inlets, stormwater pipes, culverts, and channels.

5.2 APPROVED METHODS

5.2.1 HEC-1 and HEC-HMS Programs

The HEC-1 or HEC-HMS computer program from the U.S. Army Corps of Engineers shall be used for hydrologic analysis. More information is given later on these models.

Other computer programs may be used for designing stormwater pipes, open channels, culverts, inlets, and detention ponds if they use the methods in this chapter for determining runoff hydrographs and peak flows. Examples of these include computer programs from Haestad Methods.

5.2.2 Rational Method

The Rational Method may be used to compute peak flows for drainage areas less than or equal to 25 acres when designing inlets, stormwater pipes, culverts, and channels.

5.3 DESIGN STORMS

5.3.1 Design Storms

Stormwater facilities shall be designed using the design storms in Table 5-1. The design storm distributions are contained in Appendix 5A.

TABLE 5. 1 - APPLICATION OF DESIGN STORMS

Design Storm	Stormwater Facility					
	Floodplains and Sinkholes ⁽³⁾	Detention Ponds ⁽¹⁾	Inlets	Pipes	Culverts	Constructed Channels
1-year 1-hour						• ⁽²⁾
10-year 1-hour		•	•	•		
100-year 1- hour	•	•	•	•	•	•
100-year 6- hour	•	•				

1. Detention ponds shall be designed to reduce post-development peak flows to pre-development levels for all three storms.
2. Constructed channels in back yards and side yards of residential areas shall be designed with a paved trickle channel. The trickle channel shall be designed to carry 50% of the 1-year 1-hour storm.
3. Floodplains and sinkholes shall be evaluated using both storms listed.

5.4 HEC-1 MODEL

5.4.1 Input Parameters

Runoff Volume

- The Curve Number method shall be used to determine the runoff volume.
- Curve Numbers are based on the type of land use. Typical values are given in Table 5-2.

Unit Hydrograph

- The SCS Unit Hydrograph Method shall be used. The time of concentration shall be determined using the method described in Technical Release No. 55 published by the U.S. Department of Agriculture, Soil Conservation Service.

Storage Routing

- Use the stage-discharge-volume relationship for the structure.

Computation Interval

- 5 minutes

Watershed Delineation

- Watersheds shall be subdivided into areas with homogenous land use. The subwatersheds shall have an average size of 10-25 acres, and a maximum size of 50 acres.

TABLE 5.2 - CURVE NUMBERS

Land Use	Percent Impervious	Hydrologic Soil Group			
		A	B	C	D
Urban Areas					
Parking Lots, Roofs, Driveways, and Streets	100	98	98	98	98
Commercial Development	85	89	92	94	95
Industrial Development	72	81	88	91	93
Residential Development:					
1/8 acre lots or less	65	77	85	90	92
1/4 acre lots	38	61	75	83	87
1/3 acre lots	30	57	72	81	86
1/2 acre lots	25	54	70	80	85
1 acre lots	20	51	68	79	84
Pervious Areas					
Lawns, Parks, Golf Courses, Cemeteries, etc.	-	39	61	74	80
Pasture for Grazing (not mowed)	-	39	61	74	80
Meadows (mowed for hay)	-	30	58	71	78
Brushy Areas	-	30	48	65	73
Woods	-	30	55	70	77

1. For urban areas that have a different percent impervious than those shown above, calculate a composite Curve Number using a Curve Number of 98 for impervious areas and the associated Curve Number for the pervious area from the table above.
2. For areas where there is no detailed SCS Soil Survey, assume the subwatershed is 50% Group B soils and 50% Group C soils.

5.5 RATIONAL METHOD

The following equation may be used to calculate peak flows for drainage areas less than or equal to 25 acres, and it shall be used to calculate peak flows for drainage areas less than or equal to 10 acres.

$$Q = CIA$$

where:

Q = peak flow in cubic feet per second

C = 0.95 for impervious areas

0.20 for pervious areas

A = drainage area

I = rainfall intensity

The rainfall intensity shall be determined based on Table 5-3:

TABLE 5.3 - TIME OF CONCENTRATION VERSUS RAINFALL INTENSITY

Time of Concentration (minutes)	Intensity (inches/hour)		
	1-year	10-year	100-year
10	3.2	5.5	8.1
15	2.8	4.7	7.0
30	1.9	3.2	4.8
60	1.2	2.1	3.0

The time of concentration shall be determined using the method described in Technical Release No. 55 published by the U.S. Department of Agriculture, Soil Conservation Service. The minimum time of concentration shall be 10 minutes.

APPENDIX 5A
DESIGN STORM DISTRIBUTIONS

1-HOUR RAINFALL DISTRIBUTIONS

Minutes	Cumulative Rainfall (Inches)		
	1-year	10-year	100-year
0	0.00	0.00	0.00
3	0.19	0.33	0.48
6	0.40	0.68	1.00
9	0.52	0.88	1.30
12	0.63	1.07	1.58
15	0.72	1.23	1.82
18	0.79	1.35	2.00
21	0.85	1.46	2.15
24	0.90	1.54	2.27
27	0.95	1.62	2.39
30	0.98	1.68	2.48
33	1.01	1.72	2.55
36	1.03	1.76	2.61
39	1.05	1.80	2.67
42	1.08	1.85	2.73
45	1.11	1.89	2.79
48	1.13	1.93	2.85
51	1.15	1.97	2.91
54	1.16	1.99	2.94
57	1.18	2.01	2.97
60	1.20	2.05	3.03

100-YEAR 6-HOUR RAINFALL DISTRIBUTION

Minutes	Cumulative Rainfall (Inches)
0	0.00
20	0.17
40	0.43
60	0.64
80	0.90
100	1.25
120	1.72
140	2.33
160	2.94
180	3.38
200	3.70
220	3.96
240	4.15
260	4.31
280	4.45
300	4.56
320	4.66
340	4.73
360	4.83

CHAPTER 6

INLETS / STORMWATER PIPES / MANHOLES

CHAPTER 6
INLETS / STORMWATER PIPES / MANHOLES

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6.1 DESIGN CRITERIA

6.1.1 General

The primary objective of street drainage design is to limit the amount of water flowing along the gutters or ponding at the low points to quantities that will not interfere with the passage of traffic for the design frequency. This is accomplished by placing inlets at such points and at such intervals to intercept flows and control spread.

6.1.2 Curb Inlets

Curb inlets shall be used for street drainage except where curb cuts are used per Chapter 10 and shall be designed as follows:

- Space inlets on grade to limit the spread of water as follows, using an intensity of 4 inches per hour:
 - local streets – $\frac{3}{4}$ of the driving lane
 - collector streets – $\frac{1}{2}$ of the driving lane
 - arterial streets – 4 feet in the driving lane
- At low points (sags), limit the depth of water to the top of the curb using an intensity of 4 inches per hour, and to the back of the sidewalk using an intensity of 8.1 inches per hour (100-year storm with a 10 minute time of concentration).
- Space inlets to prevent concentrated water from flowing across the road.
- Place inlets on the upstream side of intersection radii.
- Design the inlet assuming flow only through the curb opening, if a grate is present.
- Provide an overflow channel assuming that inlets in low points are 50% obstructed. The channel shall be designed to carry the portion of the 100-year storm that does not enter the inlets.

6.1.3 Surface Inlets

Surface inlets in grassed areas, parking lots, and roadside channels shall be designed as follows:

- Inlets in grass areas shall be constructed in a sump condition so that the top elevation of the berm around the inlet is at least 1 foot above the 100-year storm elevation.
- Limit the depth of water for the 100-year storm to at least 2 feet below the elevation of the lowest opening of adjacent structures.
- Provide a clear path for water to flow overland to a channel or the street assuming that inlets in low points are obstructed.
- For roadside channels, limit the depth of water to the edge of pavement or sidewalk, whichever applies, for the 100-year storm.

Surface inlets shall not be used within a roadway for street drainage.

6.1.4 Pipes

Stormwater pipes shall be designed as follows:

- Size the pipes to flow under gravity (not under pressure) for the 10-year storm.
- Size the pipes so that inlets and manholes do not overflow for the 100-year storm.
- Use a minimum pipe size of 15 inches.
- Use open channels for flows greater than 100 cfs for the 100-year storm.
- Provide a minimum velocity of 3 feet per second at full flow.
- Provide a minimum cover of 18 inches.
- Construct pipes of reinforced concrete.

Outfalls shall be extended to the rear property line in residential developments where possible.

Streams that are part of the waters of Danville shall not be routed to flow through pipes.

Pipes shall not be used to channel flows from areas upstream of a development unless the 100-year peak flow is less than 100 cfs.

6.1.5 Manholes

- Place manholes at the following locations:
 - Where 2 pipes intersect
 - At changes in pipe size
 - Where the slope changes
 - Where horizontal alignment changes
- Space manholes no more than 300 feet apart for pipes with a diameter of 36 inches or less.
- Space manholes no more than 400 feet apart for pipes with a diameter of 48 inches or larger.
- Match the crown line of the upstream pipe to the crown line of the downstream pipe.

6.1.6 Passthrough Drainage

Runoff from off-site areas shall be evaluated based on future land use as shown in the Comprehensive Plan. Pass through systems shall be designed for the 100-year storm. The upstream area shall be assumed to have detention unless it is exempted as described in Chapter 1.

6.2 INLET DESIGN PROCEDURES

6.2.1 Curb Inlets on Grade

The following programs are acceptable for computing the spread of water and the interception efficiency of curb inlets on a grade.

Other similar programs may be acceptable for use subject to approval by the City of Danville.

CURBIN – Kentucky Transportation Cabinet
QuickHEC12 – Haestad Methods

6.2.2 Curb Inlets in Low Points

Use the weir flow equation for depths less than or equal to the curb opening.

$$Q = C_w L d^{1.5}$$

where:

Q = flow in cfs

$C_w = 2.3$

L = curb opening length (ft)

d = depth of water at curb measured from the normal cross slope gutter flow line (ft)

Use the orifice equation for depths greater than the curb opening.

$$Q = C_o A [2g(d_i - h/2)]^{0.5}$$

where:

Q = flow (cfs)

$C_o = 0.67$

h = height of curb opening (ft)

A = clear area of opening (ft²)

d_i = depth at lip of curb opening (ft)

g = 32.2 (ft/sec)

6.2.3 Surface Inlets

Use the weir flow and orifice flow equation to compute flow through the grate:

For $d \leq 0.4'$, use the weir flow equation:

$$Q = C P d^{1.5}$$

where:

Q = flow in cfs

C = 3.0

d = depth of water in feet

P = perimeter of the grate in feet

For $d \geq 1.0'$, use the orifice flow equation:

$$Q = CA \sqrt{2gd}$$

where:

C = 0.67

A = clear opening area of the grate (ft²)

g = 32.2 ft/sec

d = depth of water in feet

For $0.4' < d < 1.0'$, compute the flow using both the weir flow and orifice flow equations. Use the smallest flow for a given depth.

6.3 CONSTRUCTION SPECIFICATIONS

All storm drainage structures, including stormwater pipe, curb box inlets, surface inlets, culvert pipe, and manholes, shall be installed in accordance with the Kentucky Department of Highways Standard Drawings, latest edition.

CHAPTER 7
CULVERTS AND BRIDGES

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CULVERTS AND BRIDGES**

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7.1 INTRODUCTION

As used in this manual, bridges are defined as structures 20' wide or greater (support to support) that transport vehicles over streams or constructed channels. Culverts are structures narrower than 20' wide that transport vehicles over streams or constructed channels.

7.2 CULVERT DESIGN CRITERIA

7.2.1 General

Culverts shall be located and designed to present a minimum hazard to traffic and people.

7.2.2 Alignment and Slope

The culvert shall be designed to approximate the existing alignment and slope of the stream.

A culvert shall not be placed within 50 feet of a bend in a stream or channel greater than 20 degrees.

7.2.3 Allowable Headwater

The culvert shall be designed so that:

- HW/D (headwater/barrel height) is no greater than 1.2 for the 100-year storm for drainage areas less than or equal to one square mile,
- HW/D is no greater than 1.0 for the 100-year storm for drainage areas greater than one square mile.
- The headwater is at least 12 inches below the edge of pavement for the 100-year storm, and
- The headwater is at least 24 inches below the lowest opening of upstream structures for the 100-year storm.

7.2.4 Culvert Size and Shape

A minimum culvert diameter of 15 inches shall be used to avoid maintenance problems and clogging.

7.2.5 Culvert Skew

A culvert shall be designed with a maximum skew of 45 degrees as measured from a line perpendicular to the roadway centerline.

7.2.6 End Treatments

All culverts shall be designed with inlet and outlet headwalls. The parapet wall shall be parallel to the road.

7.2.7 Outlet Protection

The outlet of culverts shall be protected with gabion mattresses or impact stilling basins in accordance with Chapter 11.

7.3 CULVERT DESIGN PROCEDURES

7.3.1 Approved Methods

Culverts shall be designed in accordance with methods described in “Hydraulic Design of Highway Culverts” (Hydraulic Design Series (HDS) No. 5) of the Federal Highway Administration (FHWA). HDS No. 5 is based on the concept of analyzing a culvert for both inlet and outlet control and designing for the control that produces the minimum performance. Design computations may be performed using the following computer programs based upon HDS No. 5. Other programs may be accepted for use subject to approval by the City of Danville.

CulvertMaster – Haestad Methods
HYDRAIN – GKY and Associates
HYPACK – Kentucky Transportation Cabinet

7.3.2 Inlet Control

Inlet control occurs when the culvert barrel is capable of conveying more flow than the inlet will accept. For inlet control, the control section is at the upstream end of the barrel (the inlet). The flow passes through critical depth near the inlet and becomes shallow, high velocity (supercritical) flow in the culvert barrel. Depending on the tailwater, a hydraulic jump may occur downstream of the inlet.

Factors that affect the flowrate for a given headwater depth during inlet control are inlet area, inlet edge configuration and inlet shape. The following definitions are important for inlet control:

- The control section is the location where there is a unique relationship between the flow rate and the upstream water surface elevation.
- Headwater depth is measured from the inlet invert of the inlet control section to the surface of the upstream pool.
- Inlet area is the cross-sectional area of the face of the culvert. Generally, the inlet face area is the same as the barrel area.
- Inlet edge configuration describes the entrance type. Some typical inlet edge configurations are thin edge projecting, mitered, square edges in a headwall, and beveled edge.
- Inlet shape is usually the same as the shape of the culvert barrel. Typical shapes are rectangular, circular, elliptical, and arch.

7.3.3 Outlet Control

Outlet control occurs when the culvert barrel is not capable of conveying as much flow as the inlet opening will accept, and the downstream end of the culvert controls the flow. Outlet control has depth and velocity that are subcritical. The tailwater depth is either assumed to be

critical depth near the culvert outlet or the downstream channel depth, whichever is higher. In addition to the inlet control factors, the following factors also affect outlet control flow:

Barrel Roughness

Barrel roughness is a function of the material used to fabricate the barrel. The roughness is represented by a hydraulic resistance coefficient such as the Manning n value.

Barrel Area and Shape

Barrel area is measured perpendicular to the flow. Barrel shape impacts the friction loss through the barrel.

Barrel Length

Barrel length is the total culvert length from the entrance to the exit of the culvert. Because the design height of the barrel and the slope influence the actual length, an approximation of barrel length is usually necessary to begin the design process.

Barrel Slope

Barrel slope is the actual slope of the culvert barrel, and is often the same as the natural stream slope. However, when the culvert inlet or outlet is raised or lowered, the barrel slope is different from the stream slope.

Tailwater Elevation

Tailwater is based on the downstream water surface elevation. Backwater calculations from a downstream control, a normal depth approximation, or field observations are used to define the tailwater elevation.

7.4 BRIDGE DESIGN CRITERIA

7.4.1 General

Bridges shall be designed to:

- pass the 100-year flow with one foot of freeboard below the bottom of the bridge structure,
- not damage the road or increase damages to adjacent property because of high velocities,
- maintain existing flow distribution in the floodplain to the extent practicable,
- minimize flow disruption and potential scour from pier spacing, pier orientation, and abutment,
- avoid failure by scour,
- pass anticipated debris,
- provide measures to counteract the sometimes unstable or unpredictable nature of alluvial streambeds or demonstrate that the risk of damage is low,
- produce minimal disruption of ecosystems and values unique to the floodplain and stream, and
- accommodate pedestrian access.

7.4.2 Backwater Increases

Bridges shall be designed so that flooding to upstream properties is not increased over existing levels. Verify this by conducting a flow profile analysis for the waterway, using the 100-yr storm flow, for conditions prior to and following construction of the bridge. Limit the allowable increase in backwater at the bridge to 1 foot during passage of the 100-yr flow.

7.5 BRIDGE DESIGN PROCEDURES

Use HEC-RAS to evaluate the effects of the bridge.

7.6 CONSTRUCTION SPECIFICATIONS

7.6.1 Circular Culvert Pipe

Circular culvert pipe shall be reinforced concrete pipe and shall be installed in accordance with the Kentucky Department of Highway Standard Drawings, latest edition.

7.6.2 Box Culverts

Box culverts shall be constructed in accordance with the Kentucky Department of Highway Standard Drawings, latest edition.

CHAPTER 8
CONSTRUCTED CHANNELS

CHAPTER 8

CONSTRUCTED CHANNELS

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FIGURES

FIGURE 8-1 – TRICKLE CHANNELS

8.1 INTRODUCTION

Constructed channels include permanent constructed channels and temporary diversions. Temporary diversions shall be designed in accordance with requirements of Chapter 11. This chapter describes permanent constructed channels and a special subset of those called paved ditches.

8.2 PERMANENT CONSTRUCTED CHANNELS

Constructed channels include roadside channels and stormwater drainage channels with regular geometric cross-sections and lining of natural or synthetic materials to protect against erosion

Safety of the general public shall be an important consideration in the selection of cross-sectional geometry of constructed channels.

The design of channels shall consider the frequency and typeS of maintenance expected and make allowance for access of maintenance equipment.

8.2.1 Design Criteria

Constructed channels shall be designed such that channel side slopes do not exceed the angle of repose of the soil and/or lining and are 3:1 or flatter for vegetation.

Constructed channels in residential areas that receive runoff from a pipe or culvert shall be constructed with a paved trickle channel. The trickle channel shall be designed to carry 50% of the 1-year storm. A detail is shown in Figure 8-1.

Channel freeboard shall be one foot or two velocity heads ($\text{velocity head} = V^2/2g$), whichever is larger.

Channels with bottom widths greater than 10 feet shall have a minimum bottom cross slope of 12 to 1.

Maximum design depth shall be based on the 100-year storm.

8.2.2 Channel Lining

Use channel linings to stabilize the slopes and bottoms of constructed channels. Evaluate vegetative lining first. If a vegetated channel is not stable, the other alternatives shall be considered in the order shown below:

- vegetative with a turf reinforced mat (TRM)
- other hard armor such as gabion mattress, dry stone masonry, tri-loc, etc.
- concrete

Where there is a base flow and the channel does not have a natural rock bottom, the bottom of the channel shall have a non-vegetative lining.

8.2.3 Manning's Equation

Use the Manning Equation to design open channels.

$$Q = [(1.49/n)AR^{2/3} S^{1/2}]$$

Where:

Q = discharge, cfs

n = Manning's roughness coefficient

A = cross-sectional area of flow, ft²

R = hydraulic radius = A/P, ft

P = wetted perimeter, ft

S = channel slope, ft/ft

Select Manning's n from Tables 8-1 and 8-2.

8.2.4 Tractive Force

After sizing the channel and determining the normal flow depth corresponding to the design storm, check the suitability of the channel lining using the tractive force method. The maximum tractive force at normal flow depth, τ_d , is calculated as:

$$\tau_d \text{ (lbs/ft}^2\text{)} = 62.4yS$$

Where:

y = normal depth (ft)

S = channel slope.

The critical tractive force, τ_c , for many linings can be found in Table 8-3. If $\tau_d < \tau_c$, the lining is acceptable. Otherwise, change the design to reduce τ_d . Options for redesign include selecting a more resistant lining or decreasing the flow velocity by decreasing the channel bed slope or side slopes or increasing the width.

For linings not listed in Table 8-3, use the manufacturer's literature to determine the critical tractive force and submit documentation with the design. For mats, nets, or TRMs use the critical tractive force in the unvegetated condition.

8.2.5 Construction Specifications

All ditches or other depressions to be crossed shall be filled before construction begins or as part of construction, and the earth fill used to fill the depressions shall be compacted using the treads of the construction equipment. All old terraces, fencerows, or other obstructions that will interfere with the successful operation of the channel shall be removed.

The earth materials used to construct the earth fill portions of the channel shall be obtained from the excavated portion of the channel or other approved source.

The earth fill materials used to construct the channel shall be compacted by running the construction equipment over the fill in such a manner that the entire surface of the fill will be traversed by not less than one tread track of the equipment.

The completed channel shall conform to the cross section and grade shown on the design.

TABLE 8.1 - MANNING'S n FOR CONSTRUCTED CHANNELS

Lining Type	Manning's n
Concrete	0.013
Grouted Stone	0.030
Stone Masonry	0.032
Bare Soil	0.020
Rock Cut	0.035
Jute Net	0.022
Straw with Net	0.033
Curled Wood Mat	0.035
6-inch D₅₀ Riprap	0.050
12-inch D₅₀ Riprap	0.060
Grass	0.045

TABLE 8.2 - MANNING'S n FOR STREAMS AND FLOODPLAINS

	Manning's n
Streams	0.045
Floodplains	
Pasture, no brush	0.035
Brush	0.10
Trees	0.120

TABLE 8.3 - SUMMARY OF CRITICAL TRACTIVE FORCES FOR VARIOUS PROTECTION MEASURES

Protective Cover	τ_c (lbs/ft ²)
Grass or Grass-legume Mixture Good Stand	1.0
Jute Net	0.45
Straw with Net	1.45
Curled Wood Mat	1.55
Turf Reinforcement Matting (TRM)	
Polyjute with grass	1.5
Landstrand with grass	2.0
Tensor Mat TM-3000 without grass	6.0
Landlok TRM 1060 without grass	6.0
Contech TRM C60 without grass	6.0
Enkamat 7010 with grass	6.0
Landlok TRM 450 with or without grass	7.0
Contech TRM C50 with or without grass	7.0
Tensor Mat TM-3000 with grass	8.0
Enkamat 7020 with grass	8.0
Enkamat 7220 with grass	8.0
Landlok TRM 1060 with grass	8.0
Contech TRM C60 with grass	8.0
Pyramat without grass	8.0
Pyramat with grass	10.0
Riprap	2.50
D ₅₀ = 6 inches	5.00
D ₅₀ = 12 inches	
6 inch Gabions	35
4 inch Geoweb	10
Dycel without Grass	>7.0
Petraflex without Grass	>32
Armorflex without Grass	12-20
Armorflex Class 30 with longitudinal and lateral cables, no grass	>34
Dycell 100, longitudinal cables, cells filled with mortar	<12
Concrete blocks, granular filter underlayer	>20

8.2.6 Maintenance

Channels shall be inspected regularly to check for points of scour or bank failure; rubbish or channel obstruction; rodent holes; breaching; and excessive wear from pedestrian or construction traffic.

Channels shall be repaired at the time damage is detected. Sediment deposits shall be removed from adjoining vegetative filter strips when they are visible.

Channels shall be reseeded and fertilized as needed to establish vegetative cover.

8.3 PAVED CHANNELS

A paved channel shall be used when the flow velocity at design capacity (using vegetative lining) exceeds 12 fps.

8.3.1 Design Criteria

Paved channels shall be designed to carry the peak flow from the 100-year storm.

The outlets of paved channels shall be protected from erosion using gabion mattresses. The length of the gabion mattress shall be one foot for each one fps of velocity. The width of the gabion mattress shall extend one foot in elevation beyond the top elevation of the paved channel.

Cutoff walls shall be constructed at the beginning and end of each channel except where the channel connects with a catch basin or inlet.

8.3.2 Material Specifications

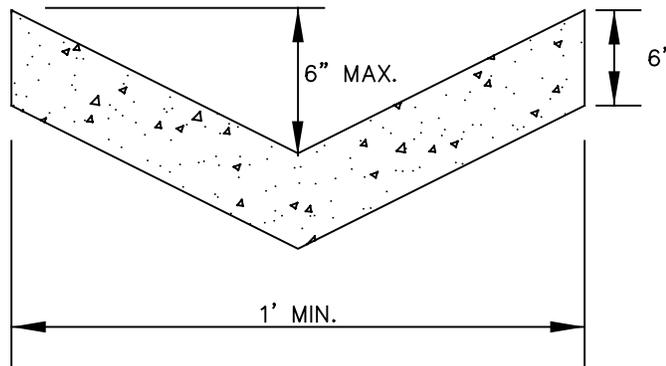
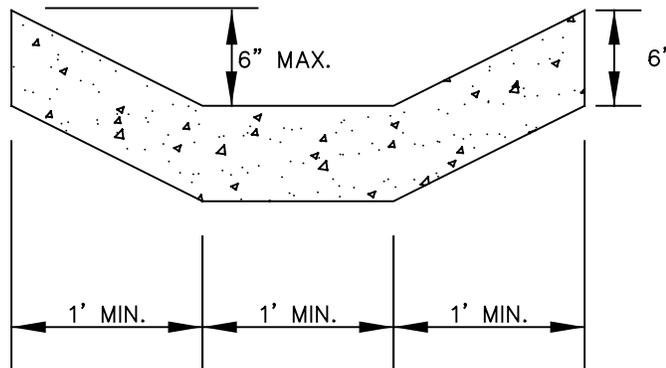
Paved channels shall be constructed of concrete or interlocking concrete blocks.

8.3.3 Construction Specifications

The subgrade shall be constructed to the required elevations. All soft sections and unsuitable material shall be removed and replaced with suitable material. The subgrade shall be thoroughly compacted and shaped to a smooth, uniform surface. The subgrade shall be moist at the time concrete is placed when pouring concrete.

8.3.4 Maintenance

Before permanent stabilization of the slope, the structure shall be inspected after each rainfall. Any discovered damages to the channel or slope shall be repaired immediately. After slope stabilization, the channel and slope shall be inspected after rainfalls of 1 inch or greater or at least once per month.



TRICKLE CHANNELS

Note: The trickle channel shall be designed to carry 50% of the 1-year storm.

CHAPTER 9

STREAMBANK STABILIZATION AND RESTORATION

CHAPTER 9
STREAMBANK STABILIZATION AND RESTORATION

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9.1 INTRODUCTION

The waters of Danville are defined in Chapter 1. In general, they are:

- natural channels with their size and shape determined by natural forces,
- compound in cross section with a main channel for conveying low flows and a floodplain to transport flood flows, and
- shaped geomorphologically by the long-term history of sediment load and water discharge that they experience.

As indicated in Chapter 1, construction is only allowed in the floodplain and stream for certain activities. The practices listed in this chapter are for two purposes:

- protecting the streambank and floodplain from the construction that must occur, and
- providing an incentive to Developers for enhancing the stream and floodplain as part of the overall development. The incentive is in the form of a water quality volume credit.

9.2 VEGETATIVE STREAMBANK STABILIZATION

9.2.1 General

In some instances, certain allowable construction will result in excavation into the streambank. In those instances when the natural streambank must be disturbed, first consider vegetative streambank stabilization methods. If those methods are not applicable, use bioengineering techniques. Use structural streambank stabilization techniques as a last resort for permanent stabilization except in instances where a small gabion mattress is needed for outlet protection. In no case will gabions be allowed within a stream unless bioengineering methods are not suitable.

In other instances, increased runoff may cause the deterioration of a natural streambank. Similarly, a natural streambank that has been previously degraded due to past impacts may be further deteriorated by new development. In these cases, the streambank shall be restored to prevent further degradation using the methods described above.

9.2.2 Design Criteria

Planned protective measures shall be compatible with the adjacent land use and the improvements that will be carried out by others.

The selection of native vegetation to be established shall be based on the soil type and chemistry, land use, flooding periods, and stream velocity. A list of recommended species is provided in Table 9-1. Soil tests shall be conducted prior to land disturbance activity to determine if soil amendments and/or fertilizers are needed. If soil tests determine that fertilization is required, then application of recommended fertilizer shall not occur until after the vegetation has germinated and established growth.

Where necessary, erosion control matting or turf reinforcement matting shall be used along with the vegetative measures to stabilize the streambanks.

The need for special matting and intensive maintenance to successfully revegetate the streambank does not render vegetation infeasible. Special efforts are a part of the cost of developing an area that must discharge directly into a natural channel.

If traditional vegetative measures described in this section are not effective, bioengineering techniques shall be considered. Again, the cost of these efforts is not sufficient reason to judge them infeasible.

Special attention shall be given to maintaining or improving habitat for fish and wildlife.

On smaller streams where a good seedbed can be prepared, herbaceous plants may be used alone to stabilize the banks. On larger streams and more difficult sites, woody shrubs and trees with herbaceous plants shall be considered.

All requirements of state law and permit requirements of local, state, and federal agencies must be met.

9.2.3 Material Specifications

Vegetation shall consist of herbaceous ground cover and/or woody shrubs and trees. Installation methods shall include direct seeding and/or the planting of bare root seedlings, hardwood cuttings, and/or containerized plants. The use of Kentucky 31 or tall fescue is not allowed in stabilizing streambanks or riparian areas.

Direct seeding shall only be conducted during March 1 to May 15 or August 1 to September 30. Bare root and cutting installation shall only be conducted during December 1 to March 15. Installation of containerized plants shall only be conducted during March 1 to May 15 and September 1 to December 31.

The surface shall be mulched with clean wheat straw at a rate of 2 tons per acre. Mulch shall be secured as described in the section on mulch. If mulch tackifiers or related methods are not applicable then erosion control matting or turf reinforcement matting (TRMs) shall be used. Many types of erosion control mats and TRMs are available from various manufacturers. Some are considered temporary because they are manufactured of organic materials that will degrade over time. Due to wildlife endangerment problems associated with the UV resistant mesh in some erosion control matting, only materials with fully degradable mesh shall be used as mulch blankets. Non-degradable products (TRMs) are appropriate where turf reinforcement is necessary. The material shall be chosen based on calculated tractive forces in accordance with manufacturers' recommendations (See Chapter 8).

If nursery stock (bare root or containerized) is used, the species listed in Table 9-1 shall be used for establishing vegetation. Direct seeding of the herbaceous species listed below shall also be used. Selected species shall be based upon the native vegetation of the watershed where work is proposed and shall reflect the original stream bank species. Exotic or pest species shall not be used.

See Section 9.4.2 for recommended species and installation requirements of hardwood cuttings.

9.2.4 Construction Specifications

Prior to seeding or planting, only fallen trees, stumps, and other debris that may force stream flow into the streambank shall be removed. Leaving other debris may be desirable for aquatic habitat.

Where feasible, the streambank side slope shall be cut back to 3:1 slope or flatter and overhanging bank edges shall be removed.

Direct seeding areas shall be roughened with a rake or similar tool. Seeding rates shall be a minimum of 10 lbs. per 1000 square feet of disturbed area.

Erosion control matting or turf reinforcement matting shall be installed in accordance with manufacturers' requirements. Erosion control fabrics, blankets, mats and nettings shall be anchored at the top of streambank by excavating a shallow trench. The material shall be laid in the bottom of trench with overlap. The trench shall be backfilled with excavated soil. The overlap material shall be laid on top of backfill and secured with dead stout stakes, metal staples, or according to manufacturer's specifications (see Figure 9-1).

Bare root or containerized stock shall be planted at the same depth as planted in the nursery. The stock shall be planted in a hole large enough to accommodate the root system when well spread. Shrubs and vines shall be planted at a minimum density of 1,700 stems per acre (one stem per 25 square feet @ 5 feet on center). Trees shall be planted at a minimum density of 450 stems per acre (one stem every 100 square feet @ 10 feet on center).

9.2.5 Maintenance

Banks shall be checked after every high water event. Gaps in vegetative cover shall be repaired at once with new plants and mulched if necessary. Exotic and pest species that become established on the bank shall be removed.

Following is a list of exotic and pest species:

- Japanese honeysuckle (vine) – *Lonicera japonica*
- Bush honeysuckle – *Lonicera mackii*
- Chinese privet – *Ligustrum chinensis*
- Tree-of-heaven – *Ailanthus altissima*
- Mimosa – *Albizia julibrissin*
- Winged wahoo – *Euonymus alata*
- Chinaberry – *Melia azedarach*
- Buckthorn – *Rhamnus cathartica*

TABLE 9.1 – NATIVE PLANT SPECIES SUITABLE FOR STREAMBANKS AND RIPARIAN BUFFERS IN THE BLUEGRASS REGION

Herbaceous Ground Covers:		
Common Name	Scientific Name	Shade/Sun
River Oats	<i>Chasmanthium latifolia</i>	shade
Indian Grass	<i>Sorghastum nutans</i>	sun
Switch Grass	<i>Panicum virgatum</i>	sun
Redtop	<i>Agrostis alba</i>	sun
Deertongue	<i>Panicum clandestinum</i>	shade
Broomsedge	<i>Andropogon virginicus</i>	sun
Big Blue Stem	<i>Andropogon gerardii</i>	sun
Frank's Sedge	<i>Carex frankii</i>	sun
Gray's Sedge	<i>Carex grayii</i>	shade
Soft Rush	<i>Juncus effuses</i>	sun
Flat Sedge	<i>Cyperus strigosus</i>	sun
Lady Fern	<i>Athyrium felix-femina</i>	shade
Sensitive Fern	<i>Onoclea sensibilis</i>	shade or sun
Cinnamon Fern	<i>Osmunda cinnamomea</i>	shade
Common Boneset	<i>Eupatorium perfoliatum</i>	sun
Golden Ragwort	<i>Senecio aureus</i>	shade or sun
Wrinkled Goldenrod	<i>Solidago rugosa</i>	sun
Tall Goldenrod	<i>Solidago gigantean</i>	sun
Beard Tongue	<i>Penstemon alluviorum</i>	sun
Monkey Flower	<i>Mimulus ringens</i>	shade or sun
Cardinal Flower	<i>Lobelia cardinalis</i>	shade or sun
Great Blue Lobelia	<i>Lobelia silphilitica</i>	shade

Vines and Shrubs:		
Common Name	Scientific Name	Shade/Sun
Cross Vine	<i>Bigononia capreolata</i>	shade
Trumpet Creeper	<i>Campsis radicans</i>	sun
Giant Cane	<i>Arundinaria gigantean</i>	shade or sun
Buttonbush	<i>Cephalanthus occidentalis</i>	sun
Sweetspire	<i>Itea virginica</i>	shade
Spicebush	<i>Lindera benzoin</i>	shade
Paw-paw	<i>Asimina triloba</i>	shade
Arrowwood	<i>Viburnum dentatum</i>	shade
Nannyberry	<i>Viburnum lentago</i>	sun
Swamp Haw	<i>Viburnum nudum</i>	shade
Ninebark	<i>Physocarpus opolifolius</i>	shade or sun
Hazelnut	<i>Corylus Americana</i>	shade or sun
Possum Haw	<i>Ilex decidua</i>	sun
Winterberry	<i>Ilex verticillata</i>	shade
Chokeberry	<i>Aronia arbutifolia</i>	sun
Elderberry	<i>Sambucus canadensis</i>	sun
Juneberry	<i>Amelanchier arborea</i>	shade
Flowering Dogwood	<i>Cornus florida</i>	shade
Silky Dogwood	<i>Cornus amomum and obliqua</i>	sun
Redosier Dogwood	<i>Cornus stolonifera</i>	shade

**TABLE 9.1 - NATIVE PLANT SPECIES SUITABLE FOR STREAMBANKS AND
RIPARIAN BUFFERS IN THE BLUEGRASS REGION
(continued)**

Vines and Shrubs (continued):		
Common Name	Scientific Name	Shade/Sun
Rough-leaf Dogwood	<i>Cornus drummondii</i>	Shade
Pagoda Dogwood	<i>Cornus alternifolia</i>	Shade
Sandbar Willow	<i>Salix interior</i>	Sun
Silky Willow	<i>Salix sericea</i>	Sun
Dwarf Willow	<i>Salix humilis var. macrophylla</i>	Sun
Pussy Willow	<i>Salix discolor</i>	Sun
Streamco Willow	<i>Salix purpurea</i>	Sun
Bankers Willow	<i>Salix x cotteti</i>	Sun
Heart-leaf Willow	<i>Salix rigida</i>	Sun

Trees:	
Common Name	Scientific Name
Black Willow	<i>Salix nigra</i>
Boxelder	<i>Acer negundo</i>
Red Maple	<i>Acer rubrum</i>
Silver Maple	<i>Acer saccharinum</i>
Green Ash	<i>Fraxinus pennsylvanica</i>
White Ash	<i>Fraxinus Americana</i>
Red Elm	<i>Ulmus rubra</i>
Persimmon	<i>Diospyros virginiana</i>
Black Gum	<i>Nyssa sylvatica</i>
Hackberry	<i>Celtis occidentalis</i>
Cottonwood	<i>Populus deltoids</i>
Sweet Gum	<i>Liquidambar styraciflua</i>
Tulip Polar	<i>Liriodendron tulipifera</i>
Sycamore	<i>Plantanus occidentalis</i>
American Beech	<i>Fagus grandiflora</i>
Ironwood	<i>Carpinus caroliniana</i>
Ohio Buckeye	<i>Aesculus glabra</i>
Shellbark Hickory	<i>Carya lacinosa</i>
Shagbark Hickory	<i>Carya ovata</i>
Black Walnut	<i>Juglans nigra</i>
Bur Oak	<i>Quercus macrocarpa</i>
Pin Oak	<i>Quercus palustris</i>
Swamp White Oak	<i>Quercus bicolor</i>
Swamp Chestnut Oak	<i>Quercus michauxii</i>

9.3 RIPARIAN BUFFER ZONES

9.3.1 General

Riparian buffer zones are areas of trees and/or shrubs located adjacent to and upgradient from perennial or intermittent streams, lakes, ponds, wetlands, and areas with groundwater recharge. They may be constructed by Developers to satisfy some or all of the required water quality volume (see Chapter 1).

The purpose of riparian buffer zones are:

- to reduce excess amounts of sediment, organic material, nutrients, pesticides, and other pollutants in surface runoff and reduce excess nutrients and other chemicals in shallow groundwater flow,
- create shade to moderate water temperatures to improve habitat for fish and other aquatic organisms,
- to provide a source of detritus and large woody debris for fish and other aquatic organisms, and
- to provide riparian habitat and corridors for wildlife.

9.3.2 Design Criteria

The buffer shall consist of a zone (identified as Zone 1) that begins at the top of bank, and extends a minimum distance of 15 feet, measured horizontally on a line perpendicular to the water course or water body and planted with tree species selected from Table 9-1.

An additional strip or area of land (Zone 2) will begin at the edge and up-gradient of Zone 1 and extend a minimum distance of 20 feet, measured horizontally on a line perpendicular to the water course or water body. Zone 2 shall be planted with shrubs and herbaceous ground cover species selected from Table 9-1. The combined width of Zones 1 and 2 shall be 100 feet or 30 percent of the geomorphic floodplain, whichever is less. A geomorphic floodplain is defined as the area adjacent to a river or stream that is built of alluvial sediments that are associated with the present depositional activity.

Figures 9-1 and 9-2 illustrate examples of Zone 1 and 2 widths for water courses and water bodies. Zone 2 may need to be adjusted to include important resource features such as wetlands, steep slopes, or critical habitats.

Buffers shall be established or maintained from top of bank to waterline along water courses and bodies where practical. The buffer canopy shall be established to achieve at least 50 percent crown cover with average canopy heights equal to or greater than the width of the water course, or 30 feet for water bodies. (See Figure 9-3).

Dominant vegetation shall consist of existing or planted trees and shrubs suited to the site and the intended purpose. Selection of locally native species shall be a priority when feasible. Plantings shall consist of six or more species in an attempt to achieve greater diversity. Individual plants

selected shall be suited to the seasonal variation of soil moisture status of individual planting sites. Plant types and species shall be selected based on their compatibility in growth rates and shade tolerance.

Necessary site preparation and planting for establishing new buffers shall be done at a time and manner to insure survival and growth of selected species. Refer to Section 9.2 for care, handling, and planting requirements for woody planting stock.

Only viable, high quality, and adapted planting stock shall be used. The method of planting for new buffers shall include hand or machine planting techniques, suited to achieving proper depths and placement for intended purpose and function of the buffer.

Site preparation shall be sufficient for establishment and growth of selected species and be done in a manner that does not compromise the intended purpose. Refer to Section 9.2 for woody planting stock quality requirements and planting rate densities. Supplemental moisture shall be applied if and when necessary to assure early survival and establishment of selected species.

Livestock shall be controlled or excluded as necessary to achieve and maintain the intended purpose. Water course crossings and livestock watering shall be located and sized to minimize impact to buffer vegetation and function.

9.3.3 Maintenance

The riparian forest buffer shall be inspected periodically, protected, and restored as needed, to maintain the intended purpose and protect it from adverse impacts such as excessive vehicular and pedestrian traffic, pest infestations, pesticide use on adjacent lands, livestock damage, and fire.

Replacement of dead trees or shrubs and control of undesirable vegetative competition shall be continued until the buffer has reached, or will progress to, a fully functional condition.

To maintain buffer function, control of erosion and sedimentation shall be continued in the upgradient area immediately adjacent to Zone 2 until the upgradient area is permanently stabilized.

For purposes of moderating water temperatures and providing detritus and large woody debris, riparian forest buffer management must maintain a minimum of 50 percent canopy cover. To achieve benefits provided by large woody debris, natural mortality of trees and shrubs may need to be supplemented by periodically falling and placing selected stems or large limbs within water courses and water bodies to imitate natural conditions.

9.4 BIOENGINEERING TECHNIQUES

Bioengineering techniques for streambank protection utilize native vegetation in combination with inert structural materials to stabilize soils that are subject to erosion and shallow mass movement.

9.4.1 Design Criteria

Establishing permanent vegetation is the preferred method for stabilizing soils along streambanks. With proper installation and maintenance, the planting of rooted stock, cuttings and direct seeding of native vegetation, in combination with erosion control fabrics, will effectively stabilize soils on slopes of 3:1 or flatter along streams with low flows and no concentrated discharges over the face of the streambank.

On streambank slopes of 3:1 or steeper, the techniques described in the following sections (with exception of the Live Staking technique) shall be employed as needed. Each technique is discussed in order of increasing effectiveness of protection based upon the slope of the streambank. The combined use of two or more techniques to accomplish streambank stabilization and protection may be applicable for some sites.

When streambanks must be disturbed, slopes shall be regraded to match the adjoining upstream and downstream slopes, if they are stable. If the adjoining slopes are not stable, the disturbed portion shall be regraded to the least gradient possible.

Reinforcement shall be provided at the base or toe of the streambank below the mean low waterline prior to implementing bioengineering techniques. Several techniques discussed are applicable for base reinforcement. All work shall begin at the base of the streambank and continue up gradient.

For sites involving the discharge of concentrated flow through a streambank and directly into a stream, protection shall be provided for the streambank opposite of the concentrated discharge. Most of the techniques discussed below will be applicable for those sites and are duly noted.

9.4.2 Live Stake

Live stakes shall be used in limited situations for streambank slopes of 3:1 or flatter with low flows and no surficial overbank discharge. This technique consists of inserting (tamping) fresh hardwood cuttings into the streambank. This technique is more applicable as a preventive measure before severe erosion problems occur.

Live hardwood cuttings shall be collected and installed during the dormant season (November through March) from areas near the site, with permission from property owners. Drainage ditches, detention ponds, and construction sites can be good sources for materials. The following table provides recommended species for hardwood cuttings. Table 9-1 provides the recommended species for rooted seedlings.

TABLE 9.2 - NATIVE PLANT SPECIES SUITABLE FOR HARDWOOD CUTTING IN THE BLUEGRASS REGION

Common Name	Scientific Name
Primary Species:	
Black willow	<i>Salix nigra</i>
Sandbar willow	<i>Salix interior</i>
Heart-leaf willow	<i>Salix rigida</i>
Silky dogwood	<i>Cornus amomum</i>
Redosier dogwood	<i>Cornus sericea</i>
American elderberry	<i>Sambucus canadensis</i>
Secondary Species:	
Tall pussy willow	<i>Salix discolor</i>
Silky willow	<i>Salix sericea</i>
Dwarf willow	<i>Salix humilis var. macrophylla</i>
Alternate-leaf dogwood	<i>Cornus alternifolia</i>
Gray dogwood	<i>Cornus racemosa</i>
Rough-leaf dogwood	<i>Cornus drummondii</i>
Boxelder	<i>Acer negundo</i>
Nannyberry	<i>Viburnum lentago</i>
Swamp Haw	<i>Viburnum nudum</i>
Arrowwood	<i>Viburnum dentatum</i>

Other practices, in combination with live stakes, shall be used for streambanks that receive high flow fluctuations or consist of fill soils.

Stakes (cuttings) shall be 2 to 3 feet in length and 0.5 to 2 inches in diameter with all outer branches removed. Basal end (inserted into ground) shall be sawed clean at an angle. Blunt end (exposed end) shall be cut square. See Figure 9-4A for a live stake detail.

Stakes shall be installed within 24 hours of cutting. Temporary storage shall occur in a moist, cool location.

Stakes shall be installed at right angles to the slope with 20 percent (1/5) of the stake left exposed. Stakes shall be spaced at a minimum of 2 to 4 per square yard and in a random configuration.

Installation shall begin at the base of the streambank working up gradient. Dead blow hammers work the best for installing stakes in soft soils. In cases where stiff soils exist, then pre-drilled holes must be used to accommodate cutting installation. The ground at the base of each stake shall be tamped firm.

When erosion control fabrics are necessary, the live stakes shall be used to help secure the material to the face of the streambank.

9.4.3 Root Wad Revetment

Root wad revetment techniques can be used for opposite bank protection from concentrated flow discharge and as toe of slope reinforcement with a high flow fluctuation in the stream. This

technique is excellent for restoring and improving fish habitats and, when used in combination with proper vegetative methods, is highly effective for stabilizing streambanks.

Root wads are tree stumps with a minimum of 6 feet of bole (trunk) above the root flare. The root wads shall be built on top of footer logs and secured with a header log. Footer and header logs shall be secured to the root wad by iron rebar. The bole shall be inserted or placed in the bank at a 30 to 45 degree angle from the downstream line of streamflow, i.e. the root flare shall face upstream.

Placed stone shall be used to further secure the root wad system. Filter fabrics may be required in loamy silts or sandy soils.

Root wads shall be backfilled with soil and planted with live stakes. Streambank above root wad shall be covered with erosion control fabrics and planted. Figure 9-5 shows the typical construction detail for root wad revetment.

9.4.4 Coir Log Revetment

Coir (coconut fiber) log revetments can be used for slope stabilization at the toe of slopes of 2:1 or flatter and as protection for streambanks opposite concentrated discharge points. Coir log revetments shall be used in combination with coir mats or jute netting, planted vegetation and/or live staking. Figure 9-6 provides a detail of staked coir log revetment.

Coir logs shall be secured with dead stout stakes inserted downgradient and against logs. Live stakes should be inserted directly into logs. Coir twine should be wrapped around dead stout stakes (continued) and over logs to hold them securely to the bank face.

Dead stout stakes are 2.5 feet long and 2 inches thick by 4 inches wide (2x4) of untreated lumber that have been cut diagonally across the 4 inch width with a 0.25 inch tip. Figure 9-4B shows in detail how the stakes are cut.

9.4.5 Live Fascine

The live fascine technique is applicable on slopes of 2:1 or flatter and utilizes cylindrical bundles of freshly cut willow (*Salix spp.*), or dogwood (*Cornus spp.*) branches placed in trenches excavated along the contours of the streambank. Live fascines can also be used to reinforce the toe of streambank slopes.

Fascines shall not be used when surficial concentrated flows are discharged over the face of the streambank or where high flow fluctuations occur. When used in combination with coir mats or jute netting and planted vegetation, live fascines can be used on slopes of 2:1 or flatter.

Coir logs shall be used in place of live fascines when bundle materials are not available; however, the coir logs shall be planted with rooted willow, dogwood, or alder.

Live fascine bundles can be 5 to 30 feet in length by 7 to 10 inches in diameter and tied together with jute or bailing twine. The bundles are secured with both dead stout stakes and live stakes of fresh cut willow.

The cuttings are composed of branches 0.5 to 1 inch in diameter and must be arranged in the bundle with growing tips in the same direction and staggered to evenly distribute growth along the bundle. See Figure 9-7 for construction detail.

Small trenches (12 inch by 12 inch) shall be constructed starting at the base of the slope, parallel to the stream channel, and spanning the entire streambank. Parallel trenches shall be constructed along the face of the slope according to the following table:

TABLE 9.3 - LIVE FASCINE TRENCH DISTANCES

Bank Slope	Slope Distance Between Trenches	Maximum Slope Length
2:1 to 2.5:1	5 to 6 feet	20 feet
2.5:1 to 3:1	6 to 7 feet	30 feet
3:1 to 3.5:1	7 to 8 feet	40 feet
3.5:1 to 4:1	8 to 9 feet	50 feet

Source: Wright, 1995.

Live fascines shall be placed end to end inside the trenches starting at the base of the slope and working up gradient. Dead stout stakes shall be tamped into bundles every 3 feet along the length and at bundle connections. Trenches shall be backfilled with soil and tamped firm around the fascine.

Live stakes shall be tamped in down gradient and against the bundles at right angles to the slope. The live stake procedures in Section 9.4.1. shall be used.

9.4.6 Brush Mattress

Brush mattresses are applicable for 1:1 slopes or flatter along streams subject to high flow fluctuations. They can also be used for opposite streambank protection. This technique is limited to streambank faces of 10 feet or less. Brush mattresses require substantial amounts of materials, which including live fascines, live stakes, dead stout stakes, and cut branches.

The slope face shall be prepared by smoothly grading the surface and constructing a small trench (12 inch by 12 inch) at the base of the slope, parallel to the stream channel, and spanning the entire streambank.

Live fascines shall be installed in the trench as described in Section 9.4.4.

Dead stout stakes shall be installed 3 feet on center in rows parallel to the channel for the entire slope face. Six inches of stake shall be left exposed above the surface. [Figure 9-8](#) shows in detail the layout of the trench and stakes.

Pieces of willow and/or dogwood cuttings 8 – 10 feet long shall be placed along bank with basal ends towards the trench. Enough brush shall be used to create a 6-inch thick mattress.

The mattress shall be secured by wrapping wire or coir rope around dead stout stakes in a criss cross pattern between stakes. Work shall begin at bottom of the slope and proceed upgradient.

The stakes shall be tamped further into ground to secure the mattress to the bank face. Live stakes shall be inserted between dead stout stakes similar to Section 9.4.1.

Cover area lightly with soil and tamp. Do not bury branches.

9.4.7 Branch Packing

Branch packing consists of alternating layers of live willow and/or dogwood cuttings and compacted soil secured with wooden poles along a trench. Branch packing is applicable for slopes of 1:1 or flatter that receive surficial discharge over the face of the streambank and high flow fluctuations in the stream channel. This technique can also be used for opposite streambank protection and in areas where severe erosion has resulted in shallow mass movement of the streambank.

The trench dimensions for this technique are limited to 12 feet long by 5 feet high and 4 feet deep. Biodegradable filter fabrics shall be used to reinforce soil layers along streams with high flow fluctuations. Placed stone or log cribs shall be used for toe of slope reinforcement at mean low waterline. See Figure 9-9 for a detail on this technique.

Wooden poles (4 inches in diameter) shall be untreated and cut at lengths to accommodate the specific depth of the site plus 4 feet. Branch cuttings shall be cut to lengths to accommodate the depth of trench plus 3 feet.

The trench shall be excavated clean and the bottom of the site sloped towards the bank from the stream channel. A stone or log crib shall be placed at the outer edge of the excavated area into and below mean low waterline.

Dead stout stakes shall be inserted 4 feet deep into the bottom of the trench on 1.5-foot centers. The first layer of brush shall be placed in the bottom of the trench with basal ends towards the bank in a criss-cross pattern 6 inches thick. The first brush layer shall be backfilled with 12 inches of equal parts soil and large gravel. The soil/gravel layer shall be compacted.

This process shall be repeated until the trench is filled. The amount of rock mixed with the soil can be reduced with each successive layer. The compacted bank face should correspond to the adjoining streambank slopes.

9.4.8 Live Cribwall and Log Crib Revetment

Live cribwalls are rectangular frameworks of logs or timbers backfilled with soil, rock and live branch cuttings. They are applicable for a bank of any gradient that receives surficial discharge over the bank and high flow fluctuations and where space is limited to stabilize the streambank.

This technique is limited in overall height of 6 feet and shall not be used where the adjoining streambed is subject to severe degradation. [Figure 9-10](#) shows a detail for live cribwall.

Branch cuttings shall be 0.5 to 2 inches in diameter and 4 to 6 feet long. Logs or timbers shall be 4 to 6 feet long in varying lengths to accommodate site conditions. Timber shall be untreated. Stone shall be 2 to 4 inches in diameter.

The work area shall be over excavated 2 to 3 feet below the streambed or toe of bank and sloped back towards bank. Long log or timber shall be placed parallel to the channel and then short logs placed on top and perpendicular. Short logs shall extend to the back of the work area (bank). The logs shall be secured with rebar or spikes. This layer shall be backfilled, covered with 12 inches of rock, and compacted.

Build successive layers using rock as backfill until cribwall is above mean low waterline. Use soil backfill in layers above mean low waterline. Compact each soil layer.

The layer building process shall be repeated placing live brush cuttings on top of each compacted soil layer. The cuttings shall be placed with basal end towards the bank and the growth ends protruding out from the cribwall.

The slope of cribwall shall correspond to the adjoining streambank slope and the final layer shall reach to the top of the original streambank not to exceed 6 feet in overall height.

Log crib revetment techniques can be very effective for opposite bank protection or toe of bank reinforcement, especially where high concentrated discharges and high stream flow fluctuations occur. They are similar in construction to live cribwalls with the exception that they are lower in height and no vegetation is used. See [Figure 9-11](#) for a construction detail.

9.4.9 Joint Planting

Joint planting is applicable to sites where the use of gabion mattresses or rubble stone to stabilize a streambank has been determined to be the only practical method. This technique is accomplished by inserting live willow stakes between the placed stone. This technique is also applicable where stone is used for toe of bank reinforcement.

Willow tree species are the best for live cutting and shall be a minimum length of 3 to 3.5 feet and 1 to 2 inches in diameter. Planting time and storage specifications are similar to live staking.

The stakes shall be inserted in random configuration at a spacing of 3 to 6 stakes per square yard. At least two thirds of the stakes shall extend in to the soil below the stone layer.

9.4.10 Maintenance and Monitoring

Streambanks shall be checked after every high water event for six months after completion. Noticeable failures in bioengineering techniques shall be repaired as necessary. Vegetation growth shall be monitored for one year after completion to determine survival rates of planted vegetation. A minimum of 75 percent of designed density must be established by end of the first year after completion. Volunteer species will be considered towards the survival density. Areas of erosion or undermining of streambank adjoining the stabilized portion of the stream shall be noted and monitored to assess whether retrofitting or repairs will be needed.

Signs shall be posted indicating a natural area that should not be mowed.

9.5 STRUCTURAL STREAMBANK STABILIZATION

Structural stream-bank stabilization refers to the stabilization of banks of live streams with permanent structural measures. Generally, the materials and processes are proprietary and include things like interlocking concrete blocks, gabions, gabion mattresses, crib walls, synthetic cellular confinement grids, and dry stone masonry.

9.5.1 Design Criteria

Structural stream-bank stabilization shall be used only in cases where vegetative stabilization in conjunction with turf reinforcement matting and vegetative bioengineering will not be effective.

Structural stabilization measures shall be planned and designed by an engineer and shall be used, only as necessary, in conjunction with vegetative techniques.

Rip-rap shall not be an approved structural stream-bank stabilization technique.

The protective measures shall be compatible with improvements planned or being carried out by others. The bottom scour shall be controlled before any permanent type of bank protection can be considered feasible unless the protection can be safely and economically constructed to a depth well below the anticipated lowest depth of bottom scour.

Streambank protection shall start and end at a stabilized or controlled point on the stream.

Changes from a natural channel alignment shall not generally be made. Alignment changes in previously modified channels shall be made to take the channel to a more natural alignment and shall consider the effect upon land use, hydraulic characteristics, and the existing channel.

Special attention shall be given to maintaining and improving habitat for fish and wildlife.

Structural measures must be effective for the design flow and be capable of withstanding greater flows without serious damage.

All requirements of state law and permit requirements of local, state, and federal agencies must be met.

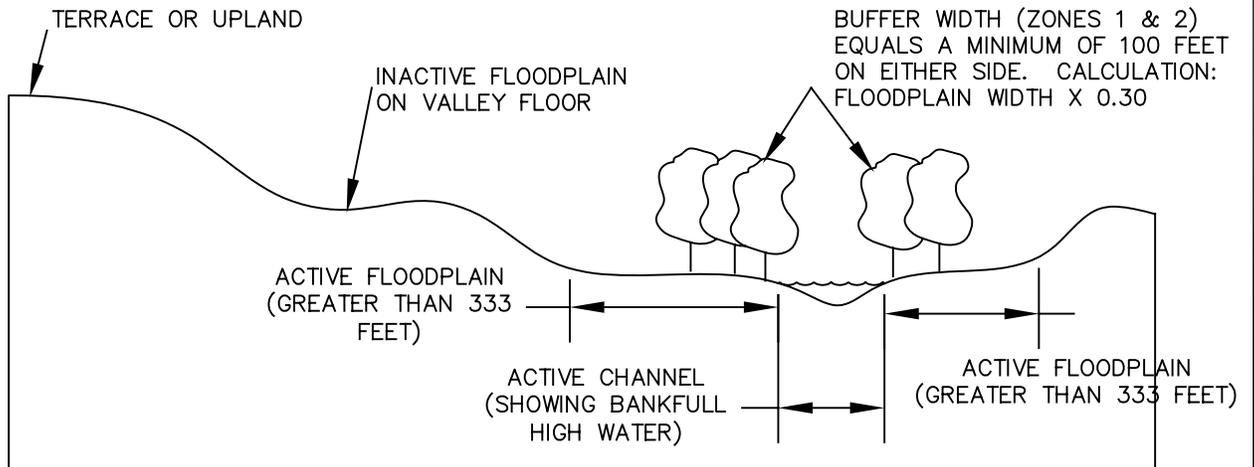
9.5.2 Specifications

All structural stream-bank protection measures shall be designed and installed in accordance with manufacturer's standards and specifications.

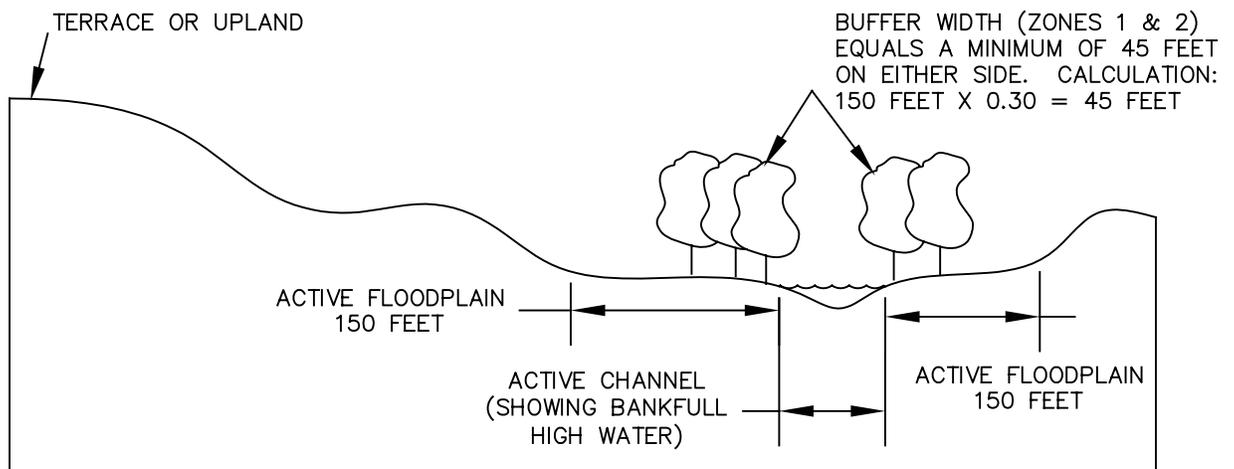
9.5.3 Maintenance

All structures shall be maintained in an "as built" condition. Inspection shall occur after each storm event for the first 6 months after construction and at least every 6 months thereafter.

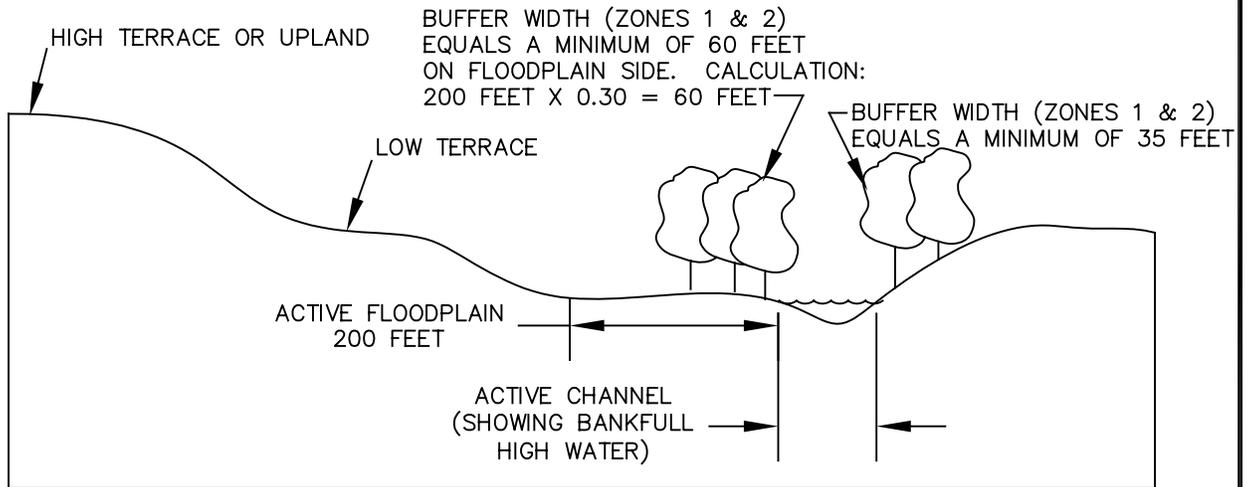
Structural damage caused by storm events shall be repaired as soon as possible to prevent further damage to the structure or erosion of the streambank.



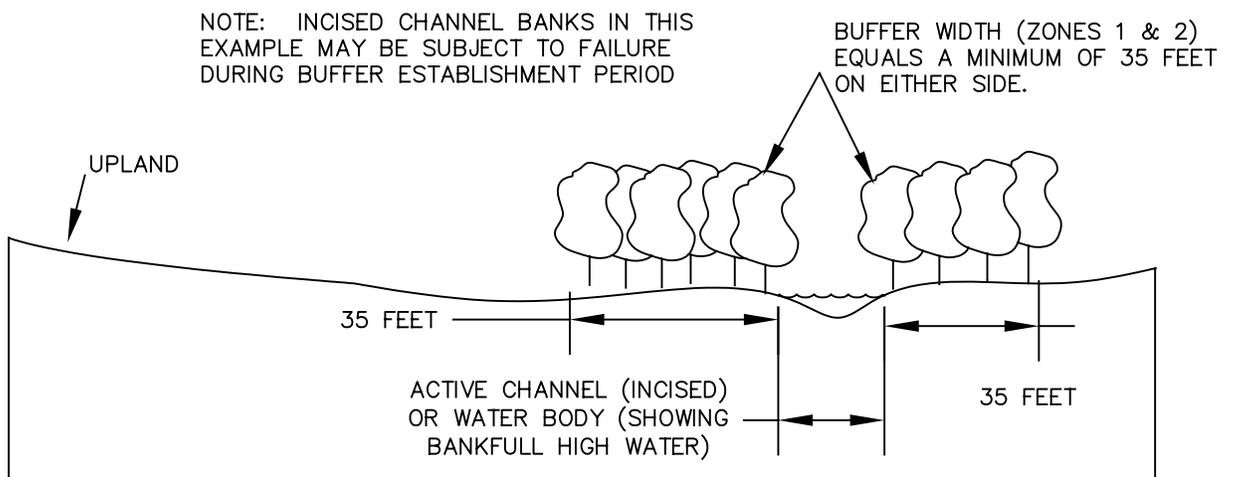
ACTIVE FLOODPLAINS GREATER THAN 333 FEET IN WIDTH



ACTIVE FLOODPLAINS LESS THAN 333 FEET IN WIDTH

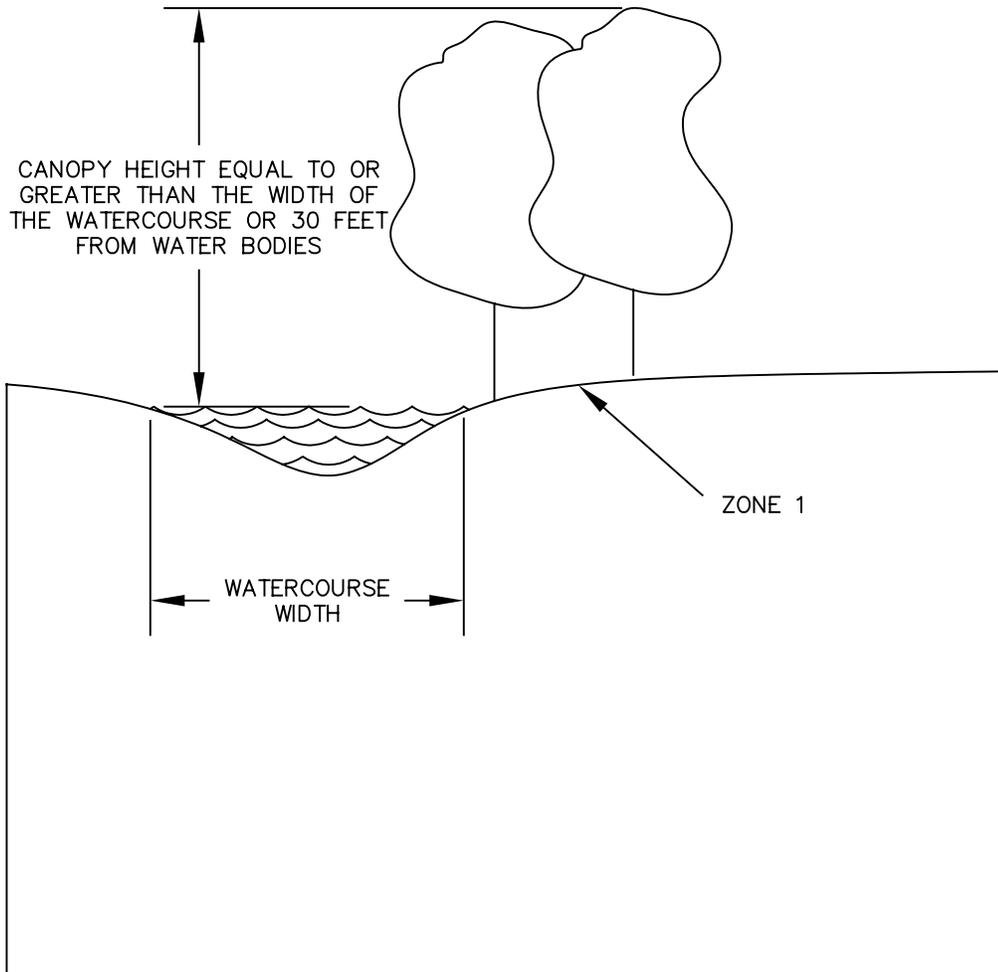


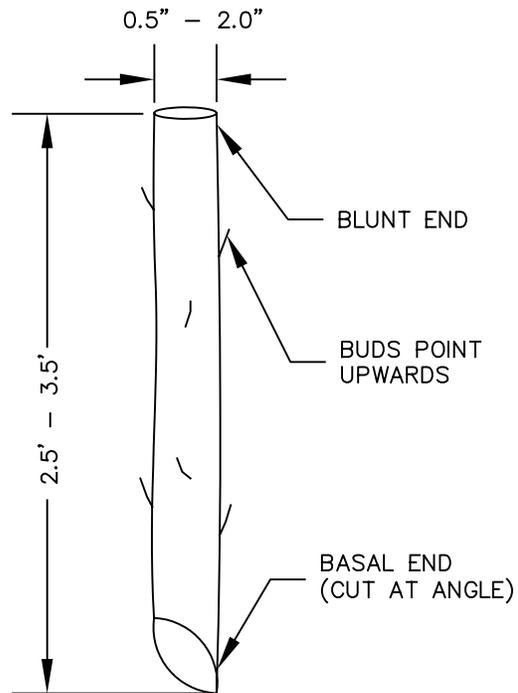
ACTIVE FLOODPLAIN ONLY ONE SIDE OF THE CHANNEL



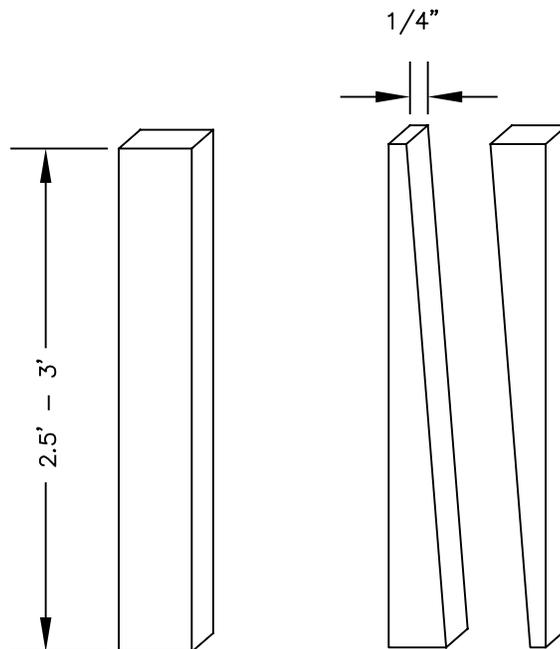
INCISED CHANNEL WITHOUT FLOODPLAINS AND ALL WATER BODIES

BUFFER WIDTH (ZONES 1 & 2)
EQUALS A MINIMUM OF 45 FEET



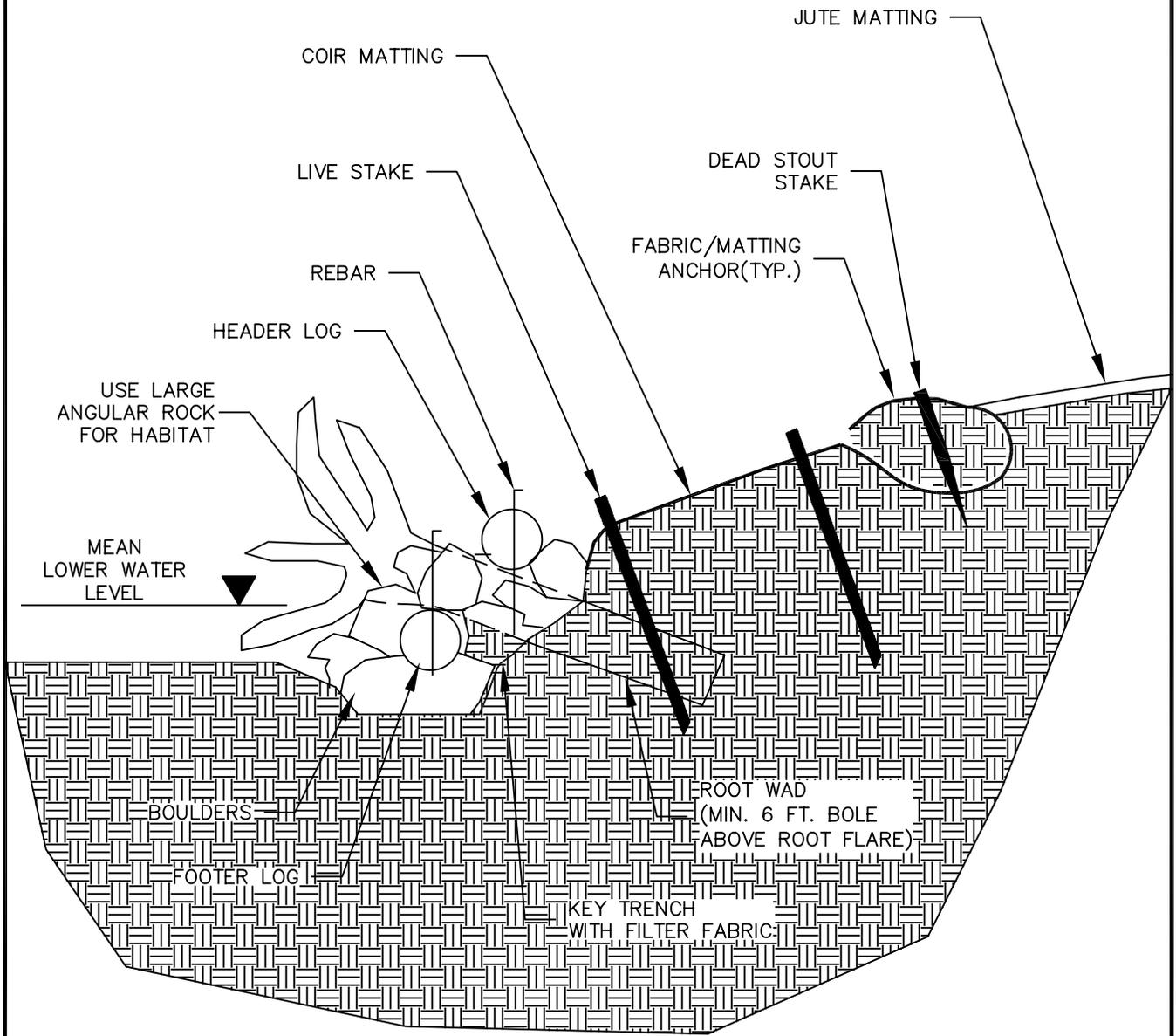


A. LIVE STAKE

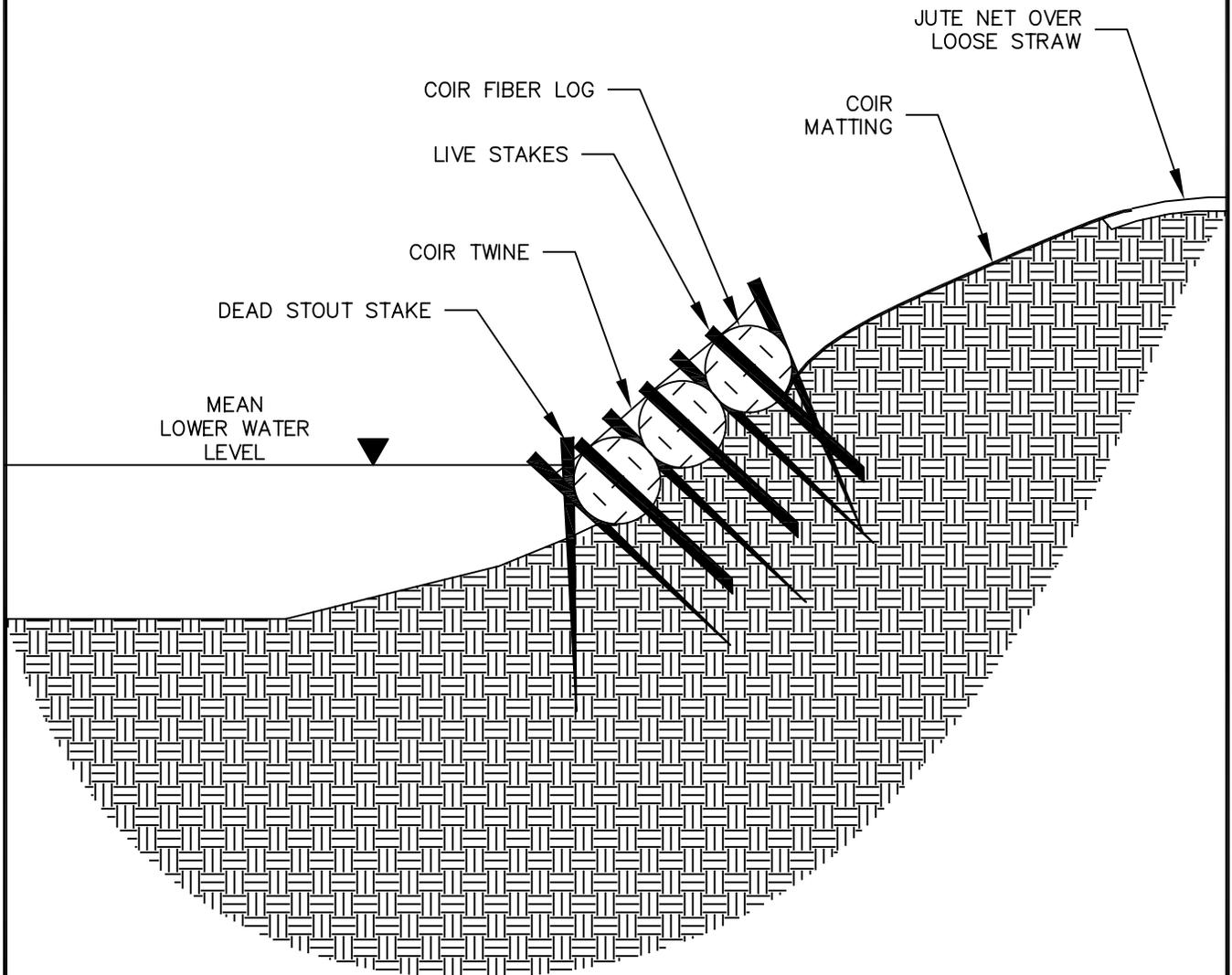


B. DEAD STOUT STAKE

SAW 2X4 TIMBER DIAGONALLY
TO PRODUCE 2 DEAD
STOUT STAKES

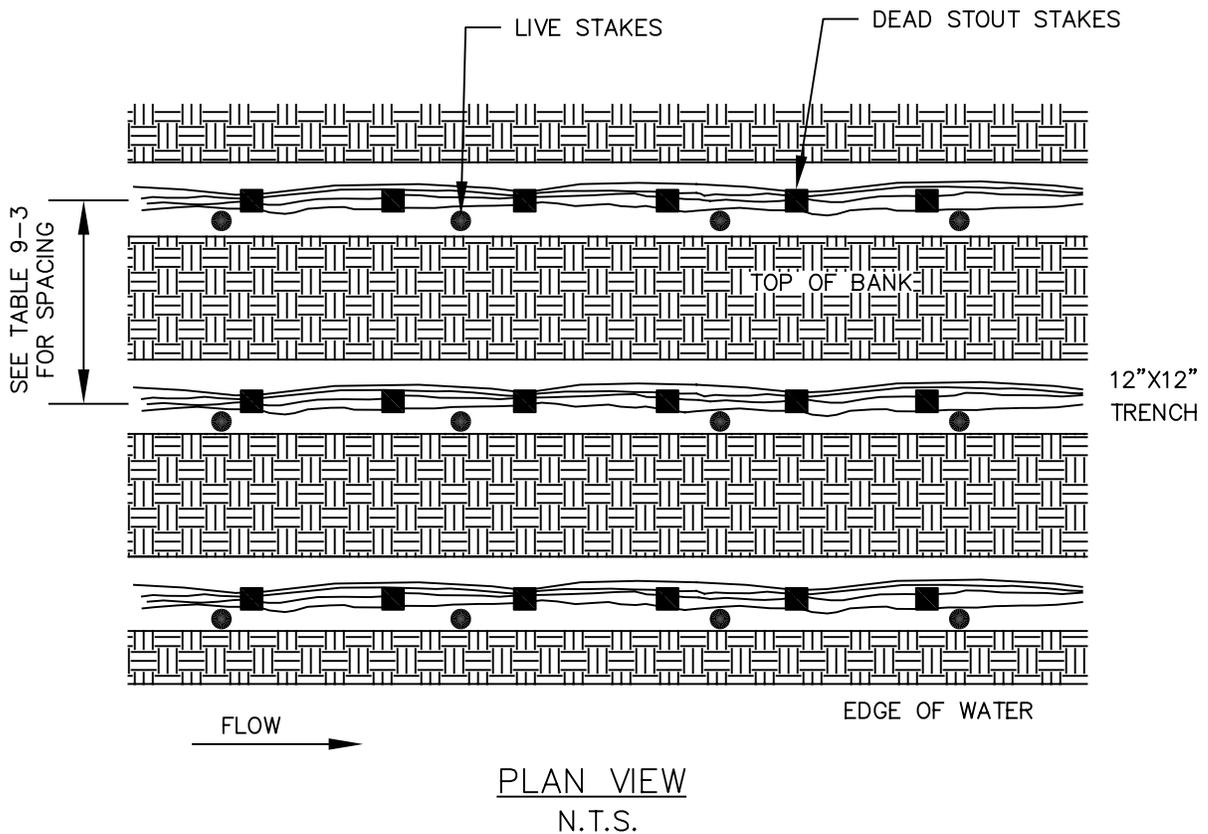
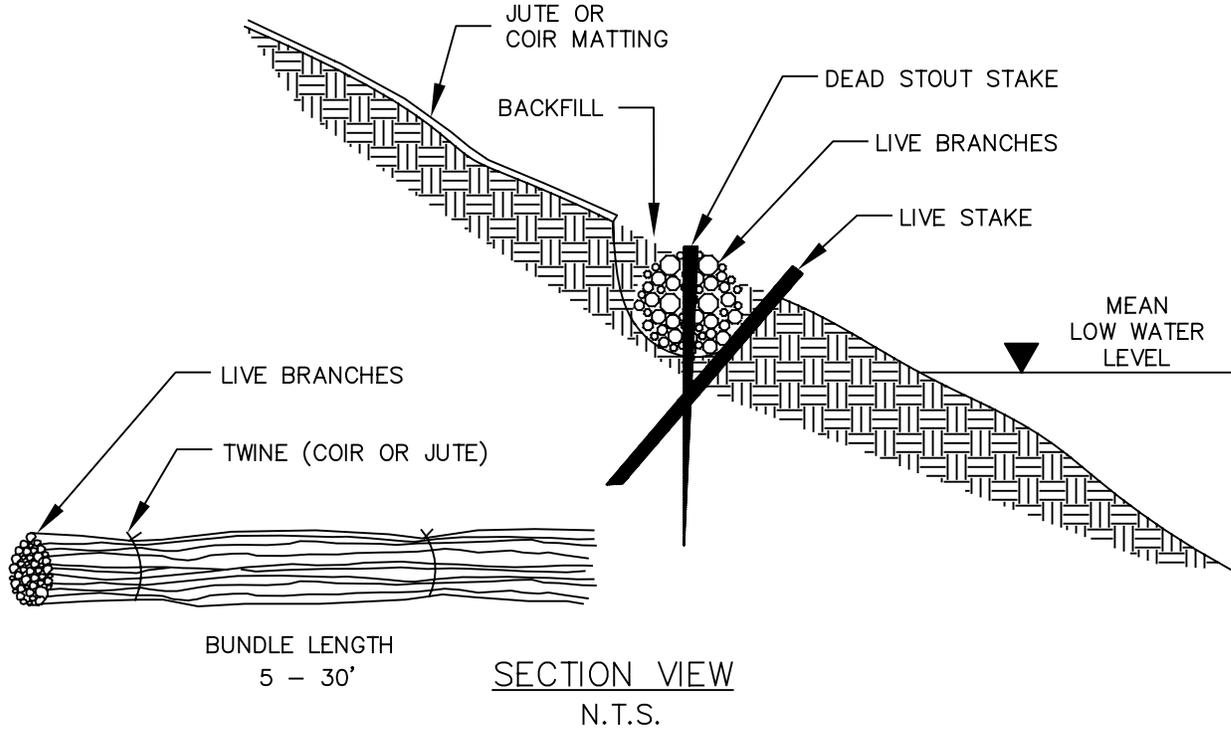


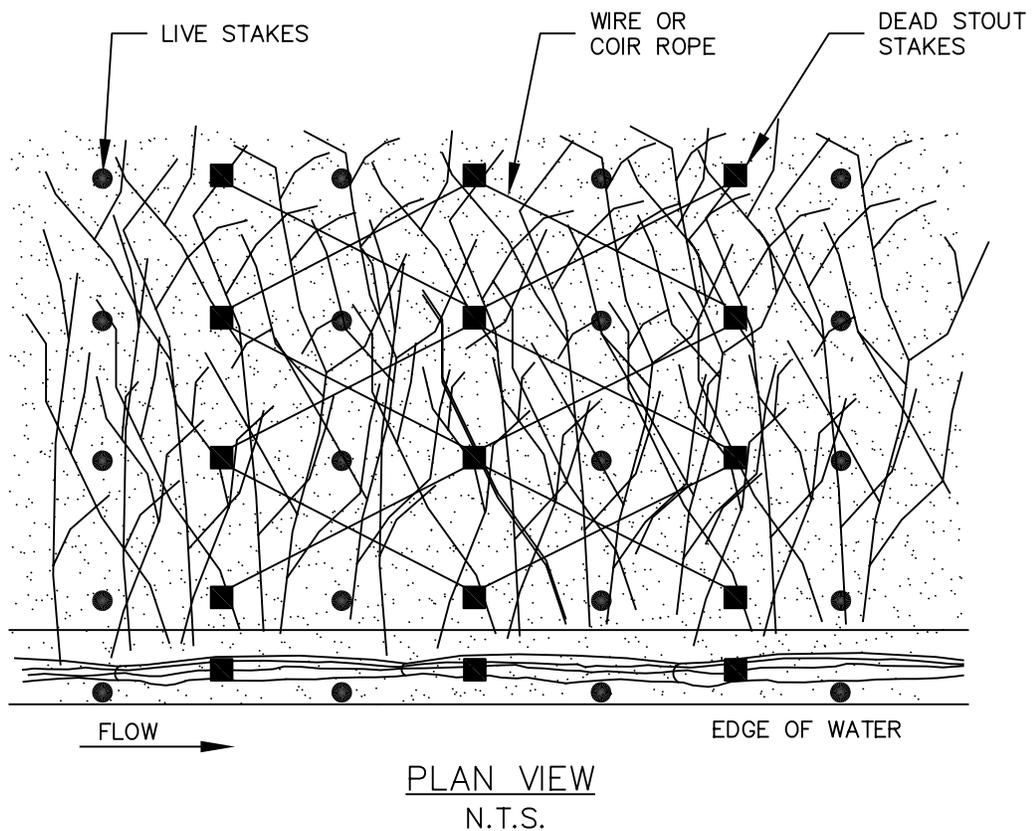
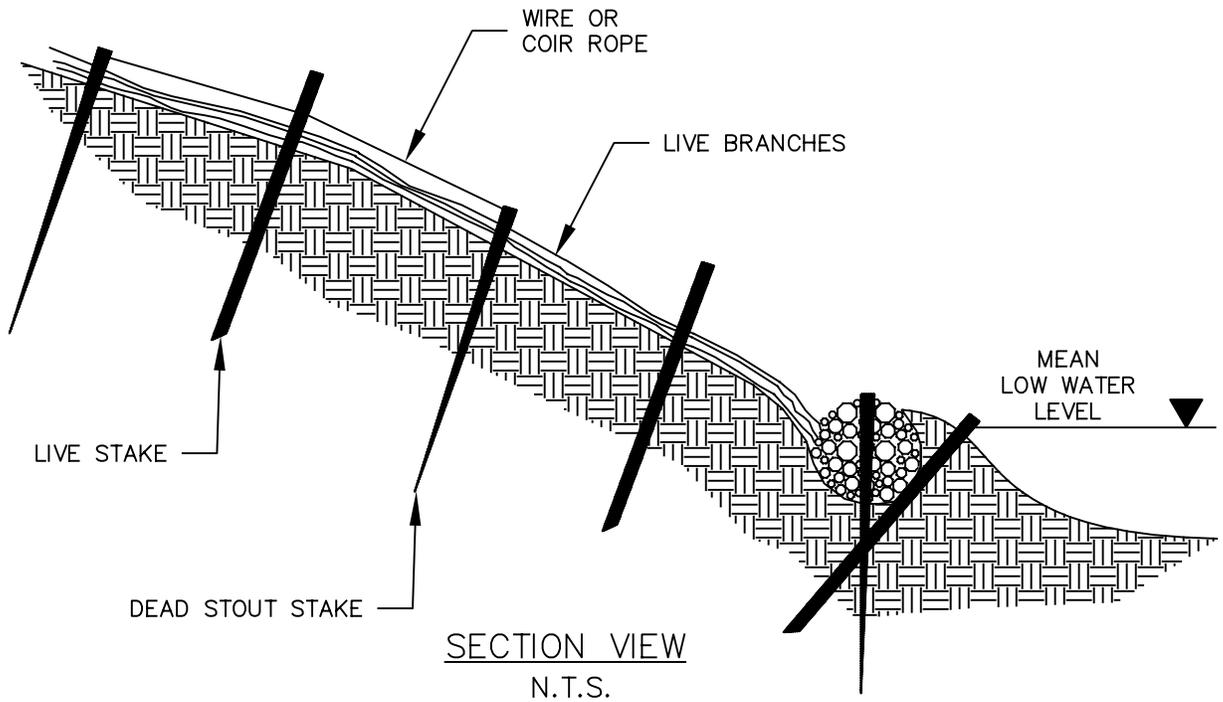
SECTION VIEW
N.T.S.

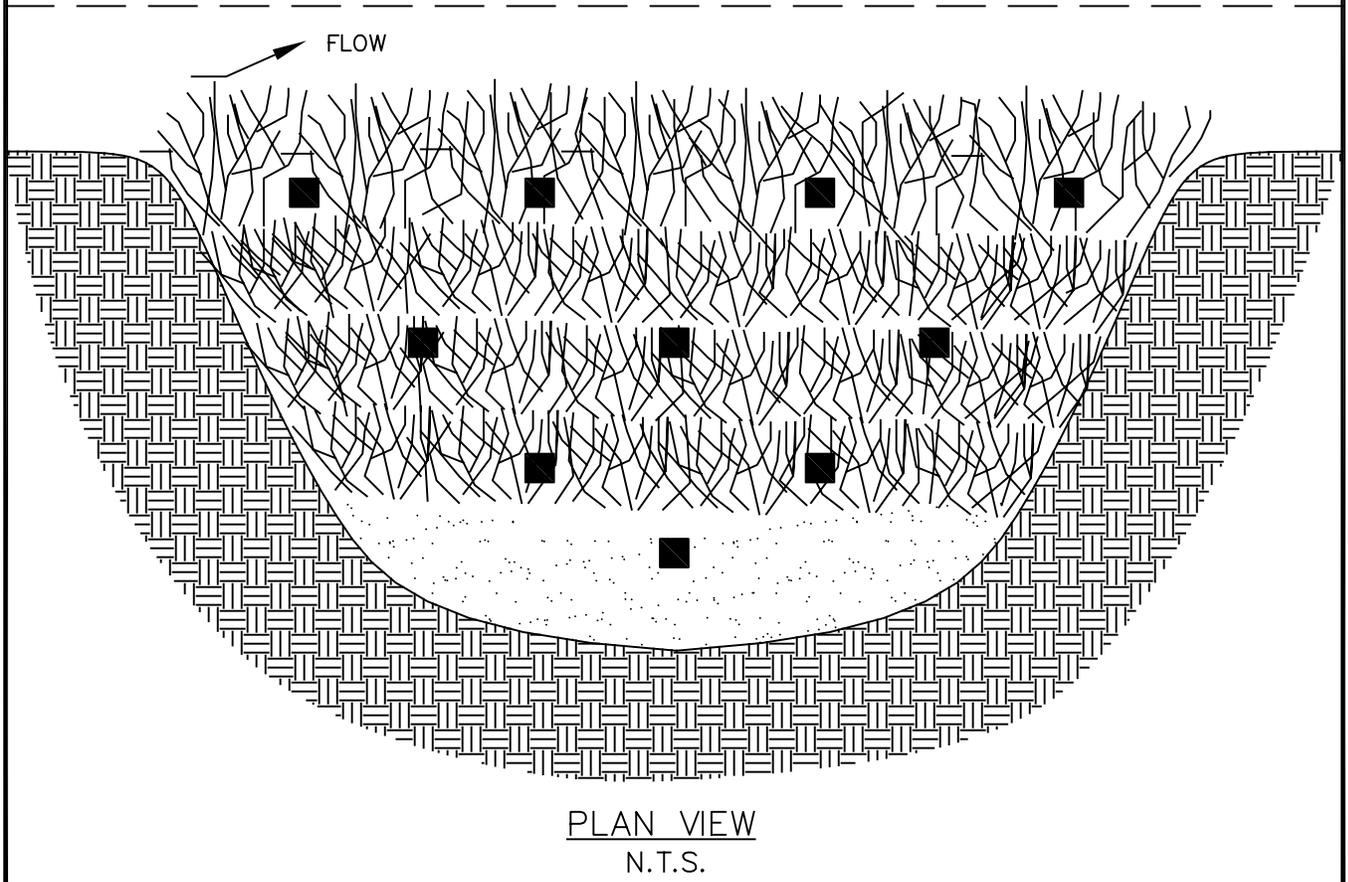
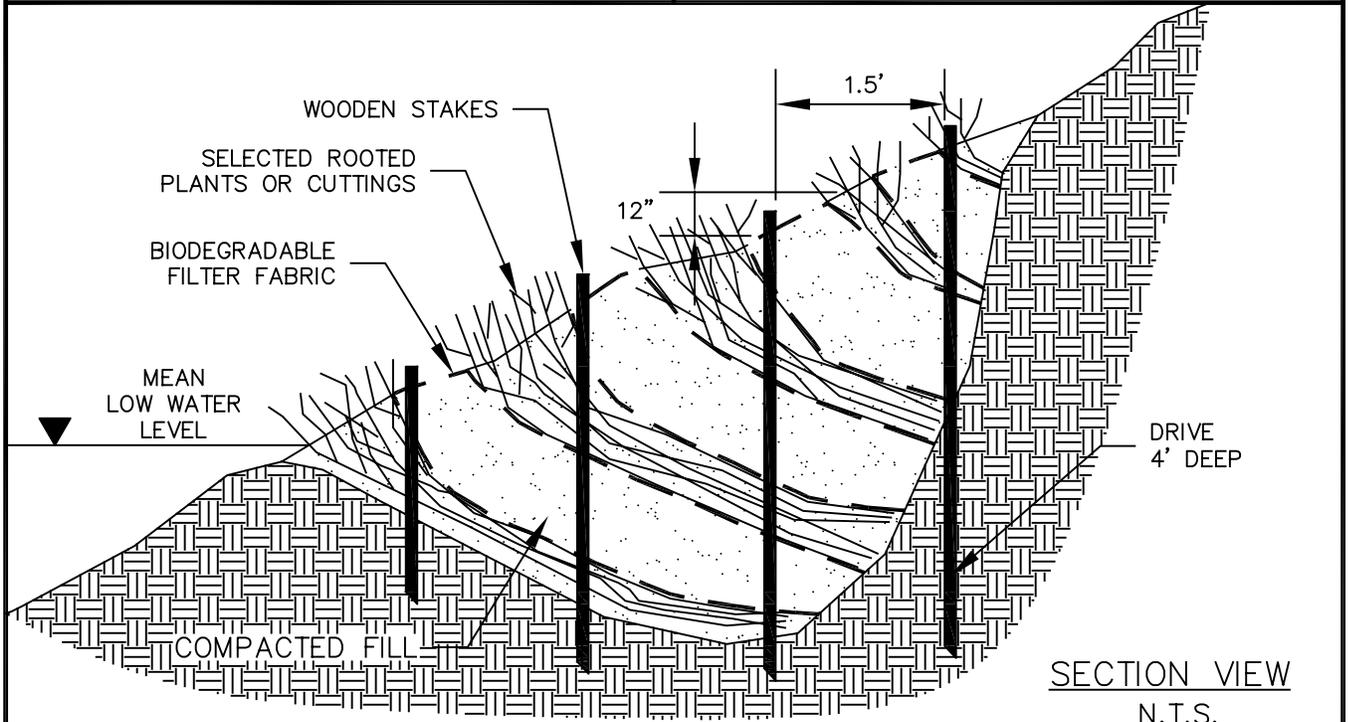


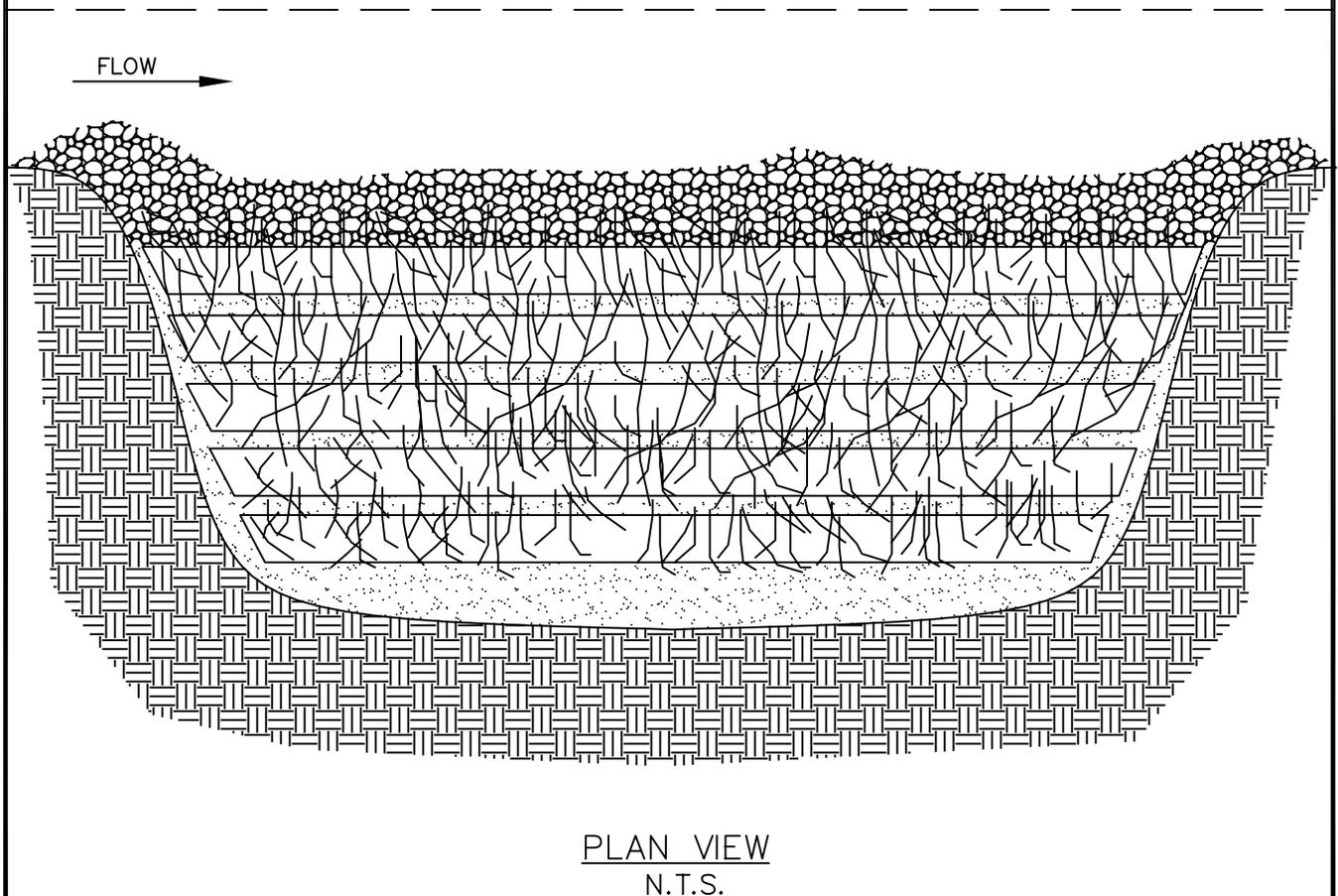
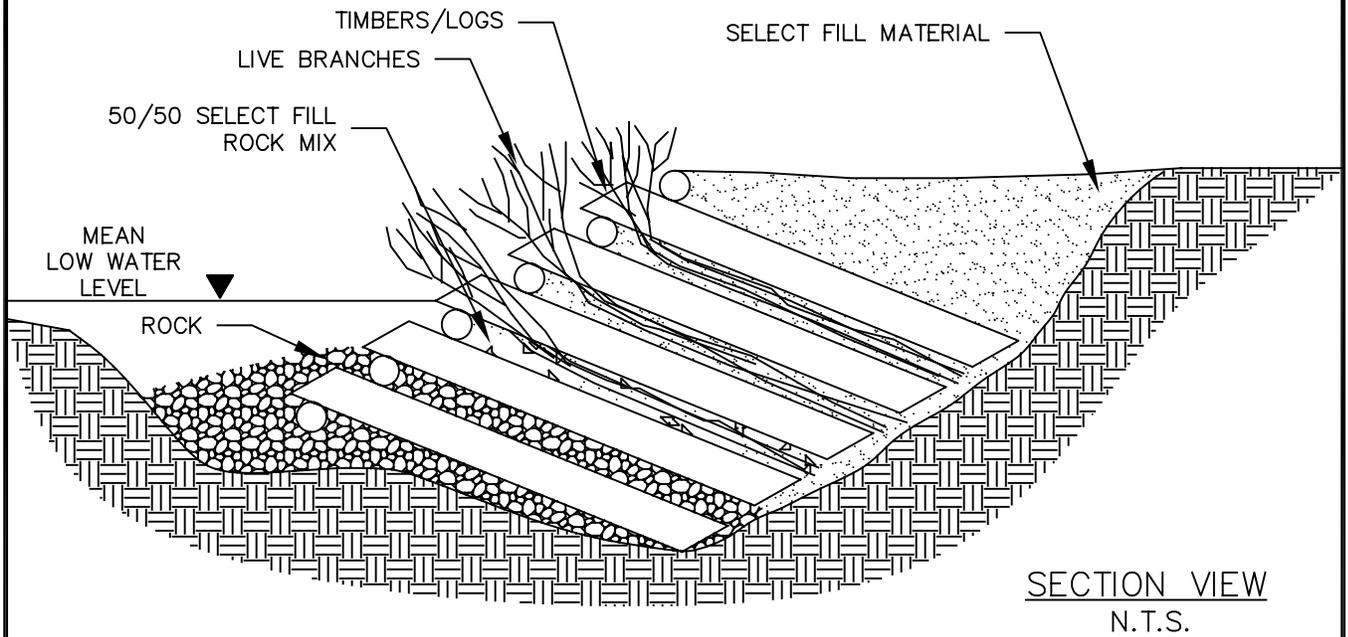
SECTION VIEW

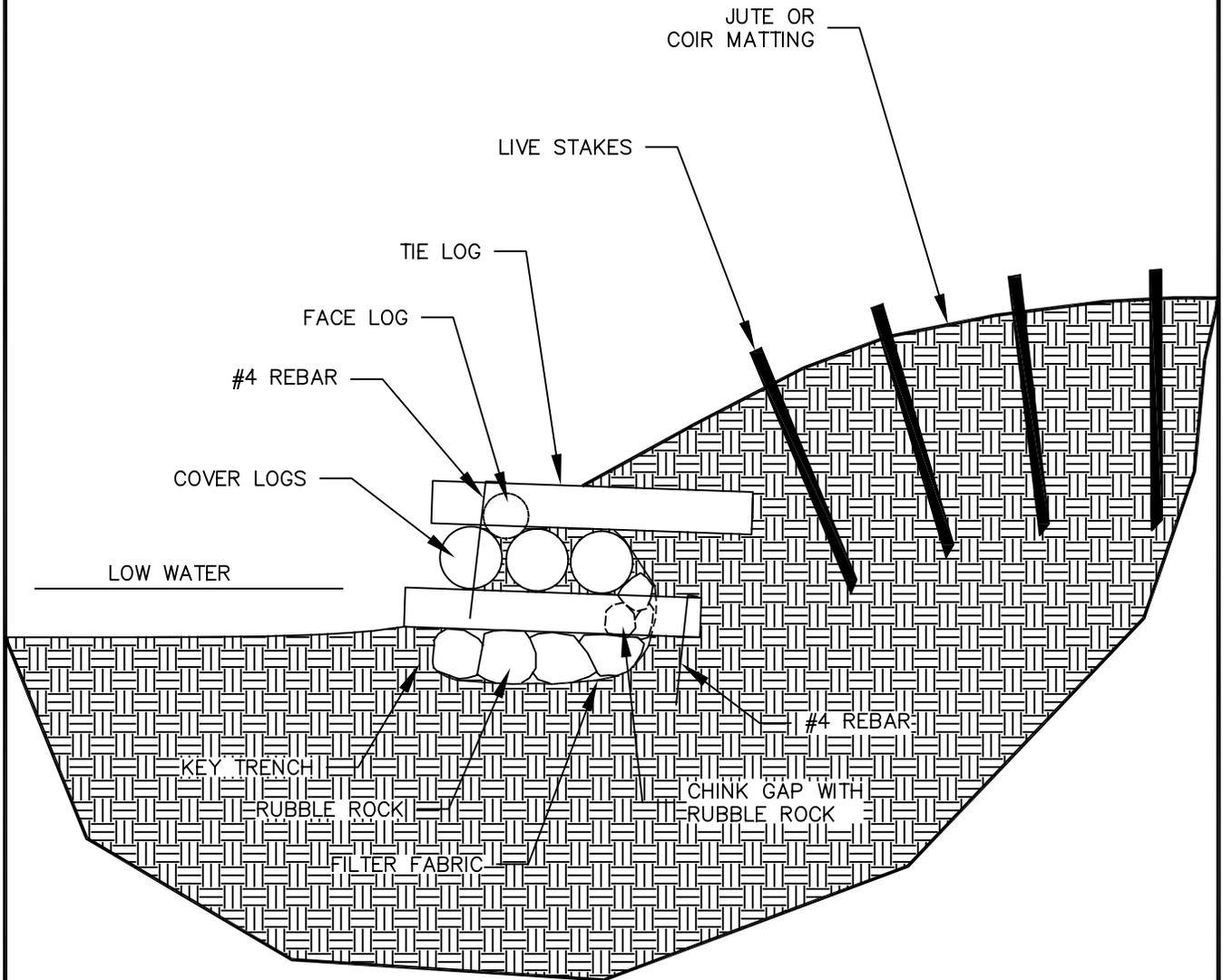
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CHAPTER 10

**STORMWATER BEST MANAGEMENT PRACTICES
FOR
WATER QUANTITY AND WATER QUALITY CONTROL**

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FOR
WATER QUANTITY AND WATER QUALITY CONTROL

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10.1 INTRODUCTION

Non-point source pollution is now responsible for up to 80 percent of pollution in waters of the U.S., which include streams, lakes, rivers, and wetlands. This is true, in part, due to significant reductions in direct discharges of pollutants by industry that have been achieved since passage of the Clean Water Act (CWA) of 1972. In urban areas, non-point source pollution occurs because stormwater runoff collects impurities while passing over roof tops, streets, parking lots, landscaping, and gutters. This polluted stormwater runoff typically enters a storm drain system and is rapidly conveyed to a lake, stream, or river. The percentage of impervious land cover in urban and suburban watersheds generally indicates the level of pollutant impact on receiving waters. In most cases, impervious cover in excess of 30 percent results in streams that are considered “degraded,” while impervious cover between 10 and 30 percent causes “impacts” on the receiving streams. Typical residential development results in approximately 35 percent of a watershed being impervious, which is more than enough to degrade the receiving waters. Realization of this fact is important, because healthy (non-impacted) streams are important for a healthy ecosystem, and a healthy ecosystem is important for all living creatures including people.

Regulatory Basis

The CWA addressed stormwater in cities larger than 100,000 people with the U.S. EPA Phase I stormwater regulations promulgated in 1990. The Phase II regulations were promulgated in 1999 and affect cities less than 100,000 like the City of Danville. The Kentucky Division of Water is the EPA’s permitting agency for Phase I and II.

On January 1, 2003, the Kentucky Division of Water issued the Phase II general permit for the cities in Kentucky covered by Phase II. This includes the City of Danville and requires the city to develop, implement, and enforce a program to address stormwater runoff from new development and redevelopment. The implementation of the requirements contained in this chapter will be a primary mechanism for accomplishing this objective. Stormwater management shall include management for quality as well as quantity (flood protection). This chapter gives detailed design information on the structural water quality and water quantity best management practices (BMPs) to implement these policies.

10.2 GENERAL DESIGN CRITERIA

Stormwater management shall include management for quality and quantity. This section provides the general design criteria for both.

10.2.1 Water Quantity Control

Water quantity controls shall be implemented so that post-development peak discharges for the design storms contained in Table 5-1 are reduced to pre-development levels.

10.2.2 Water Quality Control

Research has indicated that capturing and treating 90 percent of the total annual runoff volume provides effective water quality treatment volume based on removal of particulates. Effective removal of solid particles in the runoff also provides for removal of significant amounts of nitrogen, phosphorus, and oil and grease. Ninety percent of the annual runoff seems to be a large volume, but the storm events that cumulatively produce this runoff volume typically produce less than 1.6 inches of runoff each. Using hydrologic modeling for typical areas, the runoff depth necessary for 90 percent runoff capture can be approximated as a function of percent impervious area. These values, shown in Table 10-1, represent the water quality depth that shall be treated for each development. For example, a 20-acre development that is 40 percent impervious has a water quality depth of 0.7 inches over the whole area (not just the impervious area), resulting in a water quality volume (WQV) of 50,820 cubic feet. Water quality controls are not required for sites that are less than 10% impervious.

In addition to carrying pollutants, stormwater runoff from developed areas increases the frequency and duration of bankfull flows in the receiving streams, causing increased erosion of the stream banks and further degradation of in-stream water quality. On-site infiltration, designed for the increased runoff due to development, is the preferred solution to this impact.

TABLE 10.1 - WATER QUALITY DEPTH VERSUS PERCENT IMPERVIOUS SURFACE

% Impervious Surface	Water Quality Depth (inches)
0 to 9	0
10	0.4
20	0.5
30	0.6
40	0.7
50	0.85
60	1.0
70	1.15
80	1.3
90	1.45
100	1.6

Notes:

- 1) The Water Quality Volume (WQV) is the volume resulting from applying the prescribed Water Quality Depth to the drainage area to be developed.
- 2) For % impervious values between those given use linear interpolation.
- 3) Water quality controls are not required for sites that are less than 10% impervious.

10.3 BIORETENTION SYSTEMS

Bioretention is a practice to treat stormwater runoff using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression. The method combines physical filtering and adsorption with biological processes. The system consists of a structure to spread flow, a pretreatment filter strip or grass channel, a sand bed, pea gravel overflow curtain drain, a shallow ponding area, a surface organic layer of mulch, a planting soil bed, plant material, a gravel underdrain system, and an overflow system. Figure 10-1 shows a diagram of a bioretention system designed to receive runoff from a paved area.

10.3.1 Applicability

Bioretention systems are very effective for water quality treatment. Bioretention systems are particularly well suited for use in parking lot islands, roadside swales, and median strips.

10.3.2 Design Criteria

Size the area of the filter bed in accordance with the design WQV corresponding to the area draining to it. (See the next section for procedure).

Design the bioretention system to be on-line with an overflow catch basin, as shown in Figure 10-1, to handle volumes exceeding the design WQV.

Design the bioretention system to have a longitudinal slope of 0 to 1 percent.

Provide a pretreatment system composed of a pea gravel diaphragm and a grassed filter strip. The pea gravel diaphragm also serves as a flow spreader. Dimensions of the gravel diaphragm and grass filter strip shown in Figure 10-1 are minimums. When flow into a bioretention system is parallel to its long dimension (i.e., from a drainage swale), omit the gravel diaphragm shown in Figure 10-1 and provide a berm across the downstream end of the system to impede the flow. The top of the berm shall be level across the base of the bioretention system and be 12 to 18 inches high in the center.

Provide a planting soil bed with a minimum width of 4 feet and a minimum depth of 4 feet (including a 12 inch sand bed). The planting soil bed can be as wide as 15 feet. The area of the system is determined by the required area of the filter bed. The minimum length is 15 feet.

For widths greater than 10 feet, maintain at least a 2:1 length to width ratio.

Provide a pea gravel curtain drain, as shown in Figure 10-1. The minimum width of the curtain drain is 8 inches.

Provide a 2 to 3 inch thick mulch layer above the planting soil bed.

Grade the top of the planting soil bed to provide a shallow ponding area with a maximum depth of 6 inches.

Provide an underdrain system of gravel and perforated pipe. Design the gravel bed to be at least 8 inches deep. Connect the underdrain to the storm drainage system or design it to daylight to a suitable non-erosive outfall.

10.3.3 Design Procedures

Size the filter bed using the following equation:

$$A_f = V * (d_f) / [k * (h_f + d_f) * (t_f)]$$

where:

A_f = surface area of the sand filter bed (ft²)

V = treatment or infiltration volume (ft³)

d_f = planting bed depth (ft)

k = coefficient of permeability for planting bed (ft/day)

h_f = average height of water above the planting bed (ft); $h_f = 0.5 * h_{max}$

t_f = time required for V to filter through the planting bed (days).

Note:

$d_f = 4$ feet (including sand filter) unless it is increased by designer

$k = 0.5$ feet/day (median value of a silt loam)

$h_f = 0.5 * h_{max} = 3$ inches = 0.25 feet

$t_f = 3$ days.

Design the bioretention system to provide the minimum filter area required and to meet the design criteria.

10.3.4 Specifications

Provide planting soil with the following characteristics:

- pH of 5.2 to 7.0,
- organic content of 1.5 to 4 percent,
- magnesium of 35 pounds per acre minimum,
- phosphorus (as P₂O₅) of 75 pounds per acre minimum,
- potassium (as K₂O) at 85 pounds per acre minimum,
- soluble salts less than 500 ppm,
- clay content of 10 to 25 percent by volume,
- silt content of 30 to 55 percent by volume,
- sand content of 35 to 60 percent by volume,
- free of stones, stumps, roots, or other woody material greater than 1 inch in diameter.

Place planting soil in lifts of 12 to 18 inches and loosely compact or tamp lightly with backhoe bucket.

Provide shredded hardwood mulch aged at least 2 months. Place mulch layer 2 to 3 inches deep.

Provide clean river pea gravel for the curtain drain and diaphragm sized to meet ASTM D-448 size no. 6 with diameter ranging from 1/8 to 1/4 inch.

Provide gravel for the underdrain sized to meet AASHTO M-43 with size range of 1/2 to 2 inches in diameter.

Provide PVC piping for the underdrain satisfying AASHTO M-278 standard for rigid schedule 40 pipe. Provide 3/8 inch diameter perforations on 6 inch centers with 4 holes per row.

Plant base of bioretention system (planting soil bed) in herbaceous ground cover and shrubs. Plant side slopes of bioretention system in herbaceous ground covers, vines, and shrubs. Trees may also be used in the bioretention system. Use direct seeding for herbaceous varieties and nursery stock for vines, shrubs, and trees.

Areas to be seeded with herbaceous varieties shall be roughened with a rake or similar tool. Seeding rates shall be minimum of 10 pounds of seed mix per 1000 square feet of area.

Bare root or containerized stock shall be planted at the same depth as planted in the nursery. The stock should be planted in a hole large enough to accommodate the root system when well spread. Shrubs and vines shall be planted at a minimum density of 1,700 stems per acre (one stem per 25 square feet at 5 feet on center).

Select herbaceous species for the planting soil bed from the following list. Use a minimum of two species.

Common Name	Scientific Name
Switch Grass	<i>Panicum virgatum</i>
Swamp Milkweed	<i>Asclepias incarnate</i>
Giant Cane	<i>Arundinaria gigantean</i>
Jewelweed	<i>Impatiens capensis</i>
River oats	<i>Chasmanthium latifolia</i>
Deertongue	<i>Panicum clandestinum</i>
Boneset	<i>Eupatorium perfoliatum</i>

Select herbaceous species for the side slopes from Table 9-1 in Chapter 9. Also, select vines, shrubs, and trees from Table 9-1.

10.4 INFILTRATION SYSTEMS

Infiltration practices and/or bioretention systems reduce the adverse impacts on the receiving waters that result from increasing the impervious area. This chapter describes several infiltration practices that can be used in many different situations. Many of the practices cannot function as the sole water quality infiltration and treatment device, but will provide significant “credits” toward reducing the magnitude of the runoff that must be detained and treated.

Infiltration practices include a variety of practices such as directing downspouts to grassed areas and using modular pavement. Infiltration practices also include swales, terraforming, infiltration, and vegetative filters. Terraforming is a term for special grading practices such as terracing and berming that are intended to promote infiltration. This section presents infiltration practices and describes the minimum requirements that must be met to obtain credits to reduce water quality treatment volumes.

The infiltration volume credit listed for each practice can be used to satisfy an equal amount of water quality volume.

10.4.1 Downspouts to Grass

Discharging downspouts from roofs onto grassed yards encourages infiltration and reduces direct discharge to impervious areas such as driveways.

Infiltration Credit

When downspouts are discharged onto grass, the infiltration credit is 0.083 acre-feet per acre of roof area. The grass area shall be greater than or equal to the roof area.

Design Criteria

The lot must be graded so that the downspout discharge travels at least 30 feet over grass before reaching a driveway, roadway, paved ditch, or any other impervious conveyance.

10.4.2 Modular Pavement

Modular pavement consists of strong structural materials, typically concrete, having regularly interspersed void spaces that are filled with pervious materials such as sand, gravel, or sod. These pavements can be used as driveways or as overflow parking in areas that are used less frequently than the main parking areas for civic, commercial, and industrial facilities. Modular pavement can be used for any portion of parking up to that amount allowed by the Planning Commission.

Infiltration Credit

Any area that is paved using modular pavement can be treated as pervious for purposes of calculating WQV and post-development peak runoff, as long as appropriate design criteria and construction specifications are satisfied.

Design Criteria

Large void spaces in modular pavement shall represent at least 30 percent of the total surface area of the pavement.

Voids shall be filled with silty soil and vegetated with permanent grass. If vegetation is inappropriate, voids may be filled with sand or gravel, but the material shall be clean and uniform (poorly graded) to ensure high permeability.

Construction Specifications

Install all modular pavements following manufacturer's specifications.

To prevent premature clogging and/or failure, modular pavements shall not be placed into service until the entire contributing surface drainage area has been completely stabilized.

Clearly mark the planned area for modular pavement to prevent heavy equipment from compacting the underlying soils.

Excavate the subgrade soil using equipment with tracks or oversized tires to minimize compaction.

10.4.3 Swales

Swales are typically vegetated parabolic or trapezoidal channels with a large width to depth ratio that are used for conveying stormwater runoff. Swales can act both as vegetated filters and infiltration practices because they tend to slow runoff rates and allow for both particle settling and stormwater infiltration. Swales are encouraged wherever they can be used as an alternative to narrower, deeper channels that tend to convey flow at higher velocities. Swales are especially effective in reducing water quality impacts when used for roadside drainage instead of the traditional curb inlet/pipe system. In this application curb cuts are used instead of drop inlets in the gutter. See Figure 10-2.

Swales can be even more effective when constructed using berms or infiltration beds to encourage additional ponding and infiltration. These cases are discussed in subsequent sections.

Infiltration Credits

When swales are used, the infiltration credit is 0.25 acre-feet per acre of swale. To obtain this credit, the area draining to the swale must be at least three times the area of the swale considering that the swale itself is part of the drainage area.

To calculate the area of the swale, the width will be the average water surface width corresponding to the flowrate associated with the 100-year storm.

Design Criteria

To be considered a swale, a channel must have a width to depth ratio of at least 6:1, have a bed slope of not greater than 4 percent, and be vegetated. When swales are used for roadside drainage, curb cuts shall be provided no less frequently than one per each 100 feet of curb.

Drop inlets in swales shall be spaced no closer than once per each 300 feet in order to obtain the infiltration credit.

Grassed channels that do not satisfy the design criteria to be considered swales may be given an infiltration credit only for the channel bottom, if the bed slope does not exceed 4 percent.

10.4.4 Bermed Swales

A bermed swale or infiltration swale is a grassed swale constructed with berms or swale blocks across the swale to impound shallow pools of water, slowing flow and providing additional opportunities for particle settling and stormwater infiltration.

Infiltration Credit

Infiltration credit for a bermed swale is calculated in the same manner as the credit for a swale, except that the calculated infiltration credit can be increased by 50 percent of the water volume that can be impounded by the berms.

Design Criteria

Swale blocks or earthen berms built across the swale shall be constructed with a 2-inch diameter PVC pipe through the berm to prevent long-term ponding of water.

Berms shall be no taller than 8 inches and spaced no closer than 60 feet.

Drop inlets in swales shall be spaced no closer than once per each 300 feet in order to obtain the infiltration credit.

Grassed channels that do not satisfy the design criteria to be considered swales may be given an infiltration credit only for the channel bottom, if the bed slope does not exceed 4 percent.

10.4.5 Biofiltration Swales

A biofiltration swale is a version of a bioretention system without the pipe underdrain system. This practice encourages infiltration from the swale bottom, through a planting bed, to the underlying soil. See Figure 10-3.

Infiltration Credit

Infiltration credit for a biofiltration swale is 0.50 acre-feet per acre of swale plus 100 percent of the volume of the ponded water, when designed according to the following criteria. If biofiltration swales are designed consistent with the procedures for bioretention systems, the infiltration credit equals the design treatment volume.

Design Criteria

Biofiltration swales shall be designed to have the following characteristics:

- trapezoidal or parabolic shape;
- bottom width of 2 feet;
- side slopes no steeper than 3:1;
- longitudinal slope of 1 to 2 percent (up to 4 percent slope can be used with berms constructed as required for bermed swales);
- length, width, depth, and slope necessary to provide surface storage of the design volume with a maximum ponded depth of 18 inches;
- vegetated in accordance with requirements for vegetated channels with grass lining;
- capacity to convey the 100-year design storm with at least 6 inches of freeboard; and
- a soil bed 36 inches deep having the width of the swale bottom.

Plan the soil bed to consist of soils that have a permeability of at least 0.5 feet per day (USCS soils ML, SM or SC). If native soils do not satisfy these criteria, a prepared soil bed can be designed.

An alternative to the above criteria is to size the filter bed (i.e., planting soil bed) for a biofiltration swale consistent with a bioretention system. Then the infiltration credit would be calculated in the same manner as the credit for bioretention.

10.4.6 Terraforming

Terraforming is a term for special grading practices such as terracing and berming that are intended to promote infiltration. Bermed swales are a special case of terraforming. Terraforming can range from a small depression in permeable soil to an extensive series of bermed terraces. A simple example is given in Figure 10-4.

Infiltration Credit

The infiltration credit for terraforming is 0.25 acre-feet per acre of area terraformed plus 100 percent of the impounded water.

10.4.7 Infiltration Basins

Infiltration basins may be used in locations that have at least 5 feet of soil, with a permeability of at least 0.5 inches/hour underlying the device. The underlying 5 feet of soil must also be above the seasonal high water table.

If soils do not meet the permeability requirement, they can be modified by mixing sand and gravel in the top 5 feet of the soil underlying the device. If native soils are to be modified with sand or gravel, provide a design that shows the depth of soil to be modified and the total quantity of gravel or soil to be added. Include soil test data documenting the permeability of the soils before and after modification.

If desired, large infiltration basins can be designed much like an extended detention pond for storm peak control. The outlet structure and detention storage volumes are designed to be above the level needed to store the design WQV. The difference is that an infiltration basin does not have an extended detention outlet. Instead the WQV is allowed to infiltrate into the soils underlying the basin. If the infiltration basin is not intended for peak flow control, it shall be designed so that volumes exceeding the WQV can discharge through an overflow weir or pipe. For small excavated basins of less than one-fourth acre, volumes exceeding the WQV may be allowed to overflow onto the ground surface without use of an overflow structure, if proper erosion control measures are implemented.

The infiltration credit for an infiltration basin is simply the volume designed to be impounded before overflow or discharge to a spillway.

Design Criteria

Test soils prior to designing an infiltration basin to ensure that the site is capable of infiltration. Obtain a minimum of three soil test borings or test pits to verify that the soil is at least 5 feet deep below the base elevation and has a permeability of at least 0.5 inch/hour.

Design the floor of the basin to be as flat as possible to promote infiltration. Provide side slopes not greater than 3:1 (h:v).

Provide a sediment forebay at the inlet to the basin with a depth of at least 4 feet and a volume of at least 10 percent of the WQV.

Size the basin to store the design WQV before discharging through the peak flow control outlet. If the basin is intended only for water quality treatment, design an outlet that allows volumes in excess of the WQV to discharge to a surface water conveyance.

If a base flow will be discharged into the infiltration basin, design a low flow orifice to allow base flow to pass through.

Adjust the storage depth so that the basin will completely drain the WQV in 72 hours.

When using an infiltration basin for peak flow control, provide a minimum of 1 foot of freeboard above the 100-year design storm high water elevation.

Impoundment depths shall not exceed 15 feet and storage volumes shall not exceed 25 acre-feet.

Design earthen embankments with side slopes not steeper than 3:1 (horizontal to vertical).

Design basins to be placed outside the receiving stream except when a basin is designed as a regional detention basin and the City of Danville has approved its use as a regional basin.

Reserve adequate access from public or private right-of-way by establishing a maintenance easement. Design the access to be at least 10 feet wide, with a slope not greater than 5:1 (h:v). Design the access way to connect to the embankment so that equipment can access the top of the embankment on a slope not greater than 5:1 (h:v).

Provide a minimum 25-foot wide buffer strip between the basin and the nearest lot. Landscape the buffer strip with low-maintenance native grasses, shrubs, and trees. Provide a landscaping plan for the basin and the buffer. Objectives of landscaping include improving the appearance for adjacent residents and providing wildlife habitat.

Specifications

Embankment, outlet, and emergency spillway specifications are consistent with those for detention basins.

Excavate the basin with light equipment having tracks or over-sized tires to minimize compaction of the underlying soils. After the basin is excavated to the final design depth, deeply till the basin floor with a rotary tiller or disc harrow to restore infiltration rates. After tilling, apply a leveling drag.

Establish vegetation immediately after achieving final grade and preparing the infiltration bed. Stabilize the floor of the basin with a dense cover of water-tolerant herbaceous species consistent with requirements of bioretention systems.

10.4.8 Vegetated Filter Strips

A vegetated filter is a practice that relies upon the use of vegetation to filter out sediment and other pollutants from stormwater runoff. These filters also provide an opportunity for stormwater runoff to infiltrate. Vegetated filters can be used as water quality devices. Vegetated filters can be used for small subareas of a larger development in order to reduce the total volume to be treated by other devices in the development.

A filter strip is a practice that relies upon sheet flow across the entire width of the vegetated area. The vegetation is typically grass; however, other ground cover can be used if it provides for dense vegetation. Filter strips are typically used at the edge of a parking lot or other paved surface.

Design Criteria

Design a filter strip to have a width matching the width of the area draining to the filter.

Design a filter strip to have a smooth transition with the area draining to it so that sheet flow can be developed across the filter.

Design filter strips to have a minimum slope of 2 percent and a maximum slope of 6 percent.

Provide a dense turf or other comparable vegetated ground cover over the whole filter area.

When the contributing area draining to the filter strip is impervious, do not allow the overland flow length of the impervious surface to exceed 75 feet.

When the contributing area draining to the filter strip is pervious, do not allow the overland flow length of the contributing surface to exceed 150 feet.

Infiltration Credit

The infiltration credit for vegetated filters is 0.083 acre-feet per acre of filter.

10.4.9 Riparian Buffers

Riparian buffers are vegetated zones of trees and/or shrubs adjacent to and upgradient from perennial or intermittent streams, lakes, ponds, and wetlands. In the ideal scenario, native riparian buffers would exist adjacent to all receiving waters. However, in many agricultural areas the native riparian buffer has been partially or fully removed to create pasture or cropland right up to the top of streambank. Existing riparian buffers cannot be used for infiltration or water quality credit, but restoration or reforestation of riparian buffers can be used to provide infiltration credit.

Design Criteria

Design a plan for riparian buffer reforestation/revegetation in accordance with Ky. Division of Water Criteria.

Infiltration Credit

The infiltration credit for re-establishing a riparian buffer zone is 0.5 acre-feet per acre of buffer restored.

In order to obtain this credit, a buffer zone planting plan must be included with the improvement plans. The plan shall also provide for maintenance of the buffer zone until such time as trees and shrubs are established and the upgradient drainage area is permanently stabilized.

10.5 SAND AND ORGANIC FILTERS

In general usage, stormwater filters are a diverse group of techniques for treating stormwater quality with each using some sort of filtering media such as sand, soil, gravel, peat, compost, or vegetation. Filters will include systems with a designed filter bed composed of sand, gravel, compost, or peat and an outlet to the stormwater drainage system or a receiving stream. Systems described in this section include: surface sand filters, underground sand filters, perimeter sand filters, and organic filters.

10.5.1 Applicability

Filters can be used for water quality treatment, but are not appropriate for peak flow (quantity) control.

10.5.2 General Design Criteria

Design criteria in this section apply to all filtration devices in this section.

Provide a pretreatment cell to allow sedimentation prior to the filter bed and reduce clogging.

Locate inlet and outlet structures at extreme ends of the pretreatment cell.

Design the pretreatment or sedimentation cell to have a minimum depth of 3 feet to minimize resuspension and turbulence.

Design the bottom of the pretreatment cell to be nearly level to facilitate sedimentation.

Design the surface area of the pretreatment cell (in square feet) to be at least 0.0081 times the WQV (in cubic feet) for areas with 75 percent or more impervious surface. For areas with less than 75 percent impervious surface, design the surface area of the pretreatment cell (in square feet) to be at least 0.066 times the WQV (in cubic feet). The order of magnitude difference in the two factors derives from the fact that areas with higher percentages of impervious surface (i.e., 75 percent or more) tend to have a greater proportion of coarse grained sediments, which have a higher settling velocity.

Size the pretreatment cell with a minimum length to width ratio of 2:1.

The length to width ratio of the pretreatment cell can be less than 2:1 if baffles are provided to obtain a flow length equivalent to or greater than would be obtained with a 2:1 ratio.

Design each filtering device for a capture or storage volume equal to or greater than $\frac{3}{4}$ times the WQV.

Design filtration systems to be off-line by using a flow-splitter or other device to divert flows in excess of the WQV around the filtration systems.

Provide sufficient access to the device for construction and maintenance. Provide an access ramp with a maximum slope of 10 percent for vegetated ramps, 15 percent if the slope is stabilized with crushed stone, or 25 percent if paved.

Construct exposed piping and accessories out of durable, strong materials to avoid susceptibility to damage by vandalism.

Provide access manholes and/or grates to underground and below grade structures for each subsurface chamber. Provide manhole diameters of at least 30 inches to meet confined space access criteria. Place manhole steps to allow maintenance personnel easy access to structure bottoms. Provide a 5-foot minimum height clearance (from the top of the sand layer to the bottom of slab) for all fixed permanent underground structures. Provide lifting rings or other suitable elements to lift and replace structure top slabs.

Construct the underground sand filter with a dewatering gate valve located just above the top of the sand filter bed. Should the filter bed and/or underdrain system clog completely, the gate valve can be opened to dewater the filter chamber for needed maintenance.

10.5.3 Surface Sand Filter

A surface sand filter is shown in Figure 10-5. This system is constructed of reinforced concrete with a pretreatment (sedimentation) chamber and a filter bed chamber with a sand filter and underdrain system. Figure 10-5 also shows a flow diversion chamber at the inlet end of the structure. The filter bed has an 18-inch to 24-inch sand layer which traps or strains pollutants before runoff is collected in an underdrain system (gravel and perforated pipe) and conveyed to the receiving stream, channel or pipe. The filter bed surface may have a sand or grass cover.

Surface sand filters are open at the top, which provides easy access for maintenance, but renders these unsuitable in areas easily accessible to the general public, especially small children. Control access to surface sand filters by enclosing them in an eight-foot chain link fence. Such a configuration is most suitable to industrial and warehousing facilities rather than commercial/retail establishments where aesthetic impact is significant. Even for industrial sites consider proximity to residential areas and other locations frequented by children. In some locations an eight-foot fence may not provide adequate protection.

Design Procedures

Size the pretreatment chamber in accordance with design criteria in 10.5.2.

Size the area of the filter bed using the following equation:

$$A_f = WQV \cdot (d_f) / [k \cdot (h_f + d_f) \cdot (t_f)]$$

where:

A_f = surface area of the sand filter bed (ft²)

WQV = water quality treatment volume (ft³)

d_f = sand filter bed depth (ft)

k = coefficient of permeability for sand bed (ft/day)
 h_f = average height of water above the sand bed (ft); $h_f = 0.5 * h_{max}$
 t_f = time required for the WQV to filter through the sand bed (days).

Note:

- set d_f such that $1.5 \text{ feet} \leq d_f \leq 2 \text{ feet}$
- h_f can vary depending on the site conditions, but six feet is the maximum value.
- Use 1.7 days (i.e., 40 hours) for the filter bed draw-down time (t_f).
- Use $k = 3.5 \text{ ft/day}$.

Design the underdrain system beneath the filter bed to be at least six inches deep, with at least two inches of gravel over drain pipes and pipe slopes of at least 0.5 percent.

Design the underdrain system to ensure that the flow through rate of the filter bed is controlled by the filter media rather than the underdrain system.

Calculate the minimum volume which must be stored within the device as $V_{min} = 0.75 \text{ (WQV)}$.

Compute the water volume within the filter bed as $V_f = A_f * 0.35 * (d_f + d_u)$, where d_f is the depth of the sand bed and d_u is the depth of the gravel underdrain. The constant 0.35 represents the porosity of the sand and gravel. Figure 10-6 provides an illustration of the parameters used for calculating storage volume.

Compute the temporary storage volume above the filter bed as $V_{f-temp} = 2 * h_f * A_f$.

Compute the remaining volume required for the pretreatment chamber as $V_s = V_{min} - (V_f + V_{f-temp})$. Check that V_s is approximately 50 percent of V_{min} . If it is not, decrease h_f and recompute. Note that changing h_f will change the computed A_f .

Calculate the height in the pretreatment chamber, h_s , as $h_s = V_s/A_s$.

Check that h_s is greater than $2 * h_f$ and h_s is greater than 3 feet. If not, adjust h_f and repeat computation.

Design a junction box flow splitter with either a pipe or weir overflow to the stormwater system. Set the invert of the overflow to the elevation of the design water level in the pretreatment chamber. Design the overflow to convey the peak discharge anticipated from the 10-year storm.

Design the structural concrete components in accordance with design loads and site soil conditions.

Specifications

Select sand to meet AASHTO M-6 or ASTM C-33 requirements for medium aggregate concrete sand with size range of 0.02 to 0.04 inches.

Select underdrain gravel to meet AASHTO classification M-43 with size range of 0.5 to 2 inches.

Select geotextile fabric to have a minimum puncture strength of 125 pounds (ASTM D-751), minimum mullen burst strength of 400 psi (ASTM D-1117), and minimum tensile strength of 300 pounds (ASTM D-1682). Geotextile fabric shall have an opening size equivalent to U.S. sieve size #80 and shall provide a minimum flow rate of 125 gallons/minute per square foot.

Select underdrain piping to meet AASHTO M-278 requirements for Schedule 40 PVC pipe. Provide 3/8-inch perforations on 6-inch centers with four holes per row.

Construct the base of the sand filter structure on undisturbed soil or rock. If disturbed soil must be used as a base, recompact it to 95 percent of maximum standard dry density in 6-inch compacted lifts.

Do not allow runoff to enter the sand filter bed until the upstream drainage area is completely stabilized and site construction is completed. The sedimentation pond may serve as a temporary sediment control pond during site construction with the provision that overflows will bypass the filtration bed.

Construct the top of the filter bed completely level.

Store materials which might be damaged during construction (such as perforated PVC piping, geotextiles, etc.) in a safe location and handle carefully.

Construct overflow weirs, multiple orifices and flow distribution slots completely level to ensure adequate distribution of design flows.

Construct the main collector pipe for underdrain systems at a minimum slope of 0.5 percent. Provide observation and clean-out pipes for all underdrain piping.

10.5.4 Underground Sand Filter

Underground sand filters are suitable for intensely developed urban areas where space is at a premium. These systems are also suitable in locations that are easily accessible to the public. Figure 10-7 shows an underground sand filter. In this design, the sand filter is placed in a three chamber underground vault accessible by manholes or grate openings. The first chamber is a 3-foot deep sediment chamber used for pretreatment. It is connected to the second chamber (the sand filter bed) by an inverted elbow or submerged slot, which keeps the filter surface free from trash and oil. The filter bed is 18 to 24 inches in depth and has a protective screen of gravel over filter fabric to act as a pre-planned failure plane that can easily be replaced when the filter surface becomes clogged. During a storm, the water quality volume is temporarily stored in both the first and second chambers. Flows in excess of the filter's capacity are diverted through an overflow weir.

Design Procedures

Design procedures are consistent with those described previously for a surface sand filter with the following exceptions. See Figure 10-8 for an illustration of the volume parameters.

After computing the minimum volume which must be stored (V_{\min}) and the volume in the filter bed (V_f), compute the minimum wet pool volume in the settling basin as $V_w = 3 \text{ ft} * A_s$.

Compute the temporary storage volume required within both chambers as $V_{\text{temp}} = V_{\min} - (V_f + V_w)$.

Compute the total surface area of both chambers as $(A_f + A_s)$.

Calculate the height of temporary storage needed as $h_{\text{temp}} = V_{\text{temp}} / (A_f + A_s)$.

Check that h_{temp} is greater than or equal to $2h_f$. If not, decrease h_f and recalculate volume requirements.

Specifications

Specifications are consistent with those provided for surface sand filters with the following addition.

To help extend the design life of the sand filter bed for the underground sand filter, place a wide mesh geotextile screen on the surface of the filter bed to trap the large quantities of trash, litter, and organic detritus associated with highly urban areas. During maintenance operations the screen is rolled up, removed and cleaned, and reinstalled.

10.5.5 Perimeter Sand Filter

The perimeter sand filter consists of two parallel trench-like chambers that are typically installed along the perimeter of a parking lot. Figure 10-9 shows a perimeter sand filter. Parking lot runoff enters the first chamber that has a shallow permanent pool of water. The first trench provides pretreatment before the runoff spills into the second trench, which consists of an 18-inch deep sand layer over a gravel/perforated pipe underdrain system. During a storm event, runoff is temporarily ponded above the normal pool and sand layer, respectively. When both chambers fill up to capacity, excess parking lot runoff is routed to a bypass drop inlet.

Design Procedures

Design procedures are consistent with those described previously for a surface sand filter with the following exceptions. See Figure 10-10 for an illustration of the volume parameters.

After computing the minimum volume which must be stored (V_{\min}) and the volume in the filter bed (V_f), calculate the minimum wet pool volume in the pretreatment basin as $V_w = A_s * 2 \text{ ft}$.

Calculate the temporary storage volume required as $V_{\text{temp}} = V_{\text{min}} - (V_f + V_w)$.

Compute the total surface area of both chambers as $(A_f + A_s)$.

Check that h_{temp} is greater than or equal to $2h_f$. If not, decrease h_f and recompute areas and volumes. Note that changing h_f will change the required A_f .

Specifications

Specifications are consistent with those given for a surface sand filter.

10.5.6 Organic Filters

Organic filters are designed consistent with surface or underground filters except that the sand filter bed is replaced or modified with organic media. There are two basic options for organic filters: a peat-sand system and a compost system.

In the peat-sand system the filter bed is a minimum of 24 inches deep over the underdrain system. This 24-inch bed consists of a 6-inch sand layer overlain by an 18-inch layer of peat-sand mix.

The compost filter system consists of a fabricated leaf compost filtration bed overlying the underdrain system. The compost must be mature and humic so that the organic material is no longer rapidly decaying, and it must be locally available at a reasonable cost.

Design Procedures

Design procedures are consistent with those given previously for surface sand filters or underground sand filters except that the coefficient of permeability, k , for the organic filter is modified. For a peat-sand system, use $k = 2.75$ ft/day. For a compost system, use $k = 8$ ft/day.

Specifications

For peat-sand filter beds, select a fibric peat that is shredded, uniform, and clean.

For peat-sand filter beds, combine equal volumes of peat and sand and mix to obtain uniform distribution of peat and sand. Sand specifications are given in Section 10.5.3.

For peat-sand filter beds, place a 6-inch layer of sand over the gravel underdrain. Separate the sand layer from the gravel layer with geotextile fabric. Select sand and geotextile consistent with specifications in Section 10.5.3. Above the 6-inch sand layer, place 18 inches of the 50/50 peat-sand mixture. Construct the filter bed so that the surface of each layer is level. Provide nominal compaction of the gravel and sand layers using a mechanical tamper. Do not compact the sand-peat layer.

For a compost filter bed, select a compost that is mature and humic, composed of leaf medium rather than general yard waste compost.

For a compost filter bed, place a minimum of 18 inches above the geotextile overlying the underdrain system. Do not compact the compost filter bed.

10.6 PREFABRICATED TREATMENT DEVICES

Several manufacturers produce devices, which are effective in removing suspended solids and floating oils from stormwater runoff. These devices are typically well-suited to sites that are relatively small and have a high percentage of impervious cover. These devices are not as effective in applications where a majority of the ground cover is pervious and a high percentage of the suspended solids are eroded fine soil particles. The devices that have been approved for use include the Stormceptor, by Stormceptor Corporation, Vortechs System, by Vortechtechnics, and CDS Units. Other devices will be approved by the City of Danville on a case by case basis.

Design Criteria

Prefabricated Treatment Devices shall be designed to remove 70% of total suspended solids (minimum particle size of 50 microns) for a storm with an intensity of 2.1 inches per hour (3-month frequency storm with a time of concentration of 10 minutes).

10.7 DETENTION PONDS

A detention pond is a traditional stormwater quantity control device that is designed for peak discharge control. Detention ponds are designed to completely drain after the design storm passes. Figure 10-11 illustrates a detention pond.

10.7.1 Applicability

Detention ponds are not effective as water quality treatment devices and can only be used for water quantity control (i.e., detention).

10.7.2 Design Criteria

Design outlet structures so that detention volume is released within 24 hours.

Provide an emergency spillway sized to discharge the peak runoff from the 100-year storm assuming the principal spillway is clogged, without overtopping the crest of the pond.

Provide a minimum of 1 foot of freeboard above the calculated high water elevation for the 100-year design storm, assuming the principal spillway is not clogged.

Embankment heights shall not exceed 20 feet (measured from the downstream toe) and storage volumes shall not exceed 25 acre-feet and shall not be less than 0.3-acre feet. Regional facilities may exceed these limits, but they must comply with the applicable requirements of the Kentucky Division of Water.

Design earthen embankments with side slopes not steeper than 3:1 (horizontal to vertical).

Provide anti-seep collars where the spillway barrel passes through the embankment. Stabilize earthen embankments immediately with temporary or permanent vegetation.

Design ponds to be placed outside the receiving stream except when a pond is designed as a regional detention pond and the City of Danville has approved its use as a regional pond.

Reserve adequate access from public or private right-of-way by establishing a maintenance easement. Design the access to be at least 10 feet wide and not steeper than 5:1 (h:v). Design the access way to connect to the embankment so that equipment can access the top of the embankment on a slope not steeper than 5:1 (h:v).

Provide a minimum 25-foot wide buffer strip between the pond and the nearest property line. Landscape the buffer strip with low-maintenance native grasses, shrubs, and trees. Provide a landscaping plan for the pond and the buffer. Objectives of landscaping include improving the appearance for adjacent residents and providing wildlife habitat.

Outlet works may be a combination of pipes, weirs, and orifices and drop inlets, but design any outlet pipes to be at least 15 inches in diameter to facilitate maintenance.

Design ponds to have a minimum bottom slope of two percent with a pilot channel for low flow.

10.7.3 Design Procedures

Size the outlet structure for the maximum allowable peak discharge at the estimated peak stage.

Develop a stage-storage curve for the proposed pond.

Develop a stage-discharge curve for all outlet control structures.

Perform flood routing calculations using the post-development hydrographs determined for the design storms.

If the routed post-development peak discharge(s) from the design storm(s) exceeds the pre-development discharge or the peak stage varies significantly from the estimated peak stage, revise the pond volume and/or outlet structure design. Develop a revised stage-storage curve and a revised stage-discharge curve and rerun the flood routing.

Design the emergency spillway to handle the 100-year peak discharge from the post-development hydrograph with no conveyance through the primary outlet structure.

Evaluate the downstream effects of detention outflow to ensure that the routed hydrograph does not cause downstream flooding problems.

Evaluate the control structure outlet velocity and provide channel and bank stabilization if the velocities are greater than the natural stream velocities.

10.7.4 Material Specifications

Construct embankments of ML, CL, MH, or CH soils as determined in accordance with the Unified Soil Classification System (USCS).

Determine the maximum standard dry density (ASTM D698) of at least two distinct samples of the soils to be used for embankment construction.

All conduits used for principal spillways shall be reinforced concrete pipe (RCP). The conduits shall be sealed with rubber gaskets to form a flexible watertight seal under all conditions of service. All pipes shall meet the requirements set forth in the Kentucky Department of Highways Standard Specifications for Road and Bridge Construction, latest edition. The Design Engineer shall be responsible for determining the size and grade of pipe to be used.

Anti-seep collars shall be provided on all conduits through earthen embankments, foundations, and abutments. The number and size of anti-seep collars shall be determined based on guidance set forth in the Kentucky Department for Environmental Protection, Division of Water's Engineering Memorandum No. 5, Design Criteria for Dams and Associated Structures.

All stone shall meet the requirements set forth in the Kentucky Department of Highways Standard Specifications for Road and Bridge Construction, latest edition.

Gradation of stone material will be performed in accordance with ASTM C-33. Tests shall be performed on every 5 tons of stone installed or at least once per installation location in locations where less than 5 tons are placed.

All geotextiles shall meet the requirements for performance and strength as set forth by the design engineer. Any alternative material used on the project shall be approved by the design engineer.

The following tests shall be performed and included in the manufacturer's certifications for each shipment of geotextile or every 500 square yards (or once per lot if manufacturer's records show multiple rolls came from same lot), whichever is less:

- Mass per unit area per ASTM D-5261
- Grab tensile strength per ASTM D-4632
- Trapezoidal tear strength per ASTM D-4533
- Burst Strength per ASTM D-3786
- Puncture strength per ASTM D-4833
- Thickness per ASTM D-5199
- Apparent opening size per ASTM D-4751
- Permittivity per ASTM D-4491
- Ultraviolet light resistance per ASTM D-4355

In the case that a more recent testing standard has been released, then that standard shall be used in lieu of the listed testing standards.

10.7.5 Construction Specifications

Verify areas to be backfilled are free of debris, snow, ice, or water, and ground surfaces are not frozen.

When necessary, compact subgrade surfaces to density requirements for the backfill material and prepare subgrade or previous layer of compacted fill prior to placement of additional fill by scarifying or disking.

Cut out soft areas of subgrade not readily capable of in situ compaction. Backfill with subsoil and compact to density equal to requirements for subsequent backfill material.

Backfill areas to contours and elevations. Use materials that are not frozen. The Contractor shall keep the foundation and subgrade free from water or unacceptable materials after the fill operations have started.

Backfill systematically, as early as possible, to allow minimum time for natural settlement. Do not backfill over porous, wet, or spongy subgrade surfaces.

Place and compact soil fill materials in continuous layers not exceeding eight (8) inches loose depth. Compact soil fill materials to 95 percent of maximum dry density. Field density tests shall be performed on each lift. Areas that fail to meet the requirements will be reworked as necessary to meet the requirements and then tested again. This process shall be repeated until the compaction requirements are met.

Tests shall be performed on each 400 square feet of surface area and on each lift of the surface area.

Maintain optimum moisture content of backfill material to attain required compaction density as specified. Material deposited on the fill that is too wet shall be removed or spread and permitted to dry, assisted by disking or blading, if necessary, until the moisture content is reduced to the specified limits.

All crushed stone fill and crushed stone backfill under structures and pavements adjacent to structures shall be DGA crushed stone per Kentucky Highway Department Standard Specifications for Road and Bridge Construction, unless indicated otherwise. Stone fill and backfill materials shall be placed in layers not exceeding six (6) inches in thickness and compacted to 95 percent of maximum dry density.

Backfill shall not be placed against or on structures until they have attained sufficient strength to support all loads to which subjected without distortion, cracking, or damage. Deposit soil evenly around the structure.

Slope grade away from structures minimum two (2) inches in ten (10) feet, unless noted otherwise.

Make changes in grade gradual. Blend slopes into level areas.

Remove surplus excavation materials to designated areas.

Pipe bedding shall meet the requirements set forth in the Kentucky Department of Highways Standard Specifications for Road and Bridge Construction and the City of Danville drawings, latest editions.

The pipe trench shall be overexcavated six (6) inches and properly backfilled prior to laying pipe. In no case shall pipe be laid on solid or blasted rock.

Pipe bedding material shall be placed in six (6) inch loose lifts and compacted to 95 percent maximum dry density at ± 2 percent of the optimum moisture content.

When the subgrade is found to be unstable or to include ashes, cinders, refuse, organic material, or other unsuitable material, such material shall be removed to the depth ordered by the Design Engineer and replaced under the directions of the Design Engineer with clean, stable backfill material. When the bottom of the trench or the subgrade is found to consist of material that is unstable to such a degree that, in the judgment of the Design Engineer it cannot be removed, a

foundation for the pipe and/or other appurtenance shall be constructed using piling, timber, concrete, or other materials as the direction of the Design Engineer.

All pipe shall be laid with ends abutting and true to the lines and grades indicated on the Drawings. The pipe shall be laid straight between changes in alignment and at uniform grade between changes in grade. Pipe shall be fitted and matched so that when laid to grade, it will provide a smooth and uniform invert.

The pipe shall be thoroughly cleaned immediately prior to placement. Any piece of pipe or fitting which is known to be defective shall not be laid. If any defective pipe or fitting shall be discovered after the pipe is laid, it shall be removed and replaced with a satisfactory pipe or fitting.

The interior of the pipe, as the work progresses, shall be cleaned of dirt, jointing materials, and superfluous materials of every description. When laying of pipe is stopped for any reason, the exposed end of such pipe shall be closed with a plug fitted into the pipe bell so as to exclude earth or other material. Other precautions shall be taken to prevent flotation of pipe by runoff into trench.

All pipe shall be laid starting at the lowest point and installed so that the spigot ends point in the direction of flow.

All joint surfaces shall be cleaned immediately before jointing the pipe. The bell or groove shall be lubricated in accordance with the manufacturer's recommendation. Each pipe unit shall then be carefully pushed into place without damage to pipe or gasket. All pipes shall be provided with home marks to insure proper gasket seating. Details of gasket installation and joint assembly shall follow the direction of the manufacturer's of the joint material and of the pipe. The resulting joints shall be watertight and flexible. No solvent cement joints shall be allowed.

After the embankment has been built to final grade, scarify or till the top and side slopes to a depth of 6 inches to prepare a seed bed. Immediately seed and mulch with temporary or permanent seed according to the season (see Chapter 11).

10.8 EXTENDED DETENTION PONDS

In this manual an extended detention pond is a dry detention pond equipped with an outlet structure that provides extended detention time of 24 hours for a specific water quality treatment volume. Figure 10-12 illustrates an extended detention pond.

10.8.1 Applicability

Extended detention ponds can be used for both water quality treatment and water quantity management. For water quality treatment, the extended detention volume is at least equal to the WQV derived from Table 10-1 less any credits for infiltration or bioretention.

In locations with continuous dry weather flow, an extended detention pond will tend to be continuously wet. In this instance, quantify the base flow so that the peak flow and water quality control structures can be designed accordingly.

The pond shall be located outside the receiving stream except when a pond is designed as a regional detention pond.

10.8.2 Design Criteria

The minimum drainage area for extended detention ponds shall be 10 acres.

Design the extended detention outlet so that the “design” WQV requires at least 24 hours to discharge.

To calculate the design WQV, take the full WQV for the site, minus any credits allowed for bioretention and infiltration practices, and multiply the remainder by a treatment effectiveness factor of 1.5.

Design extended detention pond with two stages. The lower stage would be the extended detention pool sized for the design WQV. The upper stage would be larger in area and sized for storm peak control.

Design the bottom slopes with a two percent minimum slope to promote drainage.

When a base flow into the pond exists, design the lower stage as a wetland marsh. In this case, provide a permanent pool of 6 to 12 inches below the design WQV. See section 10.10 for a list of wetland plants.

Provide an emergency spillway sized to discharge the peak runoff from the 100-year storm assuming the principal spillway is clogged.

Provide a minimum of 1 foot of freeboard above the 100-year design storm high water elevation.

Embankment heights shall not exceed 20 feet (measured from the downstream toe) and storage volumes shall not exceed 25 acre-feet. The minimum storage volume shall be 0.3 acre-feet. Regional facilities may exceed these limits, but they must comply with the applicable requirements of the Kentucky Division of Water.

Design earthen embankments with side slopes not steeper than 3:1 (horizontal to vertical).

Provide anti-seep collars where the spillway barrel passes through the embankment. Stabilize earthen embankments immediately with temporary or permanent vegetation in accordance with requirements of Chapter 11.

Reserve adequate access from public or private right-of-way by establishing a maintenance easement. Design the access to be at least 10 feet wide and not steeper than 5:1 (h:v) or less. Design the access way to connect to the embankment so that equipment can access the top of the embankment on a slope not greater than 5:1 (h:v).

Provide a minimum 25-foot wide buffer strip between the pond and the nearest property line. Landscape the buffer strip with low-maintenance native grasses, shrubs, and trees. Provide a landscaping plan for the pond and the buffer. Objectives of landscaping include improving the appearance for adjacent residents and providing wildlife habitat.

10.8.3 Design Procedures

Design procedures for stormwater quantity and peak discharge control are the same for extended detention ponds and traditional dry detention ponds, except that the design WQV will be retained longer in the extended detention pond. To design the storm detention volume and peak control structure for an extended detention pond, follow the procedures given in section 10.7.3 and assume for design purposes that the elevation of the dry pond bottom corresponds to the elevation of the surface of the design WQV (i.e., the top of the extended detention pool).

The outlet may be designed with a perforated riser or a sand filter outlet.

Sand Filter Outlet

Figure 10-13 illustrates the outlet configuration that shall be used to regulate discharge of the extended detention pool.

To size this device pick a preliminary configuration and check it using the falling head permeability equation. Set t equal to 24 hours and calculate k . If the calculated k varies significantly from 3.543 ft/hr adjust the filter dimensions and recalculate.

The falling head equation is:

$$k = 2.303 * (aL/At) * \log (H/h)$$

where:

k = coefficient of permeability (ft/hr),

a = average surface area of extended detention pool (ft²),
L = depth of sand (ft),
A = surface area of filter = width of sand layer * length of sand layer (ft²),
t = time (hr),
H = height of water over the perforated pipe with full extended detention pool (ft), and
h = height of filter from the top of the perforated pipe to the top of the sand (ft).

Size the sand filter trenches relative to the underdrain pipe such that the sand filter controls the discharge rate rather than the drain pipe. Provide calculations demonstrating that the underdrain pipe will convey the design flow rate under gravity flow conditions.

10.8.4 Specifications

Specifications are consistent with those provided in section 10.7.

10.9 WET PONDS

In this manual, wet pond refers to a basin designed for both water quality and water quantity management and which has a permanent pool. Figure 10-14 illustrates a wet pond.

10.9.1 Applicability

Wet ponds can be used for water quantity management and water quality treatment. For water quality treatment, the WQV is at least equal to the WQV derived from Table 10-1, less any credits earned from bioretention and infiltration.

The pond shall be located outside the receiving stream except when a pond is designed as a regional detention pond.

10.9.2 Design Criteria

Design retention ponds to have a contributing drainage area of at least 10 acres and a surface area of at least one-fourth of an acre.

When using a wet pond with a permanent pool for water quality control, size the permanent pool to at least equal the design WQV.

To calculate the design WQV, take the full WQV for the site, minus any credits allowed for infiltration and bioretention.

Design the permanent pool to have an average depth between 3 feet and 6 feet and a maximum depth of no more than 12 feet.

Design wet ponds to be wedge-shaped with the narrow end at the inlet and the wide end at the embankment.

Provide a minimum length to width ratio of 3:1 or provide gabion baffles to extend the flow path to a length that meets or exceeds the path that would be achieved using a 3:1 length to width ratio.

Provide irregular shorelines so that the permanent pool has a natural appearance.

Provide a 10-foot wide, 12-inch deep, underwater bench around the perimeter except at the embankment.

Provide safety benches at least 10 feet wide around the perimeter above the permanent pool. Design these benches to have a slope not greater than 10:1 (h:v).

Design a liner for the permanent pool using on-site soils or other materials. Document that the proposed soils are suitable for use as a liner by providing soil classification data (Unified Soil

Classification System) and standard moisture-density data (proctor density test). Design soil liners to be at least 6 inches thick.

Provide an emergency spillway sized to discharge the peak runoff from the 100-year storm.

Provide a minimum of 1 foot of freeboard above the 100-year design storm high water elevation.

Embankment heights shall not exceed 20 feet (measured from the downstream toe) and storage volumes shall not exceed 25 acre-feet. Regional facilities may exceed these limits, but they must comply with the applicable requirements of the Kentucky Division of Water.

Design earthen embankments with side slopes not steeper than 3:1 (horizontal to vertical).

Provide anti-seep collars where the spillway barrel passes through the embankment. Stabilize earthen embankments immediately with temporary or permanent vegetation in accordance with requirements of Chapter 11.

Reserve adequate access from public or private right-of-way by establishing a maintenance easement. Design the access to be at least 10 feet wide and no steeper than 5:1 (h:v). Design the access way to connect to the embankment so that equipment can access the top of the embankment on a slope no steeper than 5:1 (h:v).

Provide a minimum 25-foot wide buffer strip between the pond and the nearest lot. Landscape the buffer strip with low-maintenance native grasses, shrubs, and trees. Provide a landscaping plan for the pond and the buffer. Objectives of landscaping include improving the appearance for adjacent residents and providing wildlife habitat.

10.9.3 Design Procedures

Design of the stormwater detention volume and peak control structure for a wet pond is similar to procedures given for a traditional dry detention pond. The permanent pool is sized to match the design WQV, which allows for effective water quality treatment. For quantity control, the pond must have capacity to hold the stormwater detention volume above the permanent pool. That portion of the stormwater detention volume equal to the design WQV is called the extended detention volume. That volume must be discharged slowly to protect the receiving stream from increased flood frequency. See Figure 10-15.

Reverse Slope Pipe

This section describes the design procedure for sizing a reverse slope pipe to discharge that portion of the stormwater detention volume equal to the design WQV. Figure 10-15 illustrates a reverse slope pipe.

Select a pipe diameter, length, and material and use the energy equation to calculate the discharge. The energy equation can be written as:

$$Q = A (2gH)^{0.5} / (1 + K_e + K_b + K_c L)^{0.5}$$

where:

Q = discharge (ft³/s),

A = cross-sectional area of pipe (ft²),

g = 32.2 ft/s²,

H = head above discharge end of pipe (ft²),

K_e = entrance loss coefficient,

K_b = bend loss coefficient (0 for no bends),

K_c = head loss coefficient for pipe, and

L = pipe length (ft).

Assume that the design WQV is placed above the permanent pool and calculate the corresponding height above the permanent pool. This is the head value, H, corresponding to the WQV.

Calculate the discharge (Q) at 0.25-foot intervals from the top of the design WQV (extended detention pool) to the bottom of the extended detention pool (i.e., top of permanent pool).

Calculate the average discharge for each 0.25-foot increment by averaging the Q calculated at the top and bottom of each increment.

Use the stage-storage curve for the ponds to determine the storage volume in cubic feet corresponding to each 0.25-foot increment of depth.

Divide each incremental storage volume by its corresponding average discharge to calculate the time required for each incremental volume to be discharged through the selected pipe.

Sum the incremental discharge durations to determine if the total design WQV required 24 hours to discharge. If not, adjust the pipe size and recalculate.

10.9.4 Specifications

Specifications are consistent with those provided in section 10.7.

10.10 CONSTRUCTED WETLANDS

Constructed wetlands can provide a very effective management measure for mitigation of pollution from runoff, because they have the ability to assimilate large quantities of suspended and dissolved materials from inflow. The term “constructed wetland” can apply to a wetland that is constructed to mitigate impacts; to a natural wetland (per a Corps of Engineers permit); or a wetland that is constructed as part of a wastewater treatment system. In this manual, a constructed wetland is a device constructed in accordance with the following criteria and procedures to treat and control stormwater.

10.10.1 Applicability

Constructed wetlands can be used for both water quality and water quantity management or for water quality only. For management of water quantity, a wetland would be constructed much like a wet pond with a 6 to 12 inch deep permanent pool. The most important criteria in determining whether a constructed wetland is applicable is the existence of a base flow that can be used to supply the permanent pool.

10.10.2 Design Criteria

For water quality control, size the extended detention pool above the permanent pool equal to the design WQV.

Design the extended detention outlet so that at least 24 hours would be required to release the design WQV.

To calculate the design WQV, take the full WQV for the site, minus any credits allowed for infiltration and bioretention.

For stormwater quantity control, determine the necessary detention volume, and design the peak control outlet consistent with the design criteria and design procedures for detention ponds in Section 10.7. The extended detention volume is a portion of the total detention volume rather than being an addition to it.

Size the surface area of the wetland according to procedures described in the following section.

Provide a sediment forebay. Design the forebay to be 4 to 6 feet deep and have a volume of at least 10 percent of the design WQV at the inlet to the constructed wetland.

Use a reverse slope pipe as the extended detention outlet and protect it from blockage using aggregate as shown in Figure 10-15.

Provide a micropool at the extended detention outlet so that the reverse slope outlet pipe can be placed 1 foot below the permanent pool surface. Design the micropool to be 4 to 6 feet deep with a volume of at least 10 percent of the WQV.

Provide a drain with a valve at the base of the micropool.

Design the permanent pool, with the exception of the sediment forebay and the outlet micropool, to be 3 to 12 inches deep with an average depth of 6 to 9 inches.

Design the grades in the constructed wetland so that the wetland will drain to the micropool at the outlet if the micropool is drained. Providing the ability to drain the wetland will facilitate maintenance and revegetation if necessary.

Design the wetland to have low marsh and high marsh in the permanent pool. Low marsh refers to a zone with 6 to 12 inches of permanent pool, while high marsh refers to a zone with zero to 6 inches of permanent pool. Design the wetland so that low marsh and high marsh each represent 35 to 45 percent of the total surface area. Design so that the total deep pool (i.e., the micropool plus the sediment forebay) represents 10 to 20 percent of the surface area.

Design the wetland to have a length-to-width ratio of at least 2:1.

Reserve adequate access from public or private right-of-way by establishing a maintenance easement. Design the access to be at least 10 feet wide and no steeper than 5:1 (h:v). Design the easement to provide access to the sediment forebay and the outlet micropool.

Check the velocity of design storm flows at the inlet to the wetland and provide a stable entrance to prevent erosion.

Design a planting plan that shows 40 to 50 percent of the shallow (12 inches or less) wetland planted with wetland vegetation. Table 10-6 provides a list of suitable varieties generally available in this region. Plan to include a minimum of three emergent wetlands species as the majority planting with at least three additional emergent species comprising the remaining planting.

10.10.3 Design Procedures

Use Table 10-7 to determine the minimum surface area required based upon the size of the watershed draining to the wetland. Values in Table 10-7 are based upon expected nitrogen and phosphorus loading rates in urban areas and the maximum loading per acre that a constructed wetland can effectively treat.

Procedures for sizing the reverse slope pipe outlet at the micropool are consistent with procedures for wet retention ponds given in Section 10.9.

**TABLE 10.2 - NATIVE HERBACEOUS SPECIES SUITABLE FOR WET PONDS AND
CONSTRUCTED WETLANDS**

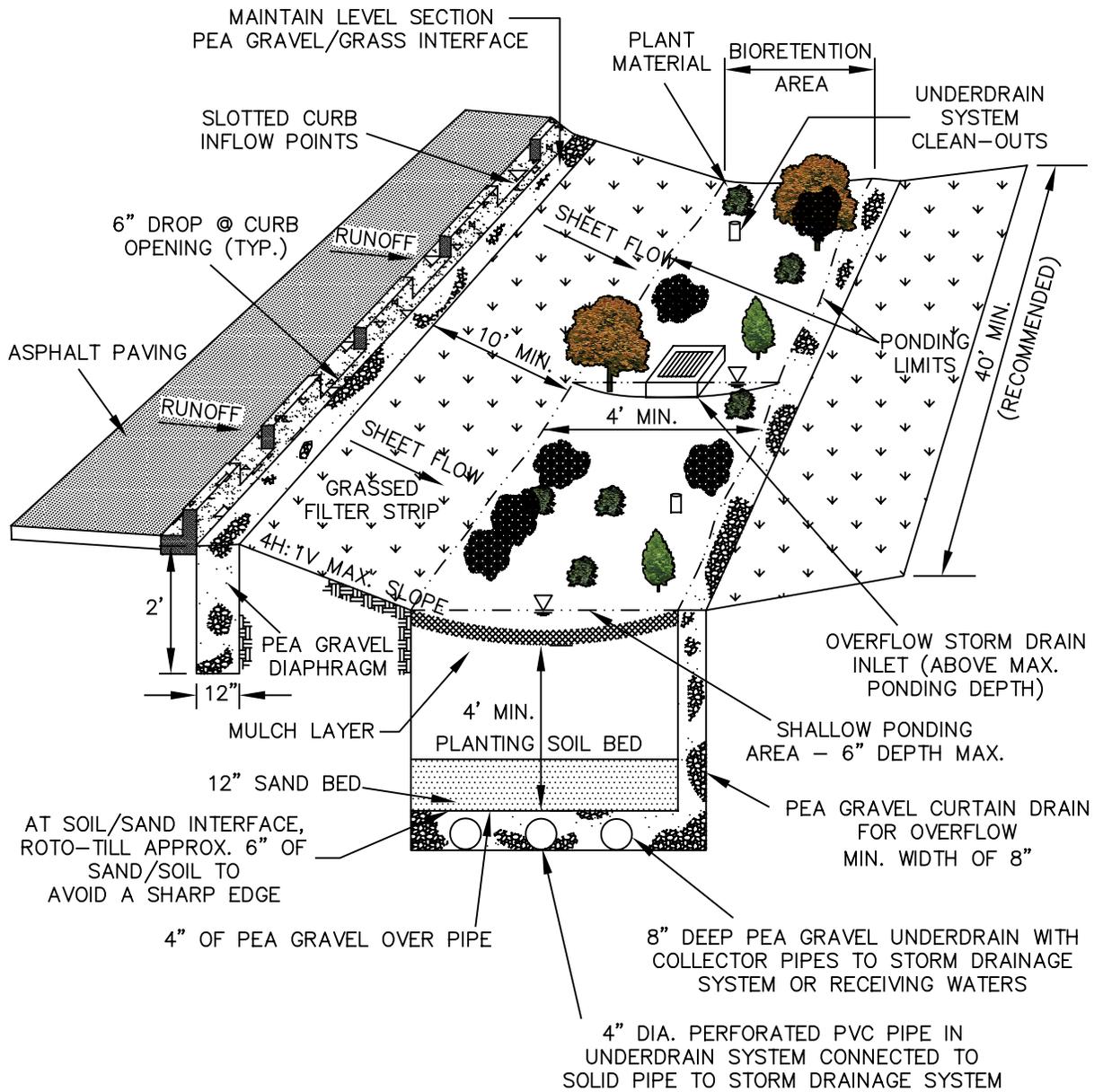
Common Name	Scientific Name	Water Depth
Switch Grass	<i>Panicum virgatum</i>	transitional
Swamp Milkweed	<i>Asclepias incarnata</i>	transitional
Giant Cane	<i>Arundinaria gigantea</i>	transitional
Jewelweed	<i>Impatiens capensis</i>	transitional
River oats	<i>Chasmanthium latifolia</i>	transitional
Deertongue	<i>Panicum clandestinum</i>	transitional
Boneset	<i>Eupatorium perfoliatum</i>	transitional
Sedges	<i>Carex spp.</i>	shallow
Soft rush	<i>Juncus effusus</i>	shallow
Rice cutgrass	<i>Leersia oryzoides</i>	shallow
Flat sedges	<i>Cyperus spp.</i>	shallow
Blueflag	<i>Iris virginicus</i>	shallow
Panic grass	<i>Panicum agrostoides</i>	shallow
Wool grass	<i>Scirpus cyperinus</i>	shallow
Pink smartweed	<i>Polygonum pennsylvanicum</i>	shallow
Green bulrush	<i>Scirpus atrovirens</i>	mid
Pickerelweed	<i>Pontederia cordata</i>	mid
Duck potato	<i>Sagittaria latifolia</i>	mid
Arrow arum	<i>Peltandra virginica</i>	mid
Bur-reed	<i>Sparganium eurycarpum</i>	mid
Spike rushes	<i>Eleocharis spp.</i>	mid
Water plantain	<i>Alisima subcordatum</i>	mid
Three square sedge	<i>Scirpus americanus</i>	mid
Yellow water crowfoot	<i>Ranunculus flabellaris</i>	deep
White water buttercup	<i>Ranunculus longirostris</i>	deep
Water lotus	<i>Nelumbo lutea</i>	deep
Spaderdock	<i>Nuphar advena</i>	deep
White water lily	<i>Nymphaea tuberosa</i>	deep
Duckweed	<i>Lemna spp.</i>	floating

Note: **transitional** = seasonally flooded edge
shallow = 0 – 6 inches, semi-flooded pool
mid = 6 – 20 inches, permanent pool
deep = 20 – 60 inches, permanent pool
floating = non rooted

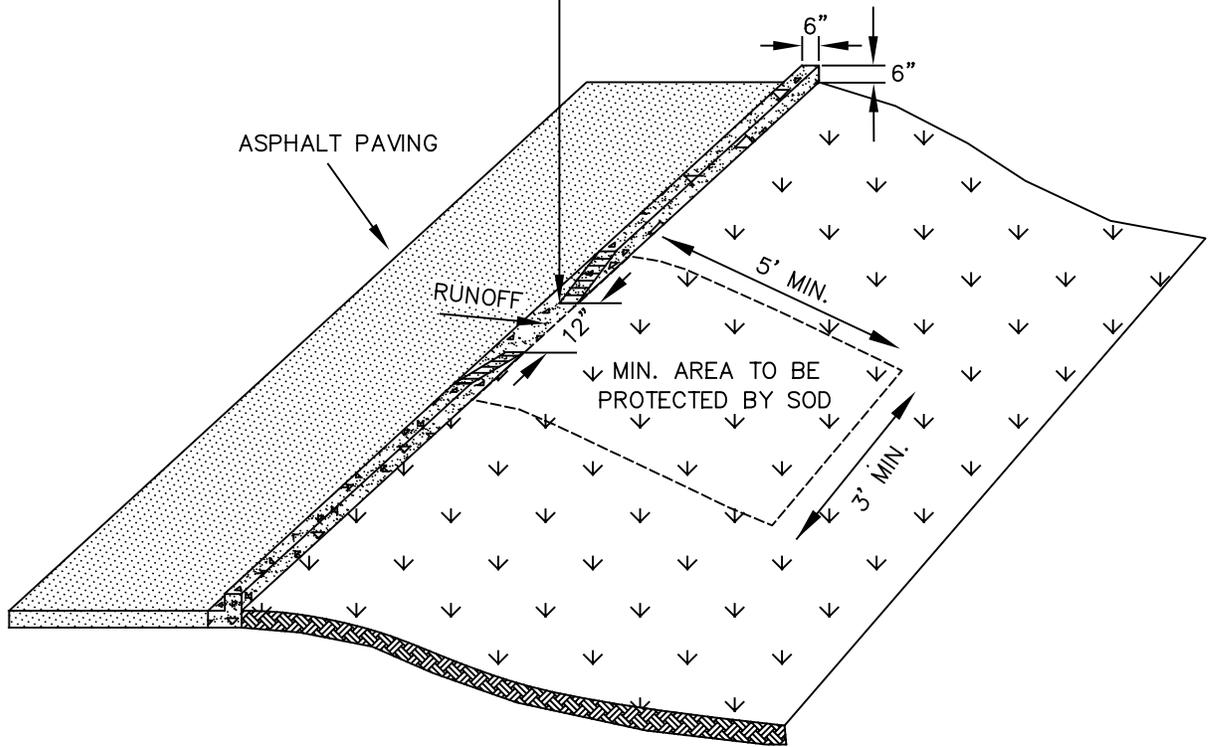
TABLE 10.3 - WETLAND SURFACE AREA

% Impervious Surface	Surface Area in Acres per Acre of Watershed
10	0.025
20	0.031
30	0.037
40	0.042
50	0.049
60	0.055
70	0.060
80	0.066
90	0.072
100	0.078

Note: Use linear interpolation for percent impervious values between those given in the table.

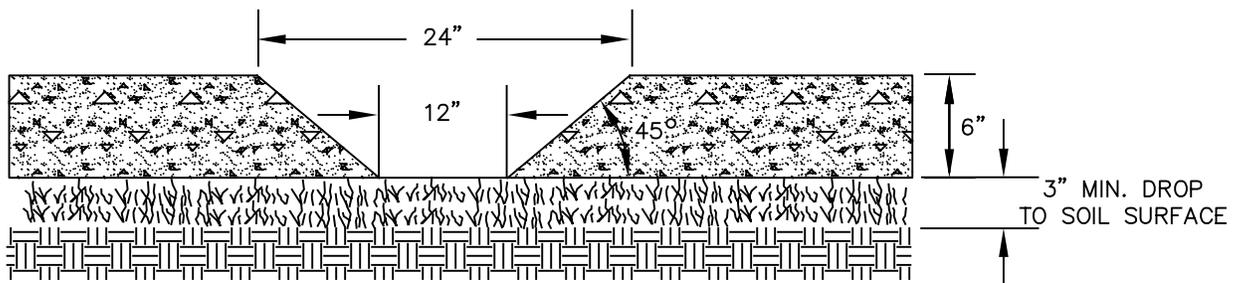


PROVIDE 3" MIN. DROP TO SOIL SURFACE
SO THAT GRASS BUILDUP DOES NOT BLOCK
CURB CUT



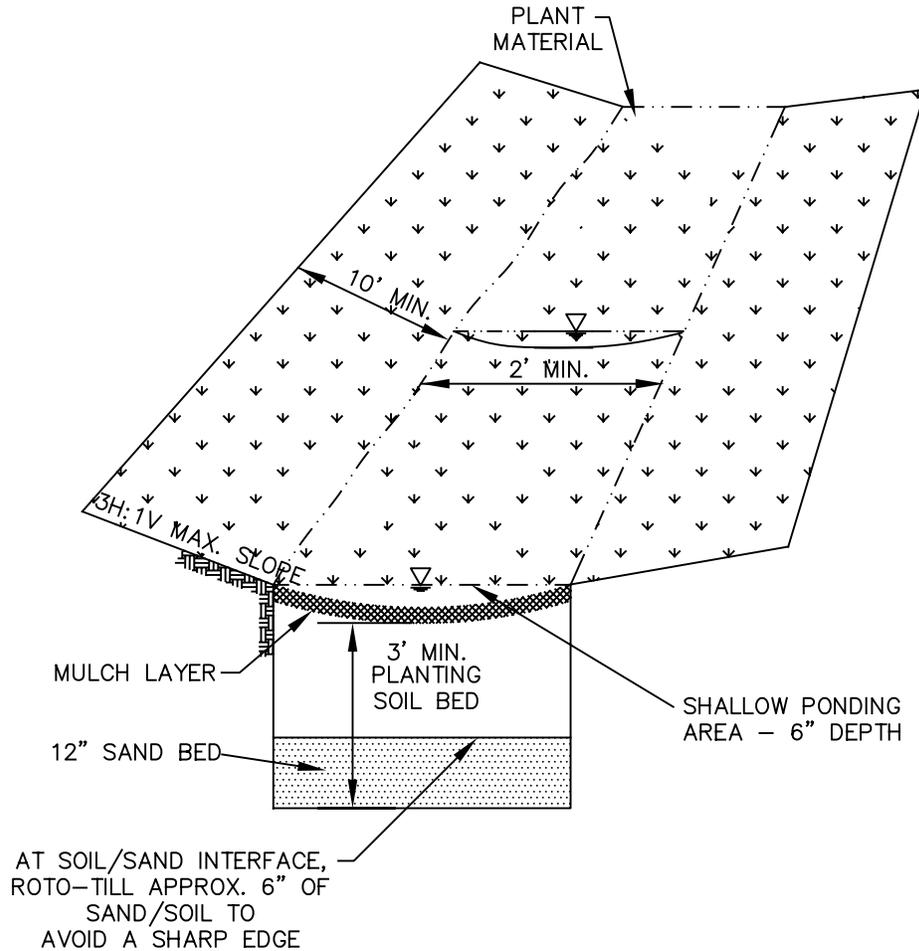
ISOMETRIC VIEW

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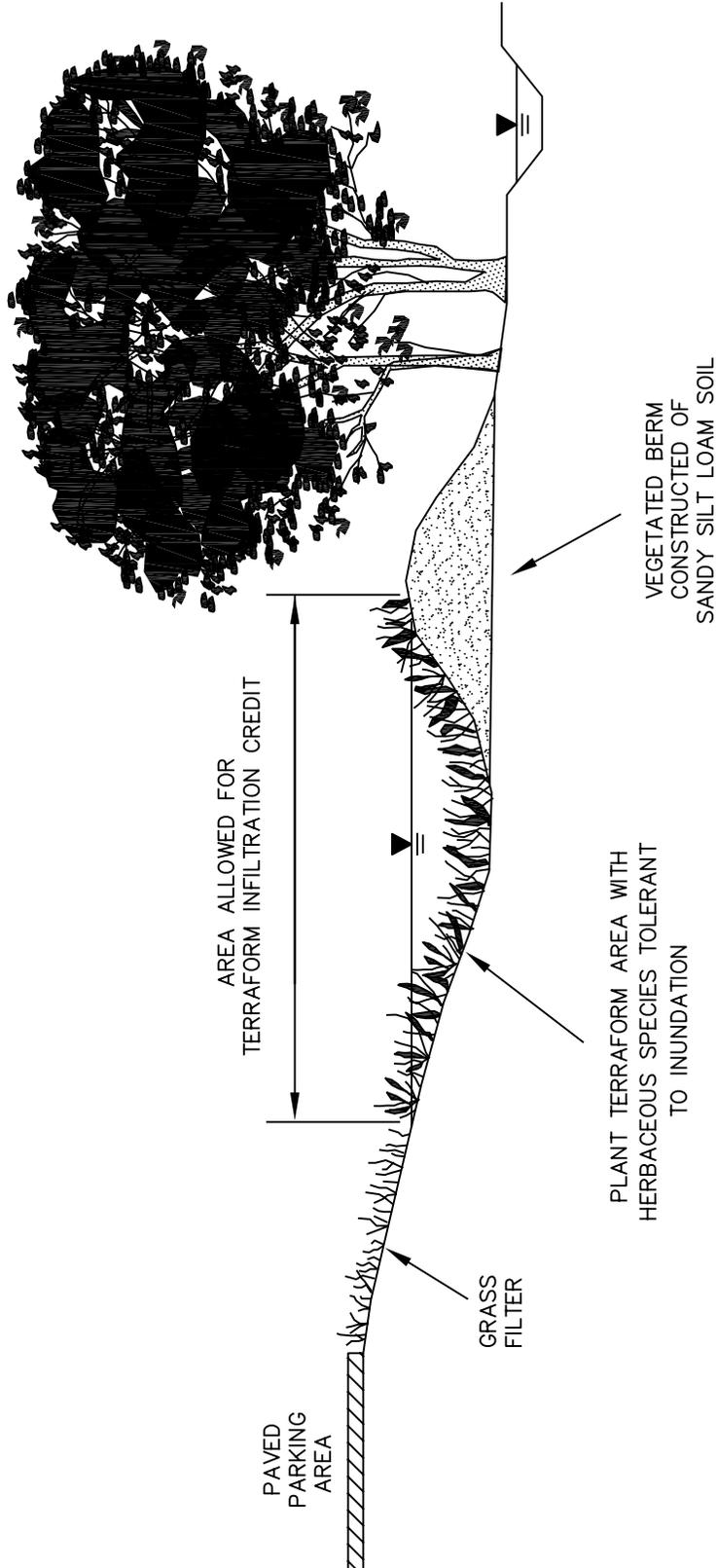


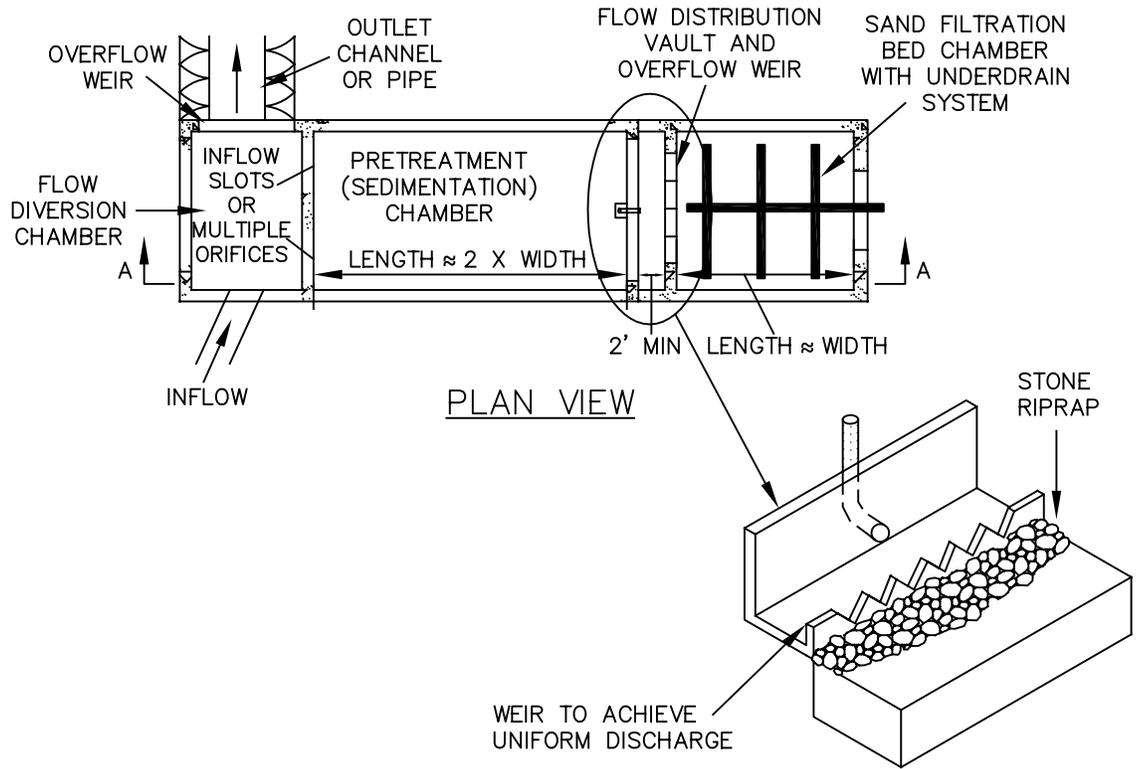
ELEVATION VIEW

N.T.S.

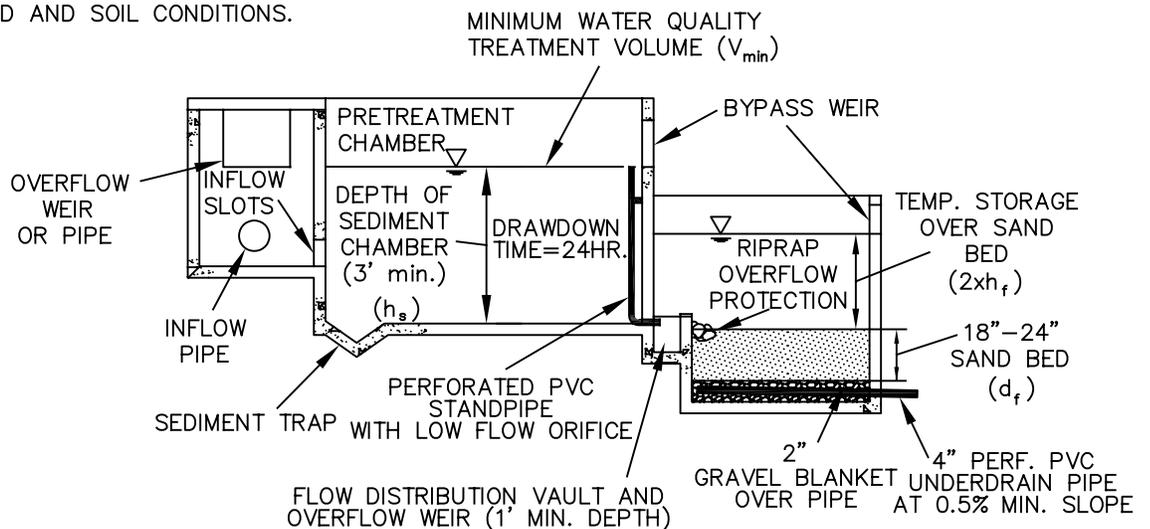


NOTE:
IF LONGITUDINAL SLOPE EXCEEDS 2 PERCENT, CONSTRUCT A BERM AT THE DOWNSTREAM END OF BIOFILTRATION SWALE. CONSTRUCT BERM SO THAT IT IS 12 TO 18 INCHES HIGH IN CENTER WITH A LEVEL TOP ACROSS THE PLANTING BED. CONSTRUCT THE BERM TO HAVE SIDE SLOPES NO GREATER THAN 2 HORIZONTAL TO 1 VERTICAL.



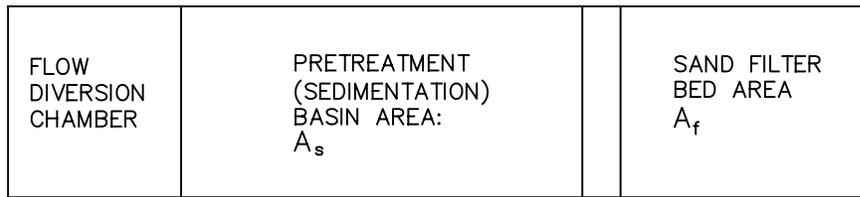


NOTE: STRUCTURAL CONCRETE DESIGNED FOR LOAD AND SOIL CONDITIONS.

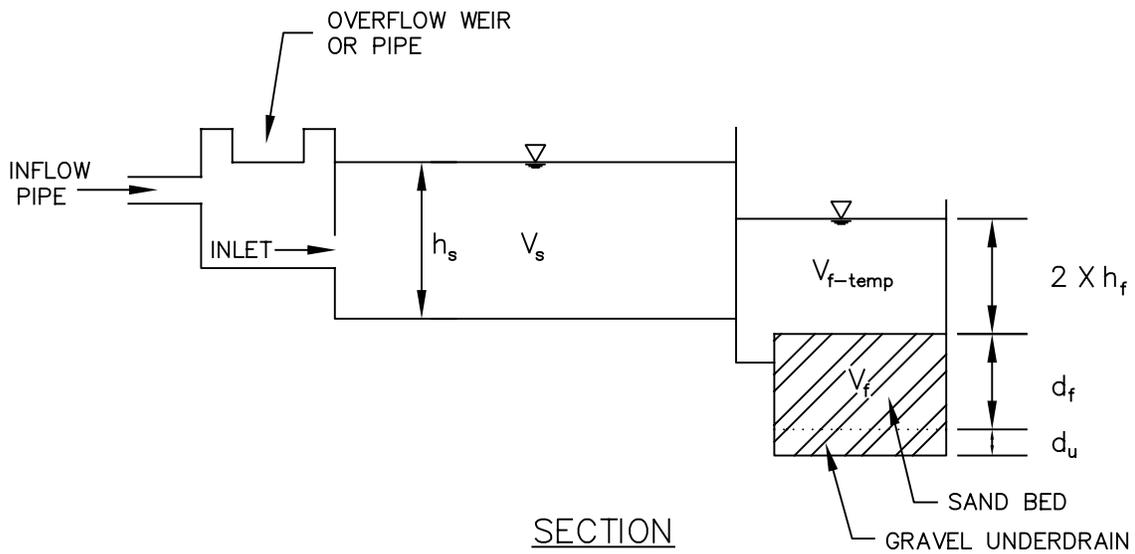


SECTION A-A

SOURCE: CLAYTOR AND SCHUELER, 1996



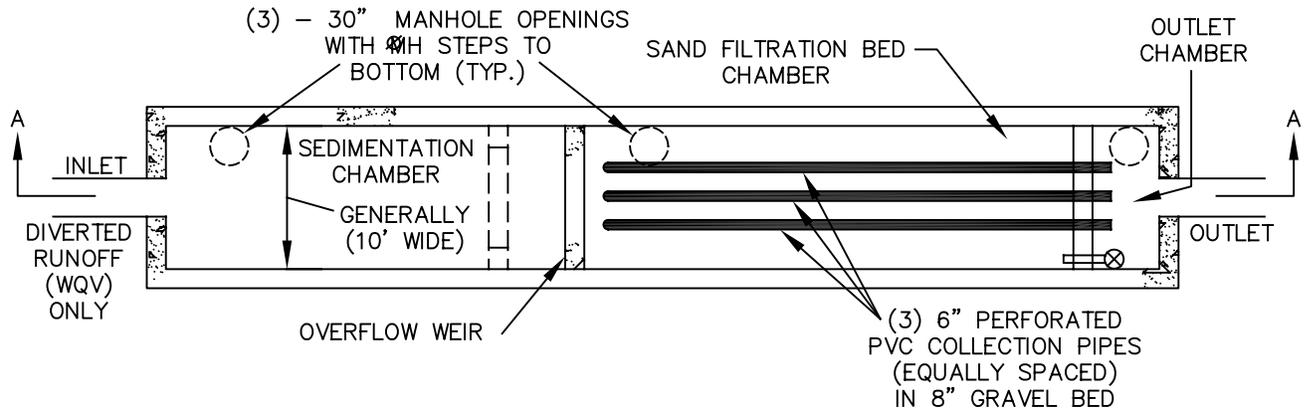
PLAN



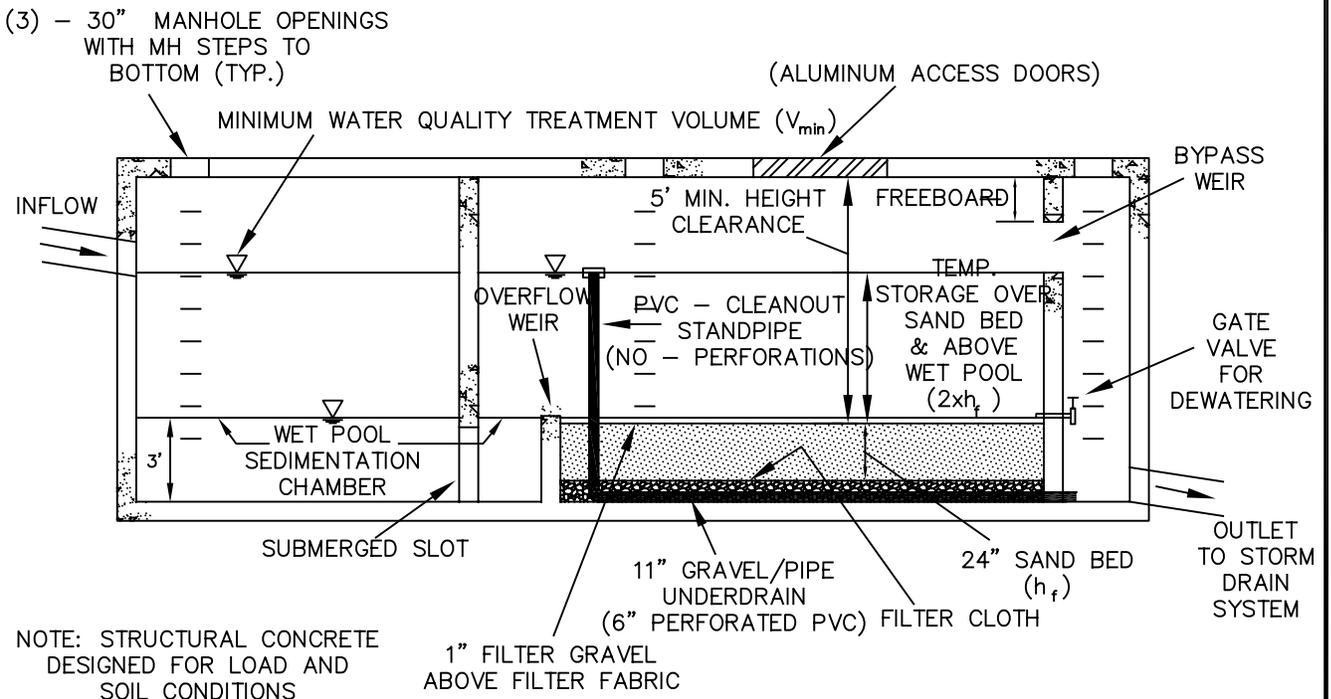
SECTION

$$V_{TOTAL} = V_s + V_{f-temp} + V_f$$

CHECK THAT $V_{TOTAL} \geq V_{MIN} = 0.75 \times WQV$

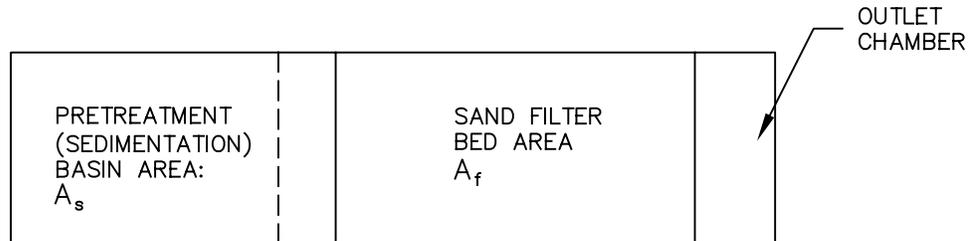


PLAN

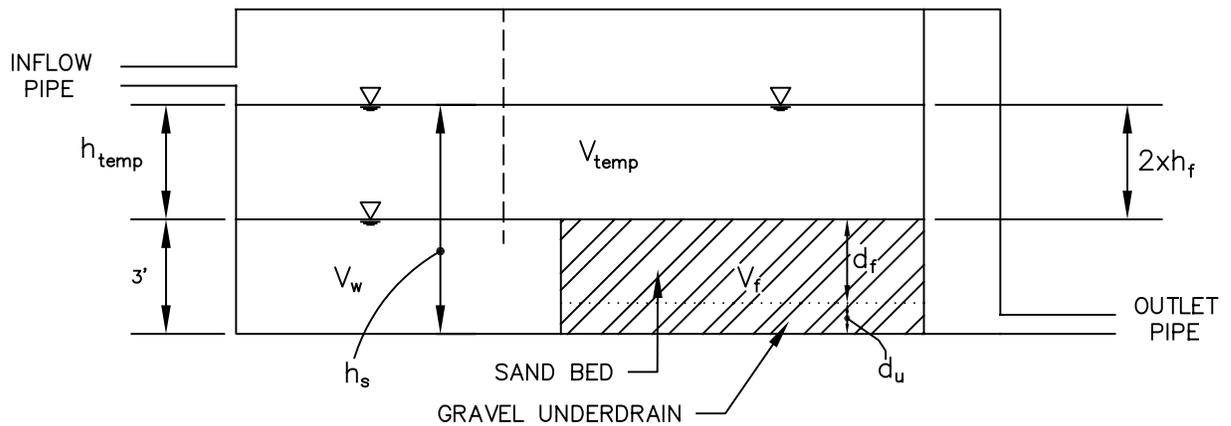


SECTION A-A

SOURCE: CLAYTOR AND SCHUELER, 1996



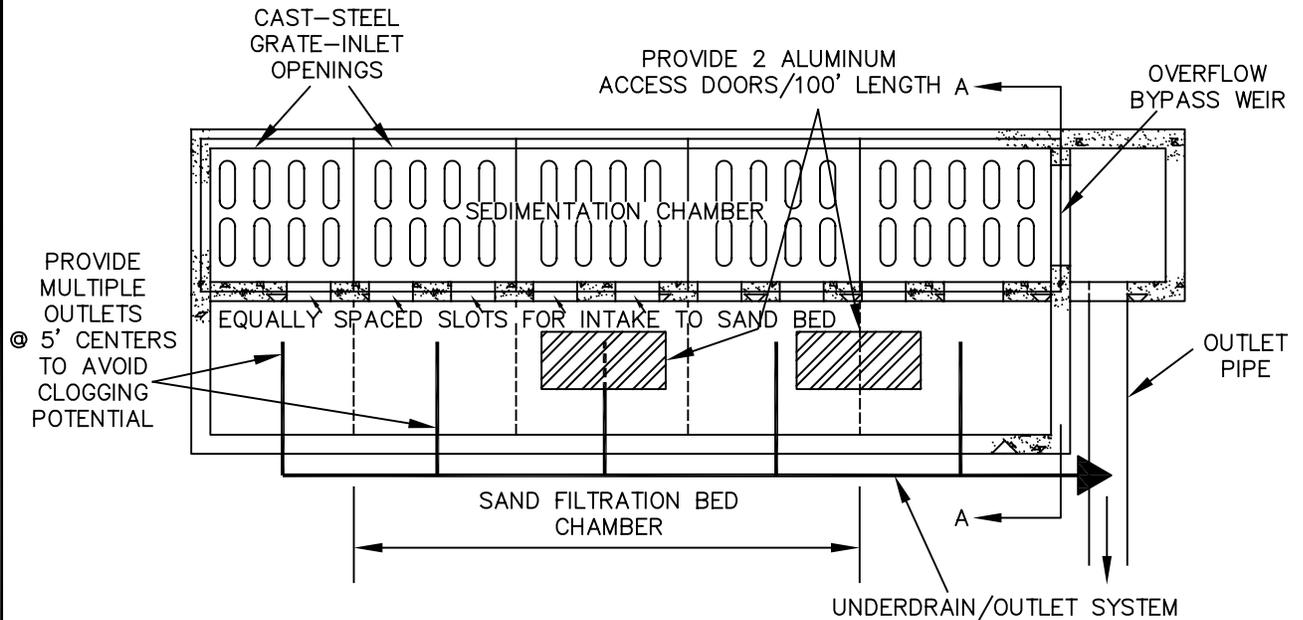
PLAN



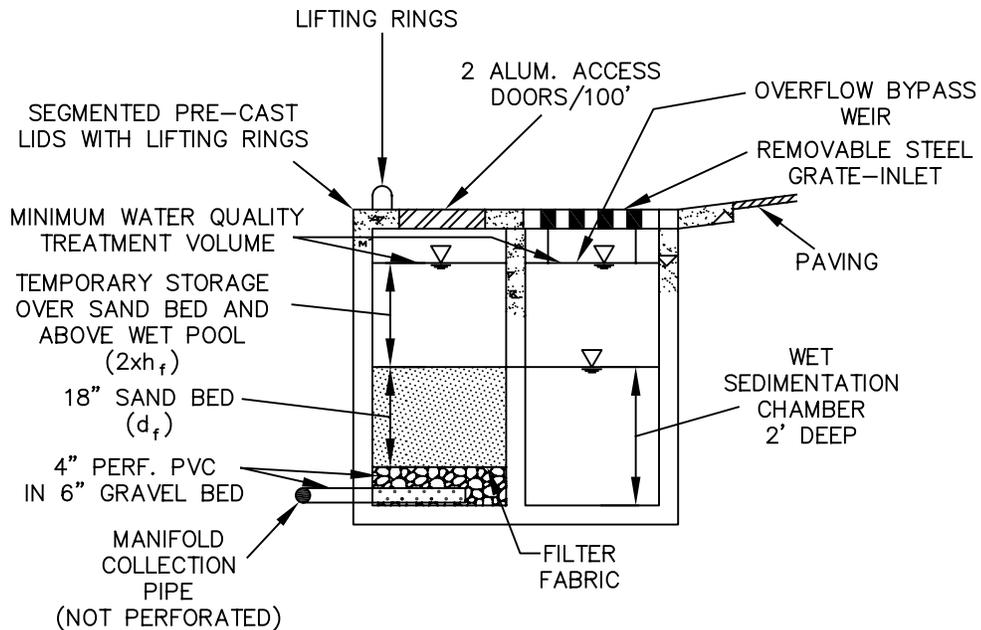
SECTION

$$V_{\text{TOTAL}} = V_w + V_{\text{temp}} + V_f$$

$$\text{CHECK THAT } V_{\text{TOTAL}} \geq V_{\text{MIN}} = 0.75 \times \text{WQV}$$

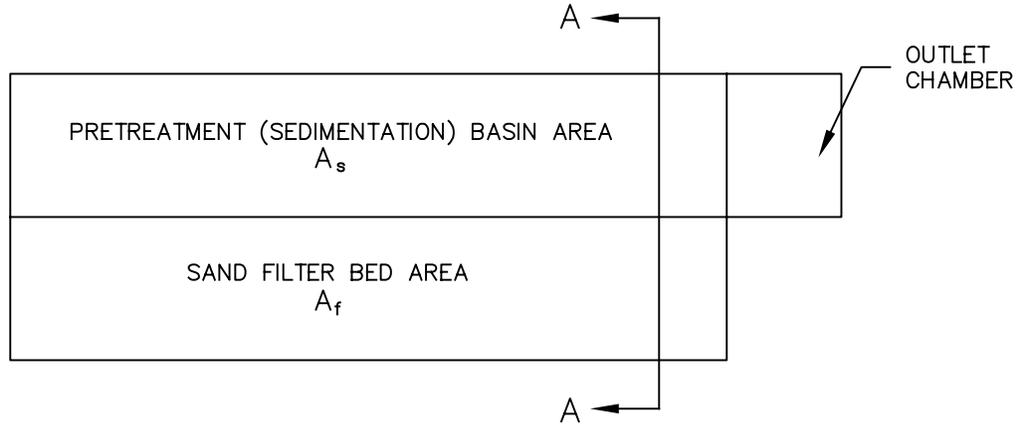


PLAN

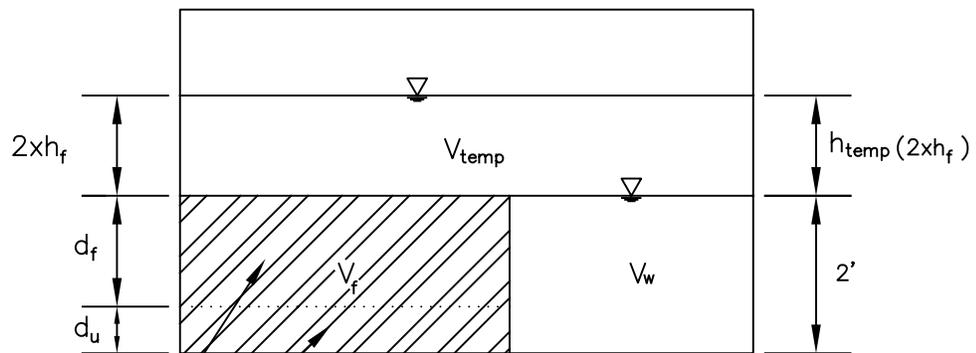


SECTION A-A

SOURCE: CLAYTOR AND SCHUELER, 1996



PLAN



SECTION A-A

SAND BED
GRAVEL UNDERDRAIN

$$V_{\text{TOTAL}} = V_w + V_{\text{temp}} + V_f$$

$$\text{CHECK THAT } V_{\text{TOTAL}} \geq V_{\text{MIN}} = 0.75 \times \text{WQV}$$

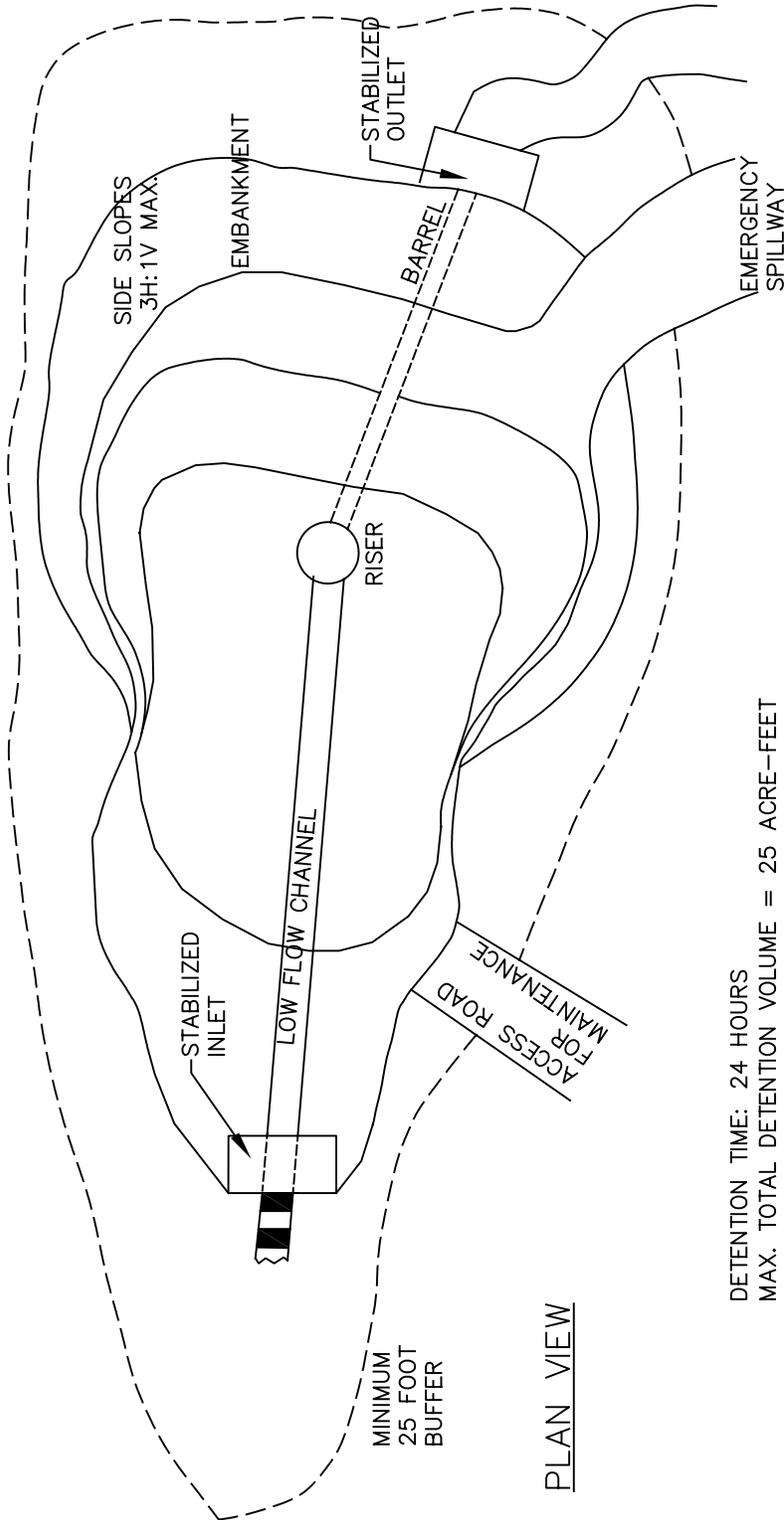
SOURCE: CLAYTOR AND SCHUELER, 1996

CITY
OF
DANVILLE

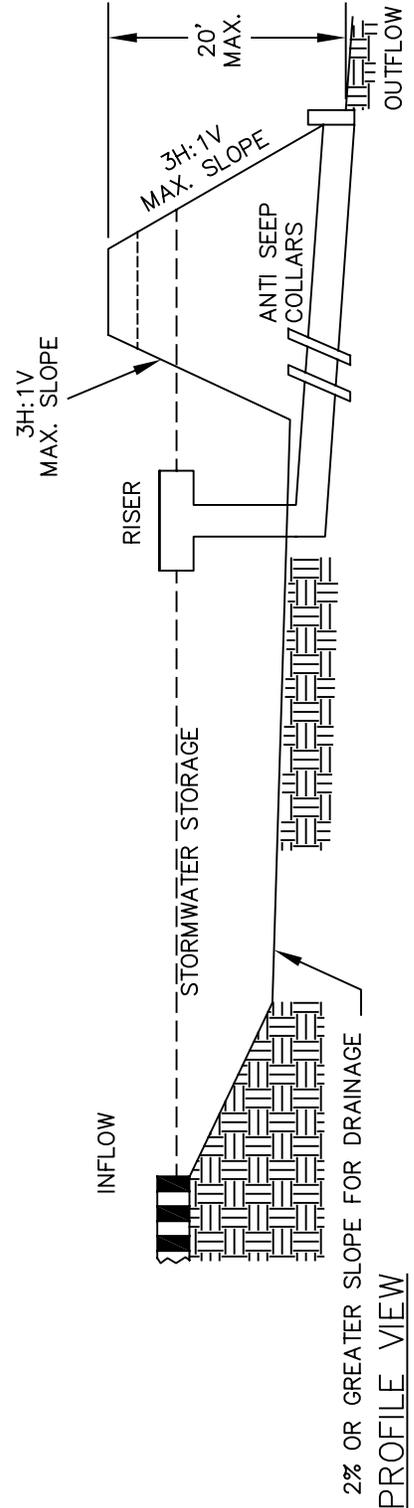
STORMWATER MANUAL

FIGURE 10-11

DETENTION POND



DETENTION TIME: 24 HOURS
MAX. TOTAL DETENTION VOLUME = 25 ACRE- FEET

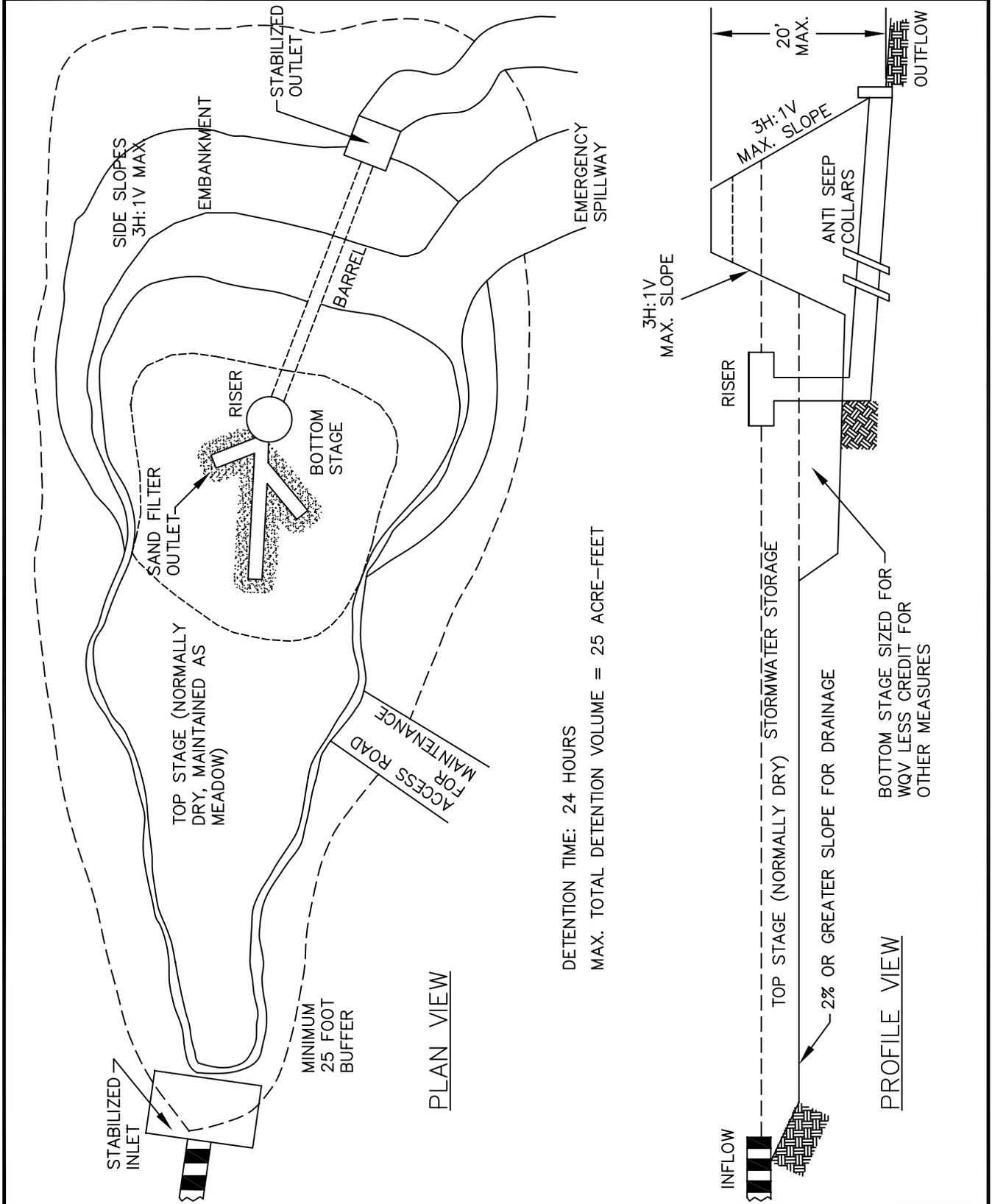


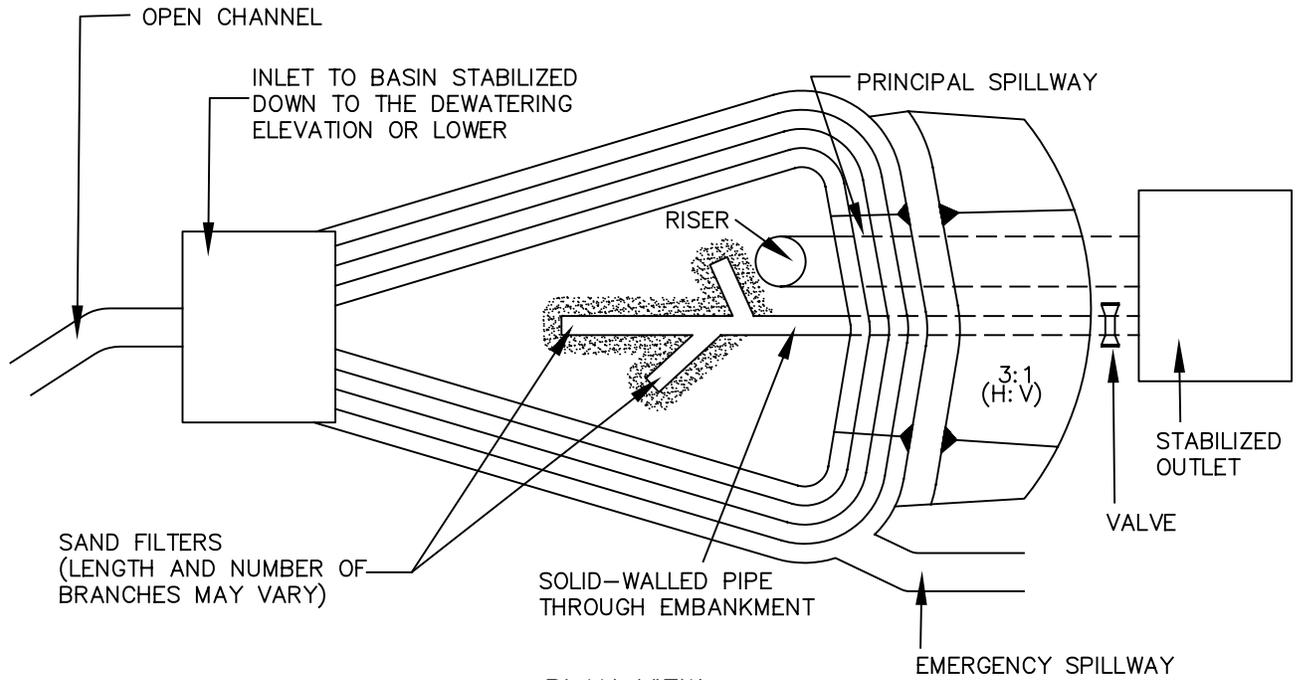
CITY
OF
DANVILLE

STORMWATER MANUAL

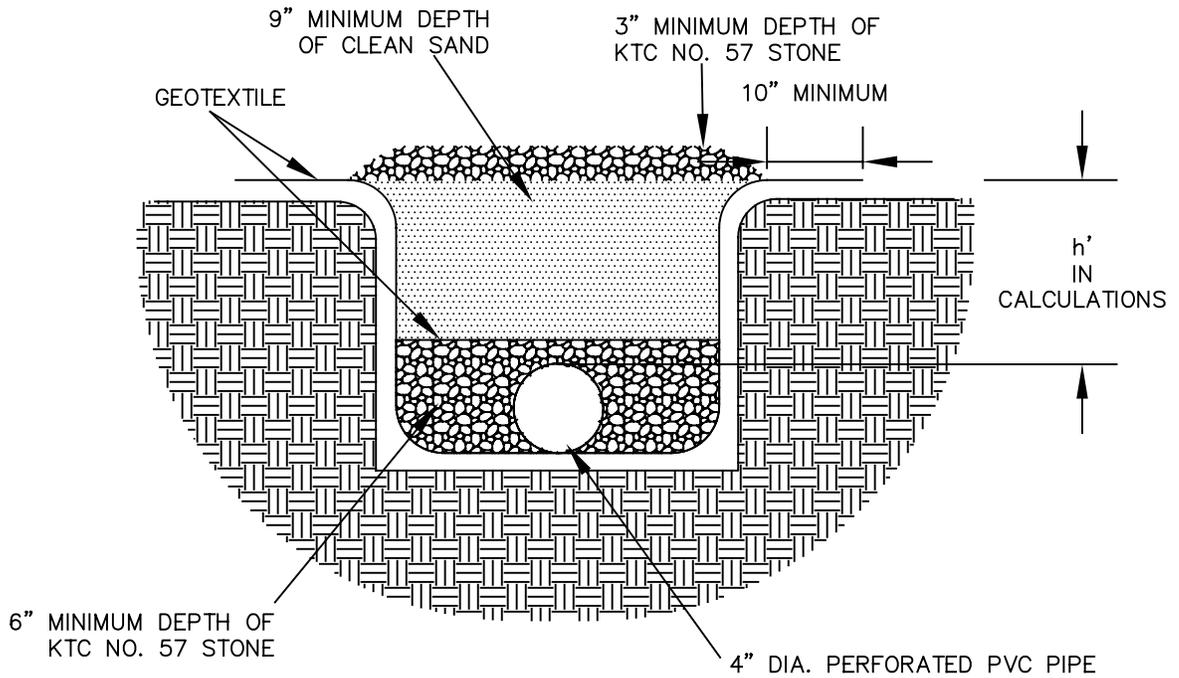
FIGURE 10-12

EXTENDED DETENTION POND

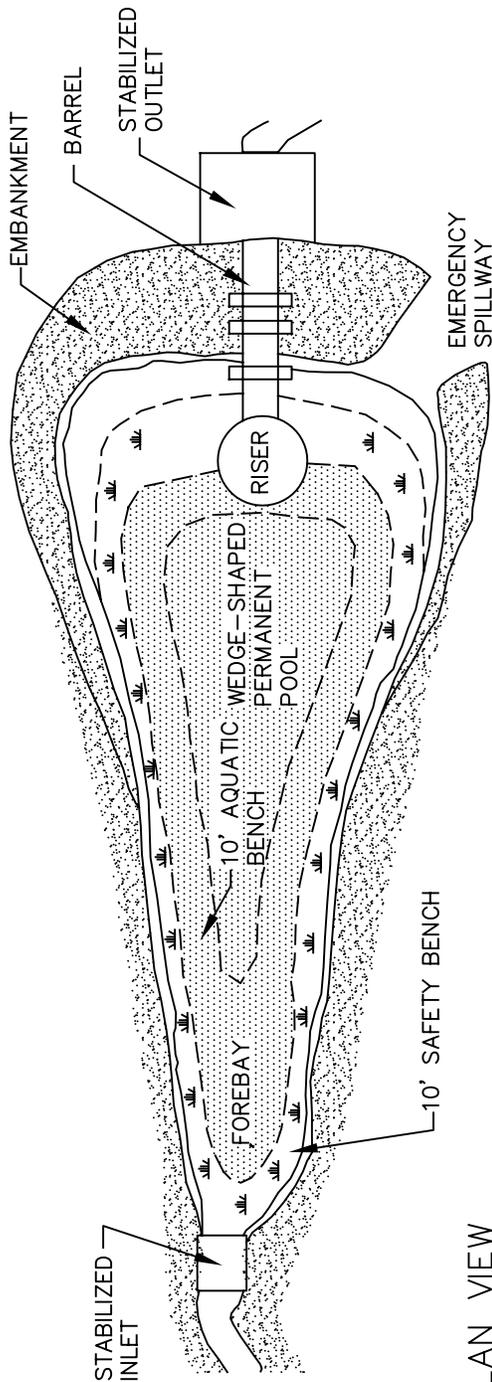




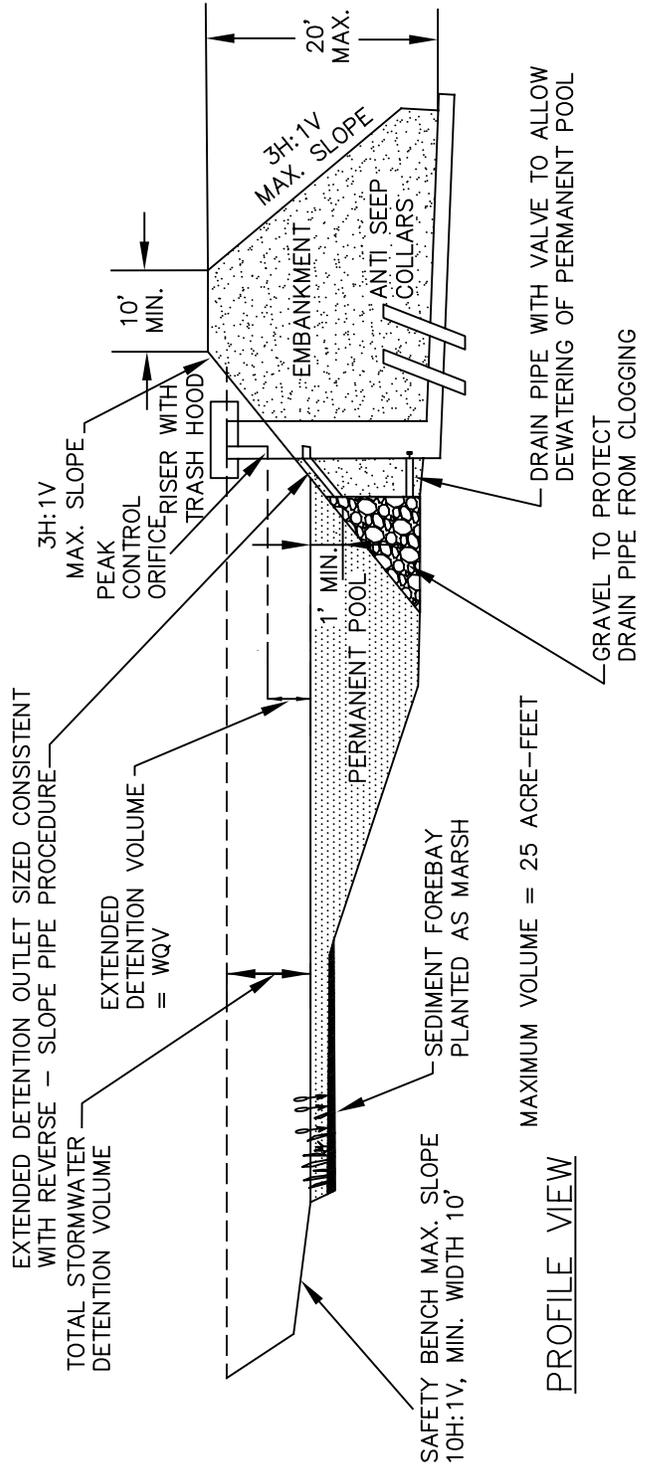
PLAN VIEW
N.T.S.



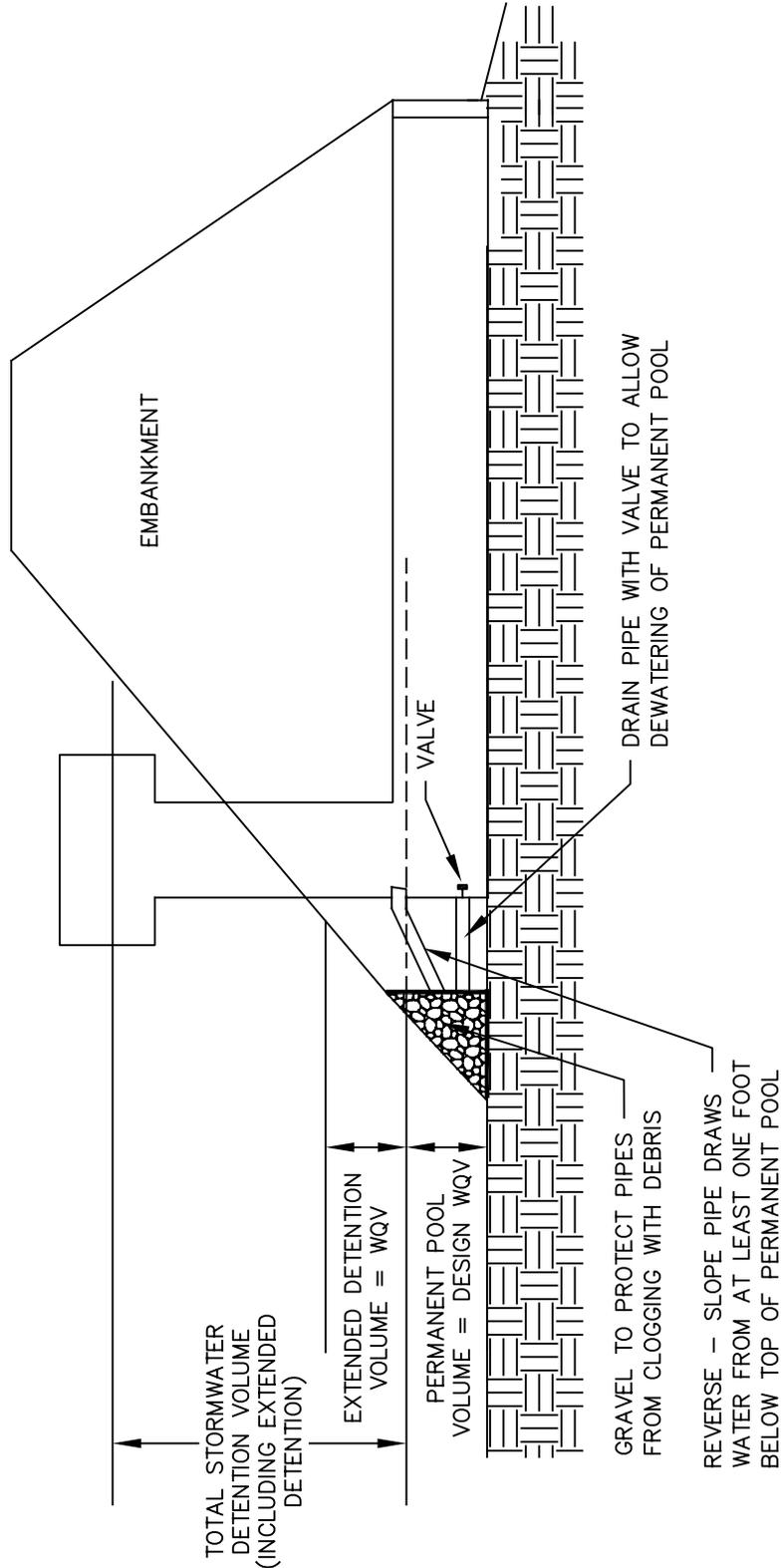
TYPICAL SECTION
N.T.S.



PLAN VIEW



PROFILE VIEW



PROFILE VIEW
N.T.S

CHAPTER 11
EROSION AND SEDIMENT CONTROL

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11.1 PURPOSE

This chapter describes requirements for the planning and implementation of nonstructural and structural best management practices (BMPs) to be used for erosion and sediment control during construction activities in the City of Danville. Erosion control refers to efforts to maintain soil on a construction site. Sediment control refers to keeping the material that erodes from leaving the site.

Sediment leaving a construction site results in the following adverse impacts to the stream environment:

- loss of habitat due to decreased light penetration,
- decreases in channel capacity
- decreases in reservoir storage capacity.

Non-structural practices, which are primarily avoidance practices, and structural practices, which require construction, are described in this chapter. A construction site will require the implementation of both types of practices. Details on the structural practices are given in Sections 11.4 and 11.5 of this manual.

11.1.1 Regulatory Basis

KPDES General Permit for Stormwater Point Sources (Construction)

Erosion and sediment control on a construction site are regulated by the Kentucky Pollutant Discharge Elimination System (KPDES) General Permit for Stormwater Point Sources (Construction). The KPDES General Permit requires, among other things:

- the submission of a Notice of Intent to the Kentucky Division of Water before construction begins,
- the preparation of a stormwater best management practices plan, which includes an erosion and sediment control plan, to be kept on-site at all times,
- a description of procedures to maintain erosion and sediment control measures during the life of construction,
- the inspection by qualified personnel, provided by the developer, of the site at least once every seven calendar days and within 24 hours of the end of a storm of 0.5 inch or greater,
- the identification of each contractor or subcontractor who will install each erosion and sediment control measure,
- the signing by each contractor or subcontractor of a statement certifying their awareness of the requirements of the KPDES Stormwater Permit for the site, and
- the submission of a Notice of Termination to the Kentucky Division of Water, at the end of the project, which certifies that all stormwater discharges associated with the construction activity have been eliminated.

KPDES General Permit for Small Municipal Separate Storm Sewer Systems

On January 1, 2003, the Kentucky Division of Water issued the stormwater general permit for cities in Kentucky, including the City of Danville, covered by the U.S. EPA Phase II stormwater regulations. This permit requires the city to develop, implement, and enforce a program to address stormwater runoff from construction activities. The implementation of the requirements contained in this chapter will be a primary mechanism for accomplishing this objective. This chapter gives detailed design information on the structural and non-structural methods for erosion and sediment control.

11.2 REQUIREMENTS

This section lists the erosion and sediment control requirements.

11.2.1 Erosion and Sediment Control Plan

The preparation of an erosion and sediment control plan integrating the nonstructural and structural practices and procedures of this chapter is a requirement for all construction projects that disturb one acre or more, and for disturbed areas of less than one acre if the site is a larger common plan for development in accordance with US EPA guidelines (possibly including construction on individual platted lots) or if discharges from the site could impair the receiving waters. For more information on permits, see Chapter 2 of this manual. More detail on the preparation of the Erosion and Sediment Control Plan is found in Section 11.3 of this manual.

Land disturbances for the construction of a structure on a single residential lot are permitted through the building permit process and must comply with the requirements of Section 11.6 of this manual.

11.2.2 Non-Structural Practices

This section describes the planning and implementation of the required nonstructural BMPs to minimize erosion and off-site sedimentation.

These BMPs include

- floodplain avoidance,
- stream buffer zones,
- reduced exposure time, and
- embankment slope minimization.

Floodplain Avoidance

No construction or grading activities are permitted in the post-development floodplains, as defined in Chapter 1 of this manual, except for road and utility crossings and permanent stormwater management facilities. Therefore, only erosion and sediment control practices related to allowable construction activities shall be permitted in the post-development floodplain. Temporary sediment control in a permanent pond shall be allowed in the post-development floodplain but not in a stream.

Vegetative Buffer Strips

Buffer strips are required adjacent to all streams and wetlands. The buffer strip width shall be 25 feet from the top of each bank and from the edge of a wetland. No grading or land clearing is allowed within the buffer zone, and native vegetation must be preserved.

Reduced Exposure Time

All on-site measures required by the Erosion and Sediment Control Plan shall be made functional before other land disturbance takes place. Permanent or temporary soil stabilization, as described under structural practices, shall be applied to disturbed or constructed areas within 14 days after final grade is reached. Soil stabilization shall also be applied to all disturbed areas not at final grade, including soil stockpiles, dams, dikes, and diversions, which have been inactive for 14 days.

Embankment Slope Minimization

Steep embankment slopes present increased opportunities for erosion and sediment production due to high runoff velocities. To minimize adverse effects of steep embankment slopes, constructed fill slopes and cut slopes shall not be steeper than 3H:1V. For slopes of 4H:1V or steeper with slope lengths of greater than 100 feet, temporary diversion ditches shall be constructed at the top of the slope and every 100 feet horizontally down the slope.

11.2.3 Structural Practices for Soil Stabilization

This section describes the planning and implementation of the required structural BMPs to minimize erosion and off-site sedimentation through the stabilization of soil materials.

The BMPs include:

- mulch,
- temporary seed,
- permanent seed,
- sod,
- road/parking stabilization,
- construction entrance,
- dust control,
- geotextiles,
- gabion mattress,
- paved ditch,
- temporary diversion ditch,
- level spreader,
- permanent vegetated waterway,
- pipe slope drain, and
- impact stilling basin.

Mulch

Mulch shall be used as a soil stabilization measure for any disturbed area inactive for 14 days or longer. Areas requiring stabilization during December through February shall receive only mulch held in place with bituminous material. Mulching shall be used whenever permanent or temporary seeding is used. Mulch shall also be used with sod placed during the periods of June 15 to September 1 or October 15 to March 1. The anchoring of mulch shall be in accordance

with Figure 11-1 except all mulch placed in December through February, on other than sod areas, shall be anchored with bituminous materials regardless of the slope.

Permanent mulches shall be used in conjunction with planting trees, shrubs, and other ground covers that do not provide adequate soil stabilization.

Temporary Seed

Temporary seeding shall be used for soil stabilization when grades are not ready for permanent seeding, except during December through February. Only rye grain or annual rye grass seed shall be used for temporary seeding. The use of mulch and erosion matting and netting with temporary seeding shall be in accordance with Figure 11-1.

Permanent Seed

Permanent seeding shall be applied within 14 days after final grade has been reached, except during December through February. Permanent seeding shall also be applied on any areas that will not be disturbed again for a year even if final grades have not been reached. The use of mulch and erosion matting and netting with permanent seeding shall be in accordance with Figure 11-1. "Seed mats" may be used for permanent seeding in accordance with manufacturers' recommendations.

Sod

Sod shall be used for disturbed areas that require immediate vegetative cover, e.g., the area surrounding a drop inlet in a grassed waterway, the design flow perimeter of a grassed waterway that will convey flow before vegetation can be established, and the inlet of a culvert. Sod may be installed throughout the year. "Seed mats" and seed with geotextiles may be used in place of sod when done in accordance with manufacturers' recommendations.

Road/Parking Stabilization

Gravel or paved material shall be used to stabilize permanent roads or parking areas or roads or parking areas used repeatedly by construction traffic. Stabilization shall be accomplished within 14 days of grading or initiation of use for construction traffic. Unstabilized roads are not acceptable except in instances where the road will be used less than one month.

Stabilized Construction Entrance

A stabilized construction entrance shall be constructed wherever vehicles are leaving a construction site to enter a public road or at any unpaved entrance/exit location where there is a risk of transporting mud or sediment onto paved roads. A construction entrance shall be constructed at the beginning of the project before construction traffic begins to enter and exit the site.

Dust Control

Dust control measures shall be implemented on all sites.

Nets and Mats

Mulch netting, erosion control matting, or turf reinforcement matting (TRM) shall be used on sloping areas as indicated in Figure 11-1. Mats or nets and permanent seeding may be used as an alternate to sod for culvert entrances and grassed waterways. TRMs shall be used at the water line to control wave action in wet ponds. TRMs shall be used in accordance with manufacturer's recommendations.

Gabion Mattress

Gabion mattresses shall be used at the outlets of all culverts and storm drains with an exit velocity greater than 5 feet per second when flowing full, except where there are paved ditches. Gabion mattresses shall also be used at the outlet of impact stilling basins.

Temporary Diversion Ditch

Temporary diversion ditches shall be used to collect sediment-laden runoff from disturbed areas and direct it to a sediment pond where applicable. Temporary ditches are those expected to be in use for less than one year. Temporary diversion ditches do not require stabilization.

Level Spreader

Level spreaders shall be constructed at the outlets of temporary diversion ditches. Level spreaders shall also be constructed at outlets of permanent constructed waterways where they terminate on undisturbed areas.

Permanent Constructed Waterway

Permanent constructed waterways shall be used to divert stormwater runoff from upland undisturbed areas around or away from areas to be disturbed during construction. A waterway expected to be in place for at least one year shall be considered permanent. Permanent waterways shall be lined with sod or permanent seeding and nets, mats, or TRMs. Design permanent constructed waterways in accordance with procedures and criteria given in Chapter 8.

Pipe Slope Drain

Pipe slope drains shall be used whenever it is necessary to convey water down a steep slope, which is not stabilized or which is prone to erosion, unless paved ditch (flume) is installed.

Impact Stilling Basin

Impact stilling basins shall be used at the outlet of culverts and pipes with calculated exit velocities greater than 15 feet per second when flowing full.

11.2.4 Structural Practices for Sediment Control

This section describes when and where specific structural sediment control practices are required. The practices include:

- check dam,
- sediment trap,
- sediment pond,
- silt fence,
- storm drain inlet protection,
- filter strip, and
- stream crossing.

Check Dam

Check dams shall be installed in newly-constructed, vegetated, open channels, which drain 10 acres or less. Check dams shall be constructed prior to the establishment of vegetation.

Sediment Trap

Sediment traps shall be installed below all disturbed areas of less than 5 acres that do not drain to a sediment pond.

Sediment Pond

A sediment pond shall be installed at the outlet of a disturbed area of 5 acres or more. The maximum drainage area for a single pond is 100 acres. The pond shall be designed to reduce peak discharges during construction to predevelopment levels for 10-year and 100-year storms.

Silt Fence

Silt fence shall be installed down-slope of areas to be disturbed prior to clearing and grading. Silt fence must be situated such that the total area draining to the fence is not greater than one-fourth acre per 100 feet of fence. Silt fence shall be used for storm drain drop inlet protection and around soil stockpiles.

Storm Drain Inlet Protection

Storm drain inlet protection shall only be used around drop inlets when the upslope area draining to the inlet has no other sediment control.

Filter Strip

Filter strips shall be used on each side of permanent constructed channels. The buffer strips described in Section 11.2.2 satisfy the filter strip requirement for streams and wetlands.

Stream Crossing

Stream crossings shall be used in cases where construction traffic, permanent traffic, or utilities must cross existing post development floodplains. If the watershed area exceeds 1 square mile at the point of crossing and a structure is necessary, the structure must be designed by a professional engineer licensed in Kentucky. If applicable, U.S. Army Corps of Engineers and the Kentucky Division of Water permits, as indicated in Chapter 2 of this manual, may be required.

Pump-Around Flow Diversion

A pump-around flow diversion shall be used to divert flow around construction activities occurring in a stream when those activities are reasonably expected to cause the erosion or deposition of sediment in the stream.

11.3 EROSION AND SEDIMENT CONTROL PLANS

An erosion and sediment control plan shall be approved by the City of Danville before construction commences for any project with a total disturbed area of one acre or more, and for disturbed areas of less than one acre if the site is part of a larger common plan for development or sale in accordance with EPA guidelines (possibly including construction on individual platted lots) or if discharges from the site could impair the receiving waters. The plan shall be developed and signed by a professional engineer or landscape architect licensed in Kentucky. All hydrologic, hydraulic, structural, and geotechnical design work included in the plan must be done and signed by a professional engineer licensed in Kentucky. The plan shall include the topics described in the following subsections.

The erosion control requirements for individual lots are covered in Section 11.6.

11.3.1 Written Description

The erosion and sediment control plan must contain a written description that shall include, at a minimum:

- a discussion of the land-disturbing project including the purpose, location, and size of area to be disturbed;
- a discussion of the topography, land cover condition, soils, percent of impervious area, and drainage patterns both before and after development;
- an identification of land use and cover conditions on adjacent property;
- the beginning and completion dates of construction activities;
- a discussion of construction sequencing, including clearing, grading, and revegetation activities as well as winter shut downs;
- a listing of erosion and sediment control BMPs, along with location, installation schedule, and the logic for each;
- a listing of stormwater pollution control and groundwater protection BMPs to minimize pollution during construction (other than erosion) that might result from construction activities (for example, gasoline or diesel spilled while refueling construction vehicles).

11.3.2 Site Map

The erosion and sediment control plan must contain a site map showing:

- current topography from field surveys or aerial photography at a minimum scale of 1"=50' with at least 2-foot contours showing pre-construction topography, drainage ways, property lines, utilities, limits of construction, and trees to be preserved;
- finished grades, building locations, paved areas, construction entrances, access or haul roads, stockpile areas and equipment storage areas overlaid on the site topographic map;
- all planned BMPs overlaid on the other features; and
- areas that are not to be disturbed.

11.3.3 Drawings and Specifications

Drawings and specifications of the BMPs shall be included in the plan.

11.3.4 Design Calculations

All hydrologic, hydraulic, structural, and geotechnical design calculations shall be included in the plan.

11.3.5 O & M Plan

An operation and maintenance (O & M) plan shall be developed that provides a schedule for inspection, maintenance, and repair of BMPs during construction activities. A maintenance schedule shall also be provided to ensure that permanent measures such as vegetation are properly established after construction is complete.

11.3.6 Responsible Parties/Construction Supervisor

The name, address, and telephone number of the parties responsible for implementing the plan shall be included in the plan. The name of the construction supervisor who will be on-site shall be included in the plan.

11.3.7 Education/Training

The education and training requirements for implementation of the plan shall be accomplished by the Engineer, who shall provide for initial training and continuing education for all construction employees and subcontractors of the contractor to inform them of the plan requirements. As work progresses and various subcontractors and/or new employees are brought onto the work site, each should be familiarized by the Engineer with the plan. At the beginning of each workweek, scheduled items of the plan to be implemented during that week should be brought to the attention of the impacted work force.

11.4 STRUCTURAL SOIL STABILIZATION BMPS

11.4.1 Mulch

Spreading mulch is a temporary soil stabilization or erosion control practice where materials such as grass, hay, wood chips, wood fibers, straw, or gravel are placed on the soil surface. Mulching prevents erosion by protecting the soil surface from raindrop impact and by reducing the velocity of overland flow. Mulch can also be used for dust control.

When used with temporary or permanent seeding, mulch can aid in plant growth by holding the seeds, fertilizers, and topsoil in place, by helping to retain moisture, and by insulating against extreme temperatures. Mulch can also improve the aesthetics of the site. Organic mulch materials such as straw, wood chips, bark, recycled paper, and wood fiber are the most effective mulches.

Design Criteria

Straw is the mulch most commonly used in conjunction with seeding. The recommended straw should come from wheat, rye, or barley and may be spread by hand or machine. Straw shall be anchored.

Wood chips are suitable for areas that will not be closely mowed, and around ornamental plantings. Chips decompose slowly and do not require tracking. Wood chips should be treated with 12 pounds slow-release nitrogen per ton to prevent nutrient deficiency in plants. Wood chips shall not be used in areas subject to street drainage or flooding.

Bark chips and shredded bark are used in landscaped plantings. Bark is also suitable mulch for areas planted to grasses and not closely mowed. Bark is not usually toxic to grasses or legumes, and additional nitrogen fertilizer is not required. Bark chips and shredded bark shall not be used in areas subject to street drainage or flooding.

Manufactured wood fiber and recycled paper sold as mulch materials are usually marketed to apply in a hydroseeder slurry with binder/tackifiers. Manufacturer's recommendations shall be followed during application.

A wide range of synthetic, spray-on materials is marketed to stabilize and protect the soil surface. These are emulsions or dispersions of vinyl compounds, asphalt, rubber, or other substances that are mixed with water and applied to the soil. They may be used to tack wood fiber hydromulches or straw, and they usually decompose in 60 to 90 days.

A variety of mulch nets and mats are available to use as mulching or to hold mulch in place. Netting and mats shall be used in critical areas such as waterways where concentrated flows are expected. Netting can help retain soil moisture or modify temperature. It stabilizes the soil surface while grasses are being established and is particularly useful in grassed waterways and on slopes. Lightweight netting may also be used to hold other mulches in place. Netting and erosion control mats shall be used in accordance with [Figure 11-1](#).

Gravel or crushed stone can be used to provide a long-term protection against erosion, particularly on short slopes. Before the gravel or crushed stone is applied it should be washed. Aggregate cover shall only be used in relatively small areas and shall be incorporated into an overall landscaping plan.

Material Specifications

Straw shall be applied at two tons per acre or 90 pounds per 1,000 square feet. Straw shall be free from weeds and coarse matter.

Wood chips shall be applied at 400 cubic yards per acre or 9 cubic yards per 1000 square feet and approximately 3 inches deep. Wood chips shall be treated with 12 pounds of nitrogen per ton.

Recycled paper (newsprint) or wood fiber shall be mixed at 50 pounds per 100 gallons of water and applied according to manufacturer's recommendations and model of hydroseeder in use.

Bark chips or shredded bark shall be applied at 70 cubic yards per acre or 1.5 to 2 cubic yards per 1000 square feet and about one-half inch thick.

Liquid mulch binders/tackifiers may be asphalt, synthetic, or wood fiber slurries applied according to manufacturer's recommendations.

Chemical soil stabilizers or soil binders/tackifiers/emulsions shall not be used alone. These materials shall only be used to bind organic mulches together.

Construction Specifications

Seed shall be applied prior to mulching except where seed is to be applied as part of a hydroseeder slurry containing mulch.

Lime and fertilizer shall be incorporated and surface roughening accomplished as needed prior to mulching in accordance with applicable sections of this manual.

Mulch materials shall be spread uniformly by hand or machine.

Mulch shall be anchored during or immediately after spreading to prevent being blown by the wind. Mulch may be anchored using a mulch anchoring tool, a liquid binder/tackifier, or mulch nettings. Nets and mats shall be installed to obtain firm, continuous contact between the material and the soil. Without such contact, the material is useless and erosion occurs.

A mulch anchoring tool is a tractor-drawn implement that is typically used for anchoring straw and is designed to punch mulch approximately two inches into the soil surface. Machinery shall be operated on the contour and shall not be used on slopes steeper than 3H:1V.

When using liquid mulch binders and tackifiers, application shall be heaviest around edges of areas and at crests of ridges and banks to prevent wind blow. Remainder of area shall have binders/tackifiers spread uniformly in accordance with manufacturer's recommendations.

When using mulch net, it shall be used in conjunction with an organic mulch and shall be installed immediately after the application and spreading of the mulch. The mulch net shall be installed over the mulch except when the mulch manufacturer recommends otherwise.

Excelsior blankets and mats with mulch are considered protective mulches and may be used alone on erodible soils and during all times of year. Erosion control mats shall be installed in accordance with manufacturer's recommendations.

Maintenance

Mulched areas shall be inspected at least weekly and after every rainfall of one-half inch or more. When mulch material is found to be loosened or removed, the mulch cover shall be replaced within 48 hours.

11.4.2 Temporary Seed

Temporary seeding stabilizes disturbed areas by the establishment of a temporary vegetative cover of rapidly growing plants on disturbed areas that are not at final grade. Temporary seeding reduces problems associated with mud or dust from bare soil surfaces during construction, reduces erosion and sediment runoff to downstream areas and/or groundwater basins, and improves the visual appearance of the construction area.

Temporary seeding shall be used on exposed soil surfaces where additional work will not occur for a period of 7 days to less than one year. Temporary seeding shall not be used during the months of December through February.

Material Specifications

Seed shall be applied in a mixture based upon the season and at rates recommended by the Kentucky Department of Highways Standard Specifications for Road and Bridge Construction. The following mixtures shall be used if an NRCS recommendation is not applicable:

<u>March 1 to August 31</u>	<u>Per 1,000 Square Feet</u>	<u>Per Acre</u>
Annual Rye Grass	0.8 lbs.	35 lbs.
<u>September 1 to November 30</u>	<u>Per 1000 Square Feet</u>	<u>Per Acre</u>
Rye Grain	2.5 lbs.	100 lbs.

Fertilizer shall be applied at a rate of 1,200 pounds per acre of 10-10-10 analysis or equivalent, unless soil test results indicate a different application rate is appropriate. Lime shall be applied at a rate of 150 pounds per 1,000 square feet or three tons per acre of agricultural ground limestone, unless soil test results indicate otherwise.

Construction Specifications

The site shall be graded as needed to permit the use of conventional equipment for seedbed preparation, seeding, mulch application, and anchoring.

The needed erosion control practices shall be installed prior to seeding such as diversions, temporary waterways for diversion outlets, and sediment ponds.

Prior to seeding, work the lime and fertilizer into the soil with a disk harrow, springtooth harrow, or similar tools to a depth of two inches. On sloping areas, the final operation shall be on the contour.

The seed shall be applied uniformly with a cyclone seeder, drill, cultipacker, seeder, or hydroseeder (slurry may include seed and fertilizer) preferably on a firm, moist seedbed. Seed no deeper than one-fourth inch to one-half inch.

When feasible, except where a cultipacker type seeder is used, the seedbed shall be firmed following seeding operations with a cultipacker, roller, or light drag. On sloping land, seeding operations shall be on the contour wherever possible.

Mulch shall be applied, in the amounts described in the mulch practice in this chapter, to protect the soil and provide a better environment for plant growth.

The mulch shall be spread uniformly by hand or mechanically so the soil surface is covered. Following application, the mulch shall be anchored or otherwise secured to the ground according to one of the following methods:

- Mechanical – Use a disk, crimper, or similar type tool set straight to punch or anchor the mulch material into the soil.
- Mulch Tackifiers/Nettings/Emulsions – Use according to the manufacturer’s recommendations. This is a superior method in areas of water concentration to hold mulch in place.
- Wood Fiber – Wood fiber hydroseeder slurries may be used to tack straw mulch. This combination treatment is well suited to steep slopes and critical areas, and severe climate conditions.

For more information on mulch application, see Section 11.4.1– Mulch.

Maintenance

New seed shall have adequate water for growth, through either natural means or irrigation, until plants are firmly established.

Seeded areas shall be inspected every two weeks after planting and after each rainfall of 0.5 inches or more. Areas requiring additional seed and mulch shall be repaired within 48 hours. If vegetative cover is not established within 21 days, the area shall be reseeded.

11.4.3 Permanent Seed

Permanent seeding is the stabilization of disturbed areas with the establishment of permanent vegetation by planting seed. The primary purpose of permanent seeding is to permanently stabilize disturbed areas in a manner that is economical, adaptable to site conditions, and allows selection of the most appropriate plant materials. Permanent seeding also reduces the erosion and sediment yield from disturbed areas while the vegetation is becoming established.

Design Criteria

Permanent seeding shall be used on disturbed areas where permanent, long-lived vegetative cover is needed to stabilize the soil and on rough graded areas that will not be brought to final grade for one year or more.

The area to be seeded shall be protected from excess runoff as necessary with diversions, grassed waterways, terraces, or sediment ponds.

Plant species shall be selected on the basis of timing of establishment, planned use of the area, and the amount or degree of maintenance that can be devoted to the area in the future.

Vegetative cover alone shall not be used to provide erosion control cover and prevent soil slippage on a soil that is not stable due to its structure, water movement, or excessive slope.

Material Specifications

Seed shall be applied in a mixture based upon the season and ultimate use of the site. Erosion and sediment control plans submitted to the City of Danville shall include seed mixtures, rates, and planting dates selected for permanent seeding. Permanent seeding may be done at any time except December through February. The following mixtures are suggested where applicable.

Kind of Seed	Per <u>Acre</u>
Permanent Seeding	
a) Creeping Red Fescue	20 lbs.
PLUS Redtop	10 lbs.
PLUS Kentucky 31 Fescue	20 lbs.
b) Kentucky Bluegrass	50 lbs.
c) Turf Quality Tall Fescue	50 lbs.

Special Seedings – Steep Banks or Cuts

- a) Tall Fescue 50 lbs.
- b) Round-Headed Bush Clover 20 lbs.
 PLUS Tall Fescue 30 lbs.
- c) Partridge Pea 20 lbs.
 PLUS Tall Fescue 30 lbs.

Waterways and Road Ditches

- a) Kentucky 31 Fescue 40 lbs.
 PLUS Rice Cut Grass 10 lbs.

Riparian and Sensitive areas

- a) Two of the following in equal portions:
 Big Bluestem, Little Bluestem,
 Indian Grass, Prairie Switchgrass,
 Rice Cutgrass, Deertongue Grass 30 lbs.
 PLUS Annual Rye 10 lbs.
 PLUS Redtop 5 lbs.
 PLUS White or Purple Prairie Clover 5 lbs.

Suggested seeding rates should be increased three times the listed rate if the permanent vegetation is to be used as a lawn.

Fertilizer shall be applied at a rate of 1200 pounds per acre of 10-10-10 analysis or equivalent, unless soil test results indicate a different rate is appropriate. Lime shall be applied at a rate of 150 pounds per 1000 square feet or three tons per acre of agricultural ground limestone, unless soil test results indicate otherwise.

Mulch shall consist of small grain straw (preferably wheat or rye) and shall be applied at the rate of two tons per acre or 100 pounds (two or three bales) per 1,000 square feet.

Soil material shall be capable of supporting permanent vegetation and have at least 25 percent silt and clay to provide an adequate amount of moisture holding capacity. An excessive amount of sand will not consistently provide sufficient moisture for good growth regardless of other soil factors.

Construction Specifications

During site preparation, topsoil shall be stockpiled for use in establishing permanent vegetation.

The site shall be graded as needed to permit the use of conventional equipment for seedbed preparation, seeding, mulch application, and anchoring.

The needed erosion control practices shall be installed prior to seeding such as diversions, temporary waterways for diversion outlets, and sediment ponds.

Prior to seeding, work the lime and fertilizer into the soil with a disk harrow, springtooth harrow, or similar tools to a depth of four inches. On sloping areas, the final operation shall be on the contour.

Where compacted soils occur, they should be broken up sufficiently to create a favorable rooting depth of six to eight inches.

The seed shall be applied uniformly with a cyclone seeder, drill, cultipacker, seeder, or hydroseeder (slurry may include seed and fertilizer) preferably on a firm, moist seedbed. Seed no deeper than one-fourth inch to one-half inch.

When feasible, except where a cultipacker type seeder is used, the seedbed shall be firmed following seeding operations with a cultipacker, roller, or light drag.

On sloping land, seeding operations shall be on the contour wherever possible.

Mulch shall be applied to protect the soil and provide a better environment for plant growth.

The mulch shall be spread uniformly by hand or mechanically so the soil surface is covered. Following application, the mulch shall be anchored or otherwise secured to the ground according to one of the following methods:

- Mechanical – Use a disk, crimper, or similar type tool set straight to punch or anchor the mulch material into the soil.
- Mulch Tackifiers/Nettings/Emulsions – Use according to the manufacturer's recommendations. This is a superior method in areas of water concentration to hold mulch in place.
- Wood Fiber – Wood fiber hydroseeder slurries may be used to tack straw mulch. This combination treatment is well suited to steep slopes and critical areas, and severe climate conditions.

For more detailed information on mulch application, see Section 11.4.1- Mulch.

Maintenance

New seed shall have adequate water for growth, through either natural means or irrigation, until plants are firmly established.

Seeded areas shall be inspected every two weeks after planting and after each rainfall of 0.5 inches or more. Areas requiring additional seed and mulch shall be repaired within 48 hours. If vegetative cover is not established within 21 days, the area shall be reseeded. If less than 85 percent groundcover is established, seed and fertilize, using half of rates originally applied, and mulch. If less than 40 percent groundcover occurs, follow original seedbed preparation methods, seeding and mulching recommendations, and apply lime and fertilizer as needed according to soil tests.

11.4.4 Sod

Sod is used to stabilize fine-graded disturbed areas by establishing permanent grass stands. Sod has several purposes or applications including:

- establishment of permanent turf immediately,
- prevention of erosion and damage from sediment and runoff by stabilization of the soil surface,
- reduction of dust and mud associated with bare soil surfaces,
- stabilization of drainageways where concentrated overland flow will occur.

Design Criteria

Sodding shall be used for disturbed areas that require immediate vegetative cover. Locations particularly suited to stabilization with sod include waterways carrying intermittent flow and the area around drop inlets in grassed waterways.

The species of sod selected shall be based on soil type, planned use of the area, and the amount of maintenance that can be devoted to the area in the future.

Sod shall not be used to provide erosion control and prevent soil slippage on a soil that is not stable due to its structure, water movement, or excessive slope.

Material Specifications

Soil material shall be capable of supporting permanent vegetation and shall consist of at least 25 percent silt and clay to provide an adequate amount of moisture holding capacity. An excessive amount of sand will not consistently provide sufficient moisture for the sod regardless of other soil factors.

Fertilizer shall be applied at a rate of 1,200 pounds per acre of 10-10-10 analysis or equivalent, unless soil test results indicate a different rate is appropriate. Lime shall be applied at a rate of 100 pounds per 1000 square feet or two tons per acre of agricultural ground limestone, unless soil test results indicate differently.

The sod shall consist of strips of live, vigorously growing grasses. The sod shall be free of noxious and secondary noxious weeds and shall be obtained from good, solid, thick-growing stands. The sod shall be cut and transferred to the job in the largest continuous pieces that will hold together and are practical to handle.

The sod shall be cut with smooth clean edges and square ends to facilitate laying and fitting. The sod shall be cut to a uniform thickness of not less than three-fourth inch measured from the crown of the plants to the bottom of the sod strips for all grasses except bluegrass. Bluegrass sod shall be cut to a uniform thickness of not less than one and one-half inches.

The sod shall be mowed to a height of not less than two inches and no more than four inches prior to cutting.

The sod shall be kept moist and covered during hauling and preparation for placement on the sod bed.

Construction Specifications

The area to be sodded shall be protected from excess runoff, as necessary, with appropriate BMPs.

Lime and fertilizer shall be worked into the soil with a disk harrow, springtooth harrow, or other suitable field equipment to a depth of four inches.

Prior to sodding, the soil surface shall be cleared of all trash, debris, and stones larger than one and one-half inches in diameter, and of all roots, brush, wire, and other objects that would interfere with the placing of the sod.

Compacted soils must be broken up sufficiently to create a favorable rooting depth of six to eight inches.

After the lime and fertilizer have been applied and just prior to the laying of the sod, the soil in the area to be sodded shall be loosened to a depth of one inch. The soil shall be thoroughly dampened immediately after the sod is laid if it is not already in a moist condition.

No sod shall be placed when the temperature is below 32⁰F. No frozen sod shall be placed nor shall any sod be placed on frozen soil.

When sod is placed during the periods of June 15 to September 1 or October 15 to March 1, it shall be covered immediately with a uniform layer of straw mulch approximately one-half inch thick so the green sod is barely visible through the mulch.

Sod shall be carefully placed and pressed together so it will be continuous without any voids between the pieces. Joints between the ends of strips shall be staggered.

On gutter and channel sodding, the sod should be carefully placed on rows or strips at right angles to the centerline of the channel (i.e., at right angles to the direction of flow). The edge of the sod at the outer edges of all gutters shall be sufficiently deep so that surface water will flow over onto the top of the sod.

On steep graded channels, each strip of sod shall be staked with at least two stakes not more than 18 inches apart.

Sod shall be tamped or rolled after placing and then watered. Watering shall consist of a thorough soaking of the sod and of the sod bed to a depth of at least 4 inches. The sod should be maintained in a moist condition by watering for a period of 30 days.

On slopes 3H:1V or steeper, or where drainage into a sod gutter or channel is one-half acre or larger, the sod shall be rolled or tamped and then chicken wire, jute, or other netting pegged over the sod for protection in the critical areas. The netting and sod shall be staked with at least two stakes not more than 18 inches apart. The netting shall be stapled on the side of each stake within two inches of the top of the stake. The stake should then be driven flush with the top of the sod.

When stakes are required, the stakes shall be wood and shall be approximately ½ inch by ¾ inch by 12 inches. They shall be driven flush with the top of the sod with the flat side against the slope and on an angle toward the slope.

Maintenance

In the absence of adequate rainfall, watering shall be performed daily or as often as necessary during the first week to maintain moist soil to a depth of 4 inches. Watering shall be done during the heat of the day to prevent wilting. After the first week, sod shall be watered as necessary to maintain adequate moisture content.

The first mowing of sod shall not be attempted until the sod is firmly rooted. No more than one-third of the grass leaf shall be removed by the initial and subsequent cuttings. Grass height shall be maintained between 2 inches and 3 inches.

Where sod does not establish properly, the sod should be replaced immediately. Areas requiring resodding should be prepared in the same manner as the original installation.

11.4.5 Road/Parking Stabilization

Road/parking stabilization refers to the stabilization of access roads, subdivision roads, parking areas, and other on-site vehicle routes with stone immediately after grading. The primary purpose of road/parking stabilization is to reduce erosion from roadbeds caused by construction traffic during wet weather. Stabilization also reduces regrading needed for permanent roadbeds by reducing erosion between the time of initial grading and final stabilization.

Design Criteria

Road/parking stabilization shall be used wherever roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.

Stabilization shall be accomplished with a minimum depth of six inches of crushed stone. Stabilized construction roadbeds shall be at least 14 feet wide for one-way traffic and at least 20 feet wide for two-way traffic. Figure 11-2 illustrates road/parking stabilization.

Temporary roads shall follow the contour of the natural terrain to the extent possible. Slopes shall not exceed 10 percent.

Temporary parking areas shall be located on naturally flat areas to minimize grading. Grades shall be sufficient to provide drainage but shall not exceed 4 percent.

All cuts and fills shall be 2H:1V or flatter.

Drainage ditches shall be provided as needed.

Material Specifications

Crushed stone shall be KTC aggregate No. 2 (1.5 to 3 inches in diameter), or equivalent.

Construction Specifications

The roadbed or parking surface shall be cleared of all vegetation, roots, and other objectionable material.

All roadside ditches, cuts, fills, and disturbed areas adjacent to parking areas and roads shall be stabilized with appropriate temporary or permanent vegetation according to the applicable standards and specifications contained in this manual.

Geotextile filter fabric may be applied beneath the stone for additional stability in accordance with fabric manufacturer's specifications.

Both temporary and permanent roads and parking areas may require periodic top dressing with new gravel. Seeded areas adjacent to the roads and parking areas shall be checked regularly to ensure that a vigorous stand of vegetation is maintained. Roadside ditches and other drainage structures shall be checked once each week to ensure that they do not have silt or other debris that reduces their effectiveness.

11.4.6 Construction Entrance

A stabilized construction entrance is a portion of the construction road that is constructed with filter fabric and large stone. The primary purpose of a stabilized construction entrance is to reduce the amount of soil tracked off the construction site by vehicles leaving the site. The stabilized entrance will also reduce erosion and rutting on that portion of the road where it is installed.

Design Criteria

A stabilized construction entrance shall be constructed in the following locations:

- Wherever vehicles are leaving a construction site and enter onto a public road.
- At any unpaved entrance/exit location where there is risk of transporting mud or sediment onto paved roads.

A stabilized construction entrance shall be constructed of crushed stone a minimum of 6 inches thick laid over geotextile (filter fabric).

The width shall be at least 20 feet and as wide as the entire width of the access. At sites where traffic volume is high, the entrance shall be wide enough for two vehicles to pass safely. The length shall be at least 50 feet. The entrance shall be flared where it meets the existing road to provide a turning radius. A standard drawing for a stabilized construction entrance is provided in Figure 11-3, with notes provided in Figure 11-4.

Stormwater and wash water runoff from a stabilized construction entrance shall drain to a sediment trap or sediment pond. If conditions on the site are such that the majority of the mud is not removed by the vehicles traveling over the gravel, then the tires of the vehicles shall be washed before entering a public road.

Pipe placed under the entrance to handle runoff shall be protected with a mountable berm.

Dust control shall be provided in accordance with Section 11.2.3 and 11.4.7.

Material Specifications

Crushed stone shall be KTC aggregate No. 2 (1.5 to 3 inches in diameter), or equivalent.

Geotextile filter fabric shall meet or exceed the minimum properties provided in the following table:

GEOTEXTILE REQUIREMENTS

Physical Property	Requirements
Grab Tensile Strength	220 lbs. (ASTM D1682)
Elongation Failure	60% (ASTM D1682)
Mullen Burst Strength	430 lbs. (ASTM D3768)
Puncture Strength.	125 lbs (ASTM D751) (modified)
Equivalent Opening	Size 40-80 US std Sieve) (CW-02215)

Construction Specifications

Vegetation, roots, and all other obstructions shall be cleared in preparation for grading. Prior to placing geotextile (filter fabric), the entrance shall be graded and compacted to 80% of standard proctor density.

To reduce maintenance and loss of aggregate, the geotextile shall be placed over the existing ground before placing the stone for the entrance. Stone shall be placed to depth of 6 inches or greater for the entire width and length of the stabilized construction entrance.

If wash racks are used, they shall be installed according to manufacturer's specifications.

Maintenance

The stabilized construction entrance shall be inspected once each week and after there has been a high volume of traffic or a storm event greater than 0.2 inches.

The entrance shall be maintained in a condition that will prevent tracking or flow of sediments onto public rights-of-way. This may require periodic top dressing with additional stone, as conditions demand, and repair and/or cleanout of any structures used to trap sediment.

All materials spilled, dropped, washed, or tracked from vehicles onto roadways or into storm drains must be removed immediately.

11.4.7 Dust Control

Dust control is the reducing of surface and air movement of dust during land disturbing, demolition and other construction activities. The purpose of dust control is to prevent the air movement of sediments to off-site areas or other onsite areas without sediment control where they could subsequently be washed into surface waters. Dust control shall be planned in association with earthmoving/site grading activities and areas with frequent construction traffic.

Design Criteria

Construction activities shall be phased to minimize the total area unstabilized at any given time, thereby reducing erosion due to air and water movement. Plans submitted to the City of Danville shall illustrate construction phasing and describe dust and erosion control measures to be implemented at each phase.

Construction roads shall be watered as needed to minimize dust.

Existing trees, shrubs, and ground cover shall be retained as long as possible during the construction. Initial land clearing should be conducted only in those areas to be regraded or where construction is to occur. Areas to be cleared only for new vegetation or landscaping shall be stabilized with seed and mulch immediately following clearing.

Vegetative cover is the most effective means of dust and erosion control, when appropriate. See sections on Temporary Seed, Permanent Seed, Mulch, and Sod in this manual.

When areas have been regraded and brought to final grade, they shall be stabilized using temporary or permanent seed and mulch or other measures.

Mulch with mulch binders may be used as an interim dust control measure in areas where vegetation may not be appropriate.

Material Specifications

See sections on Temporary Seed, Permanent Seed, Sod, Mulch, Construction Road/Parking Stabilization, and Construction Entrance.

Construction Specifications

See sections referenced in Material Specifications above.

When construction is active on the site, dust control shall be implemented as needed. When using tillage as a dust control measure, begin plowing on windward side of area. Chisel-type plows spaced about 12 inches apart, springtoothed harrow, and similar plows are examples of equipment that may produce the desired effect.

Maintenance

The site shall be observed daily for evidence of windblown dust and reasonable steps shall be taken to reduce dust whenever possible. When construction on a site is inactive for a period, the site shall be inspected at least weekly for evidence of dust emissions or previously windblown sediments. Dust control measures must be implemented or upgraded if the site inspection shows evidence of wind erosion.

11.4.8 Nets and Mats

Mulch netting, erosion control matting, and turf reinforcement matting (TRM) make up a group of materials that are used to stabilize mulch and soil in order to prevent erosion and aid in the establishment of vegetative cover.

Some mats and TRMs are manufactured by weaving or bonding fibers made from synthetic materials such as polypropylene, polyester, polyethylene, nylon, polyvinyl chloride, glass, and various mixtures of these. These materials are intended to be longer lasting or even permanent in certain applications.

Some nets and mats are formed of biodegradable materials such as jute, coconut, or other wood fibers that have been formed into sheets of mulch that are more stable than loose mulch. Netting is typically made from jute, other wood fiber, plastic, paper, or cotton and can be used to hold the mulching and matting to the ground. Netting can also be used alone to stabilize soils while the plants are growing; however, it does not retain moisture or temperature well.

Design Criteria

Erosion control matting can be used to stabilize channels and swales and on recently planted slopes to protect seedlings until they become established. Refer to Figure 11-1 for guidance on using matting on slopes. See Chapter 8 for additional information on stabilizing vegetated channels.

Effective netting and matting require firm, continuous contact between the materials and the soil. If there is no contact, the material will not hold the soil and erosion will occur underneath the material.

Material Specifications

Nets and mats shall be suitable for their intended purpose. With the wide variety of materials available, the product used should be determined by the designer according to its application.

Construction Specifications

Nets and mats shall be installed according to the manufacturer's recommendations. In the event that the manufacturer's recommendations conflict with any requirement of this manual, the most conservative requirement, in terms of protection of public health and the environment, shall govern. See Figure 11-5 for details on placement of straw or mats. See Figures 11-6 and 11-7 for details regarding placement of TRMs.

11.4.9 Gabion Mattress

Gabion mattresses are acceptable when used as water energy dissipating devices placed at the outlets of pipes or paved channel sections. Gabion mattresses are also known as reno mattresses. The purpose of gabion mattresses is to prevent scour at stormwater outlets and to minimize the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Design Criteria

Gabion mattresses shall be used at the outlets of all pipes, box culverts, stilling basins, and paved ditch sections.

For outlets of 36 inches (width or diameter) or less, the length of the gabion mattress shall be 12 feet. For outlets greater than 36 inches, the gabion mattress length shall be 4 times the width or height of the outlet, whichever is greater. See Figure 11-8.

If the pipe discharges directly into a well-defined channel, the mattress shall extend across the channel bottom and up the channel banks to an elevation 1 foot above the maximum tailwater depth or to the top of the bank (whichever is less). See Figure 11-9. The side slopes of the channel shall not be steeper than 2:1 (Horizontal:Vertical).

If the pipe discharges onto a flat area with no defined channel, the width of the apron shall be in accordance with Figures 11-10 and 11-11.

The mattress shall be constructed with no slope along its length (0.0 percent grade). The invert elevation of the downstream end of the mattress shall be equal to the invert elevation of the receiving channel. There shall be no overfall at the end of the mattress.

Where the outlet structure is supported by a concrete foundation, the first 3 feet of the mattress shall extend the depth of the foundation. See Figure 11-8.

For calculated outlet velocities of 5 to 10 feet per second when flowing full, the depth of the gabion mattress shall be at least 12 inches.

For calculated outlet velocities of greater than 10 feet per second when flowing full, the depth of the gabion mattress shall be at least 18 inches, except when an impact stilling basin is used. In that instance, a minimum depth of 12 inches is required.

When the mattress is placed on grades of 5% or greater, #8 reinforcing bar anchors at 18 inches on centers shall be installed.

Gabion mattresses shall be secured together in accordance with manufacturer's recommendations.

The mattress shall be located so that there are no bends in the horizontal alignment.

For paved channel outlets, the end of the paved channel shall merge smoothly with the gabion mattress in the receiving channel section. There shall be no overfall at the end of the paved section.

Where the bottom width of the paved channel is narrower than the bottom width of the receiving channel, a paved transition section shall be provided.

Material Specifications

The gabion mattress shall be manufactured from galvanized wire with a minimum tensile strength of 40,000 psi.

The stone to be used shall be quarry run crushed limestone 3-6 inches in size.

Filter fabric placed below the gabion mattress shall have the minimum material specifications of the geotextile described in the material specifications for a construction entrance (Section 11.4.6).

Construction Specifications

The subgrade for the mattress shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density approximately that of the surrounding undisturbed material. Brush, trees, stumps, and other objectionable material shall be removed.

Placement of the mattress and the fill rock shall follow immediately after subgrade preparation and be in accordance with methods recommended by the manufacturer.

The anchors shall be 3 feet long and driven or pushed into the subgrade. Where rock is encountered, the anchors shall be cut off even with the mattress.

Filter fabric shall be placed between the mattress and the subgrade.

Maintenance

Outlets shall be inspected at least weekly during the construction process and after every storm event of one-half inch or more. If the mattress is damaged or displaced, it shall be repaired immediately.

11.4.10 Temporary Diversion Ditch

A temporary diversion ditch is an earth channel with a supporting ridge or berm on the lower side constructed across the slope. See Figure 11-12 for an illustration. Temporary diversion ditches usually have a life expectancy of one year or less with a low failure hazard. Permanent diversions are called permanent constructed waterways and shall be designed in accordance with requirements in Chapter 8. Diversions can be constructed for various purposes including:

- to divert storm runoff away from unprotected slopes to a stabilized outlet,
- to divert sediment-laden runoff from a disturbed area to a sediment pond, or
- to shorten the flow length within a long, sloping drainage area.

Design Criteria

Temporary diversion ditches must have stable outlets. The combination of conditions of site, slopes, and soils should be so that the ditch can be maintained throughout its planned life.

Temporary diversion ditches shall not be constructed 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 diversion.

Temporary diversion ditches shall be designed for the 10-year, 6-hour storm event in accordance with methods given in the next section for permanent constructed channels.

A typical diversion cross section consists of a channel and a supporting ridge. In the case of an excavated-type diversion, the natural ground serves as the diversion ridge. Diversion cross

sections must be adapted to the equipment that will be used for their construction and maintenance.

The channel may be parabolic or trapezoidal in shape. V-shaped ditches shall not be constructed

A diversion's location will be dictated by outlet condition, topography, land use, soil type, and length of slope. Diversions must be located so that water will empty onto an established area such as a stable watercourse, waterway, or structure.

The channel grade for diversions may be uniform or variable. The permissible velocity for the soil type and vegetative cover will determine the maximum grade. The grade should be such as to minimize standing water and wetness problems.

Level diversions with blocked ends may be used when an adequate underground outlet is provided.

Any high sediment-producing area above a diversion should be controlled by good land use management or by structural measures to prevent excessive sediment accumulation in the diversion channel. If movement of sediment into the diversion channel cannot be controlled, one of the following measures should be used:

- Design the channel to include extra capacity for the storage of sediment, keep the velocity of flow for the design storm greater than 1.5 feet per second, and provide for clean out of the diversion channel when the sediment storage capacity has been depleted.
- Provide a minimum 15-foot wide filter strip of close-growing sod adjacent to the diversion channel and remove excessive accumulations of sediment to maintain a vigorous growth.

Temporary diversions above steep slopes or across graded rights-of-way shall have a berm with a minimum top width of 2 feet, side slopes of 2:1 or flatter and a minimum height of 18 inches measured from the channel bottom.

Diversions installed to intercept flow on graded rights-of-way shall be spaced 200 to 300 feet apart.

A level lip spreader shall be used at diversion outlets discharging onto areas already stabilized by vegetation.

Construction Specifications

All dead furrows, ditches or other depressions to be crossed shall be filled before construction begins or as part of construction, and the earth fill used to fill the depressions will be compacted using the treads of the construction equipment. All old terraces, fence rows, or other obstructions that will interfere with the successful operation of the diversion shall be removed.

The base for the diversion ridge is to be prepared so that a good bond is obtained between the original ground and the fill material. Vegetation is to be removed and the base thoroughly disked prior to placement of fill.

The earth materials used to construct the earth fill portions of the diversions shall be obtained from the diversion channel or other approved source.

The earth fill materials used to construct diversions shall be compacted by running the construction equipment over the fill in such a manner that the entire surface of the fill will be traversed by not less than one tread track of the equipment.

When an excess of earth material results from cutting the channel cross section and grade, it shall be deposited adjacent to the supporting ridge unless otherwise directed.

The completed diversion shall conform to the cross section and grade shown on the design.

Fertilizing, seeding, and mulching shall conform to the recommendations in the applicable vegetative standard and specification.

Maintenance

Bare and vegetated diversion channels shall be inspected regularly to check for points of scour or bank failure; rubbish or channel obstruction; rodent holes, breaching, or settling of the ridge; and excessive wear from pedestrian or construction traffic.

Damaged channels or ridges shall be repaired at the time damage is detected. Sediment deposits shall be removed from diversion channels and adjoining vegetative filter strips regularly.

Diversions shall be reseeded and fertilized as needed to establish vegetative cover.

11.4.11 Level Spreader

Level spreaders are storm flow outlet devices constructed at zero grade across the slope whereby concentrated runoff may be discharged at non-erosive velocities onto undisturbed areas stabilized by existing vegetation. A level spreader is illustrated in Figure 11-13.

Level spreaders dissipate storm flow energy at the outlet by converting storm runoff into sheet flow and discharging it onto areas stabilized by existing vegetation without causing erosion.

Level spreaders are used at diversion outlets and other locations where sediment free storm runoff is intercepted and diverted from graded areas onto undisturbed stabilized areas. The practice applies only in those situations where the spreader can be constructed on undisturbed soil and where the area directly below the level spreader is stabilized by existing vegetation. The water must not be allowed to reconcentrate below the point of discharge.

Design Criteria

The length of the level spreader shall be based on the peak flow from the 100-year storm in accordance with the following table

100-year Peak Flow (cfs)	Minimum Length (ft)
Up to 10	15
11 to 20	20
21 to 30	30
31 to 40	40
41 to 50	50

Construction Specifications

The minimum acceptable width shall be 6 feet. The depth of the level spreader as measured from the lip shall be at least 6 inches and the depth shall be uniform across the entire length of the measure.

The grade of the channel for the last 15 feet entering the level spreader shall be less than or equal to 1%.

The level lip of the spreader shall be constructed on zero percent grade to insure uniform conversion of channel flow to sheet flow.

Level spreaders shall be constructed on undisturbed soil.

The entrance to the spreader shall be graded in a manner to insure that runoff enters directly onto the zero percent graded channel.

Storm runoff converted to sheet flow shall discharge onto undisturbed areas stabilized with vegetation.

All disturbed areas shall be stabilized immediately after construction is completed in accordance with the mulching and vegetation requirements of this manual.

Maintenance

The level spreader shall be inspected after each storm event and at least once each week. Any observed damage shall be repaired immediately.

11.4.12 Pipe Slope Drains

Pipe slope drains are made of flexible pipe and reduce the risk of erosion on slopes by discharging runoff to stabilized areas. See Figures 11-14 and 11-15. They carry concentrated runoff from the top to the bottom of a slope that has already been damaged by erosion or is at high risk for erosion. They are also used to drain saturated slopes that have the potential for soil

slides. Pipe slope drains can be either temporary or permanent depending on the method of installation and material used.

Pipe slope drains shall be used whenever it is necessary to convey water down a slope that is steep or otherwise prone to erosion. Pipe slope drains may be used with other devices; including diversion dikes or swales, sediment traps, and level spreaders (used to spread out stormwater runoff uniformly over the surface of the ground).

Design Criteria

Each pipe slope drain shall serve a maximum drainage area of five acres. The pipe slope drain shall be designed to handle the peak runoff for the 10-year storm.

Material Specifications

The pipe shall be heavy duty flexible tubing designed for this purpose, e.g., nonperforated, corrugated plastic pipe, or specially designed flexible tubing.

A standard flared end section or a standard T-section pipe fitting secured with a watertight fitting shall be used for the inlet.

Extension collars shall be 12-inch long sections of corrugated pipe. All fittings shall be watertight.

Construction Specifications

The pipe slope drain shall be placed on undisturbed or well-compacted soil.

Soil around and under the entrance section shall be hand-tamped in 4-inch to 8-inch lifts to the top of the dike to prevent piping failure around the inlet.

Filter cloth shall be placed under the inlet and extended 5 feet in front of the inlet and be keyed in 6 inches on all sides to prevent erosion. Backfilling around and under the pipe with stable soil material hand compacted in lifts of 4 inches to 8 inches shall be done to ensure firm contact between the pipe and the soil at all points.

The pipe slope drain shall be securely staked to the slope using grommets provided for this purpose at intervals of 10 feet or less.

All slope drain sections shall be securely fastened together and have watertight fittings.

The pipe shall be extended beyond the toe of the slope and discharged at a nonerosive velocity into a stabilized area (e.g., gabion mattress) or to a sediment trap or pond.

The pipe slope drain shall have a minimum slope of 3 percent or steeper.

The height at the centerline of the earth dike shall range from a minimum of 1.0 foot over the pipe to twice the diameter of the pipe measured from the invert of the pipe. It shall also be at least 6 inches higher than the adjoining ridge on either side. At no point along the dike will the elevation of the top of the dike be less than 6 inches higher than the top of the pipe.

All areas disturbed by installation or removal of the pipe slope drain shall be immediately stabilized.

Maintenance

The pipe slope drain shall be inspected after every rainfall and at least weekly. Any necessary repairs shall be made immediately.

Check to see that water is not bypassing the inlet and undercutting the inlet or pipe. If necessary, install headwall or sandbags.

Check for erosion at the outlet point and check the pipe for breaks or clogs. Install additional outlet protection if needed and immediately repair the breaks and clean any clogs.

Do not allow construction traffic to cross the pipe slope drain and do not place any material on it.

If a sediment trap has been provided, it shall be cleaned out when the sediment level reaches 1/3 to 1/2 the design volume.

The pipe slope drain shall remain in place until the slope has been completely stabilized or up to 30 days after permanent slope stabilization

11.4.13 Impact Stilling Basin

Impact stilling basins are concrete structures placed at the outlets of culverts and pipes with calculated exit velocities greater than 15 feet per second. The purpose of an impact stilling basin is to dissipate energy at a high velocity outlet to protect the receiving channel.

Design Criteria

Impact stilling basins shall be designed in accordance with the Kentucky Department of Highways Standard Drawings, latest edition.

Construction Specifications

Construction specifications shall comply with the Kentucky Department of Highways Standard Specifications for Road and Bridge Construction, latest edition.

11.5 STRUCTURAL SEDIMENT CONTROL BMPS

11.5.1 Check Dam

A check dam is a small temporary dam constructed across a swale or drainage ditch. The purpose of a check dam is to reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch. This practice also traps small amounts of sediment generated in the ditch itself. However, this is not a sediment-trapping practice and should not be used as such.

Design Criteria

Check dams shall be limited to use in small, open channels that drain 10 acres or less.

Check dams shall not be used in streams.

Check dams are especially applicable where the gradient of waterways is close to the maximum for a grass lining.

Check dams can be constructed of stones, coir logs, or wood fiber logs. See Figures 11-16 and 11-17.

The maximum height of a check dam shall be three feet above the ground on which the rock is placed.

The center of the portion of the check dam above the flat portion of the channel shall be at least 1 foot lower than the outer edges. The outer edges of the check dam shall extend up the side slopes of the channel to a point 3 feet in elevation above the center portion of the check dam or to the top of the side slopes.

The maximum spacing between rock check dams in a ditch should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

The spacing of coir and wood fiber check dams is one log every 100 feet for velocities of 5 fps, 50 feet for velocities between 5 and 7.5 fps, and 25 feet for velocities greater than 10 fps.

Material Specifications

Stone check dams shall be constructed of KTC Class 2 channel lining.

Coir log or wood fiber log check dams shall be constructed of a single log with a diameter of at least 20 inches.

Construction Specifications

Stone shall be placed by hand or mechanically as necessary to achieve complete coverage of the ditch and to ensure that the center of the dam is at least 1 foot lower than the outer edges. Stone shall also be placed to extend 3 feet in elevation above the center portion of the check dam or to the top of the channel side slopes.

Coir and wood fiber logs shall be laid on the channel bottom.

Check dams must be removed when their useful life has been completed. In temporary ditches and swales, check dams shall be removed and the ditch filled in when it is no longer needed. In permanent channels, check dams shall be removed when a permanent lining can be installed. In the case of grass-lined ditches, check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale. The area beneath the check dams shall be seeded and mulched or sodded (depending upon velocity) immediately after check dams are removed.

If stone check dams are used in grass-lined channels that will be mowed, care shall be taken to remove all stone from the channel when the dam is removed. This shall include any stone that has washed downstream.

Maintenance

Regular inspections shall be made to ensure that the measure is in good working order and the center of the dam is lower than the edges. Erosion caused by high flows around the edges of the dam shall be corrected immediately, and the dam shall be extended beyond the repaired area.

Check dams shall be checked for sediment accumulation after each rainfall. Sediment shall be removed when it reaches one-half of the original height or before.

Check dams shall remain in place and operational until the drainage area and channel are completely stabilized or up to 30 days after the permanent site stabilization is achieved.

11.5.2 Sediment Trap

A sediment trap is formed by a excavation of an area in a suitable location to retain sediment and other waterborne debris. Sediment traps are considered temporary structures.

This standard establishes minimum acceptable criteria for the design and construction of sediment traps formed by excavation. This standard is limited to sites where the drainage area is less than 5 acres.

Sediment traps shall be used where physical site conditions or other restrictions prevent other erosion control measures from adequately controlling erosion and sedimentation. Sediment traps may be used down slope from construction operations that expose areas to erosion. Sediment traps shall be removed after the exposed areas are adequately protected against erosion by vegetative or mechanical means.

General Design Criteria

Erosion control practices such as seeding, mulching, sodding, diversion dikes, etc., shall be used in conjunction with sediment traps to reduce the amount of sediment flowing into the trap.

The amount of sediment entering a trap can be reduced by the use of stabilized diversion dikes and ditches. The trap shall not be located in a stream. It shall be located to trap sediment-laden runoff before it enters the stream.

The minimum capacity of the sediment trap to the elevation of the crest of the spillway shall be 3,600 cubic feet for each acre within the drainage area that will be disturbed by construction during the design life of the trap.

The trap dimensions necessary to determine the designed sediment volume shall be clearly shown on the plans to facilitate plan review, construction, operation, and maintenance. Trap depth shall be at least 2 feet at the inlet and 4 feet at the outlet. Effective trap width shall be at least 10 feet and trap length shall be at least 30 feet. See Figure 11-18.

The erosion and sediment control plan shall indicate the final disposition of the sediment trap after the upstream drainage area is stabilized. The plans shall indicate methods for the removal of excess water lying over the sediment, stabilization of the pond site, and the disposal of any excess material.

Construction Specifications

The area to be excavated shall be cleared of all trees, stumps, roots, brush boulders, sod, and debris. All channel banks and sharp breaks shall be sloped to no steeper than 1:1. All topsoil containing excessive amounts of organic matter shall be removed.

Seeding, fertilizing, and mulching of the material taken from the excavation shall comply with the applicable soil stabilization sections of this manual.

Any material excavated from the trap shall be placed in one of the following ways so that it will not be washed back into the pond by rainfall:

- Uniformly spread to a depth not exceeding 3 feet and graded to a continuous slope away from the trap.
- Uniformly placed or shaped reasonably well with side slopes assuming the natural angle of repose for the excavated material behind a berm width not less than 12 feet.

Maintenance

Sediment shall be removed from the trap when the capacity is reduced to 50 percent of the design volume. Plans for the sediment trap shall indicate the methods for disposing of sediment removed from the pond.

11.5.3 Sediment Pond

A sediment pond is formed by a barrier or dam constructed across a drainage way or other suitable location to retain sediment and other waterborne debris. Sediment ponds are considered temporary structures. They can be converted to permanent detention ponds or storage structures for runoff control if they are designed and constructed in accordance with applicable requirements of storage structures given in Chapter 10.

This standard establishes minimum acceptable criteria for the design and construction of sediment ponds formed by an embankment, excavation, or a combination of embankment and excavation. This standard is limited to sites where failure of the structure would not

- result in loss of life,
- damage homes,
- damage commercial or industrial buildings,
- damage highways or railroads,
- interrupt public or private utility service (hazard class “A” only),

Sediment ponds shall be designed and constructed so that

- the height of the dam is 20 feet or less, as measured from the natural streambed at the downstream toe of the dam to the top of the dam,
- the drainage area is more than 5 acres but less than 100 acres,

Sediment ponds shall be removed within three years after construction.

Sediment ponds are appropriate where physical site conditions or other restrictions prevent other erosion control measures from adequately controlling erosion and sedimentation. Sediment ponds may be used down slope from construction operations that expose areas to erosion. Sediment ponds shall be removed after the exposed areas are adequately protected against erosion by vegetative or mechanical means.

General Design Criteria

Design and construction shall comply with all federal, state, and local laws, ordinances, rules, and regulations regarding dams.

Erosion control practices such as seeding, mulching, sodding, diversion dikes, etc., shall be used in conjunction with sediment ponds to reduce the amount of sediment flowing into the pond.

The amount of sediment entering a pond can be reduced by the use of stabilized diversion dikes and ditches. The pond shall not be located in a stream. It shall be located to trap sediment-laden runoff before it enters the stream.

A sand filter outlet shall be used in the bottom of the pond. See Figure 11-19.

Permanent ponds designed for stormwater detention or water quality treatment may serve as temporary sediment ponds if site conditions make the use of these structures desirable. At the time of conversion from a sediment pond to a permanent stormwater management pond, excess sediment shall be cleaned from the pond. If the pond is converted to a water quality basin, the sand in the sand filter outlet shall be replaced with clean sand unless it is shown to be clean.

The minimum capacity of the sediment pond to the elevation of the crest of the pipe spillway shall be 3,600 cubic feet for each acre within the drainage area that will be disturbed by construction during the design life of the sediment pond.

Detention storage shall be provided above the sediment storage volume to reduce peak flows for the 100-year 1-hour storm to preconstruction levels.

Pond dimensions necessary to determine the designed sediment volume shall be clearly shown on the plans to facilitate plan review, construction, operation, and maintenance.

The pond configuration shall be such that the effective flow length through the pond is at least two times the average width of the pond. Baffles will be used when necessary to prevent short-circuiting by increasing the effective flow length.

The minimum freeboard for the maximum applicable design storm shall be 1.0 foot.

For embankments of 5 feet or less, the minimum top width shall be 5 feet. For embankments of over 5 feet, the minimum top width shall be 10 feet.

Embankment side slopes shall be no steeper than 3H:1V.

Sediment pond plans shall indicate the final disposition of the sediment pond after the upstream drainage area is stabilized. The plans shall indicate methods for the removal of excess water lying over the sediment, stabilization of the pond site, and the disposal of any excess material.

Vegetation shall be established upon completion of construction of the embankment, emergency spillway and other areas disturbed by construction.

Sand Filter Outlet Design Criteria

Figure 11-19 illustrates an outlet that shall be used to regulate discharge from the sediment pond. To size this device, pick a preliminary configuration and check it using the falling head permeability equation. Set t equal to 48 hours and calculate k . The calculated k should not be greater than 0.146 ft/hr. If necessary, adjust the filter dimensions and recalculate.

The falling head equation is:

$$k = 2.303 * (aL/At) * \log (H/h)$$

where:

k = coefficient of permeability (ft/hr),

a = average surface area of sediment pond at the elevation of the principal spillway (ft²),

L = depth of sand (ft),

A = surface area of filter = width of sand layer * length of sand layer (ft²),

t = time (hr),

H = height of water over the perforated pipe with top of pool at principal spillway (ft), and

h = height of filter from the top of the perforated pipe to the top of the sand (ft).

Pipe Spillway Design Criteria

The capacity of the pipe spillway (trickle tube) shall be sufficient to pass the runoff of a 10-year storm. The minimum diameter of the conduit shall be 8 inches. Pipes may be designed by using (1) peak runoff of the design storm or (2) flood-routing the design storm.

The crest elevation of the principal spillway shall be at the elevation of the designed sediment volume. See Figure 11-20.

The trickle tube shall discharge at approximately the lowest elevation of the valley cross section at the downstream toe of the dam. Protection using gabion mattresses, concrete aprons, or other acceptable materials will be used to convey pipe discharge to a stable channel or a level spreader in an erosion free manner.

Anti-seep collars shall be installed around the pipe barrel for all installations where the height of earth fill over the top of pipe is 5 feet or greater. The combination of the number of collars and the collar projections must increase the length of the line of seepage by at least 15 percent. Where more than one collar is used, they shall be spaced approximately 25 feet apart.

Emergency Spillway Design Criteria

For embankments of 5 feet or less in height, the embankment shall be used as an emergency spillway and the downstream slope shall be 5H:1V or flatter. In addition, the downstream slope of the embankment shall be immediately protected with rock riprap.

Emergency spillways shall be constructed for all sediment ponds having an embankment height greater than 5 feet. The spillway cross section shall be trapezoidal with a minimum bottom width of 8 feet and side slopes of 2H:1V or flatter.

For embankments greater than 5 feet in height, the emergency spillway channel shall be located so that it will not be constructed over fill material. The channel shall be located so there are no sharp turns or bends. The channel shall return the flow of water to a defined channel downstream from the embankment.

The crest of the emergency spillway shall be set at the elevation required to pass the 10-year storm through the pipe spillway. In no case shall the difference in elevation between the crests of the pipe spillway and the emergency spillway be less than 1.0 foot.

The minimum capacity of the emergency spillway shall be that required to pass the peak-rate of runoff from the 100-year storm with one foot of freeboard, assuming the pipe spillway is blocked.

The maximum allowable velocity of flow in the exit section of vegetated emergency spillways shall be 6 feet per second. For spillways with erosion protection other than vegetation, velocities or critical shear forces shall be in the safe range for the type of protection used.

The emergency spillway shall have a control section at least 20 feet in length. The control section is a level portion of the spillway channel at the highest elevation in the channel.

Construction Specifications

The foundation area shall be cleared of all trees, stumps, roots, brush, boulders, sod, and debris. All channel banks and sharp breaks shall be sloped to no steeper than 1:1. All topsoil containing excessive amounts of organic matter shall be removed. The surface of the foundation area shall be thoroughly scarified before placement of the embankment material.

A cutoff trench shall be backfilled with suitable material. The trench shall be kept free of standing water during backfill operations.

The pipe conduit barrel shall be placed on a firm foundation. Selected backfill material shall be placed around the conduit in layers, and each layer shall be compacted to at least the same density as the adjacent embankment. All compaction within 2 feet of the pipe spillway shall be accomplished with hand operated tamping equipment.

All borrow areas outside the pond and in the drainage area shall be graded and left in such a manner that water will not be ponded.

The material placed in the fill shall be free of all sod, roots, frozen soil, stones more than 6 inches in diameter, and other objectionable material. The placing and spreading of the fill material shall occur in approximately 6-inch horizontal layers or of such thickness that the required compaction can be obtained with the equipment used. Each layer shall be compacted in a way that will result in achieving 95 percent of the maximum standard dry density.

The distribution and gradation of materials throughout the fill shall be such that there will be no lenses, pockets, stakes, or layers of material differing substantially in texture or gradation from the surrounding material. Where it is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the upstream and center portions of the fill.

The moisture content of fill material shall be such that the required degree of compaction can be obtained with the equipment used.

Fill shall not be placed on frozen, slick, or saturated soil.

The topsoil material saved in the site preparation shall be placed as a top dressing on the surface of the emergency spillways, embankments, and borrow areas. It shall be evenly spread.

A protective cover of herbaceous vegetation shall be established on all exposed surfaces of the embankment, spillway, and borrow areas to the extent practical under prevailing soil and climatic conditions.

Seedbed preparation, seeding, fertilizing, and mulching shall comply with the applicable sections of this manual.

Any material excavated from the pond shall be placed in one of the following ways so that its weight will not endanger the stability of the side slopes and where it will not be washed back into the pond by rainfall:

- Uniformly spread to a depth not exceeding 3 feet and graded to a continuous slope away from the pond.
- Uniformly placed or shaped reasonably well with side slopes assuming the natural angle of repose for the excavated material behind a berm width not less than 12 feet.

Maintenance

Sediment shall be removed from the pond when the capacity is reduced to 50 percent of the design volume. Plans for the sediment pond shall indicate the methods for disposing of sediment removed from the pond.

11.5.4 Silt Fence

Silt fence is a temporary barrier to trap sediment that consists of a filter fabric stretched between supporting posts, with the bottom entrenched in the soil and with a wire support fence. The purpose of a silt fence is to intercept and detain water allowing the settling of small amounts of sediment from disturbed areas during construction operations to prevent sediment from leaving the site and entering streams.

Design Criteria

Silt fences are appropriate where the size of the drainage area is no more than one-fourth acre per 100 feet of silt fence length; the maximum slope length behind the barrier is 100 feet; and the maximum gradient behind the barrier is 50 percent (2H:1V). Silt fences can be used at the toe of stock piles where the slope exceeds 2H:1V; but, in that case, the slope length should not exceed 20 feet.

Silt fences can be used in minor swales or ditch lines where the maximum contributing drainage area is no greater than 2 acres

Under no circumstances shall silt fences be constructed in streams or in swales or ditch lines where flows are likely to exceed 1 cubic foot per second (cfs).

Silt fences composed of synthetic fabric have an expected usable life of 6 months.

Material Specifications

Synthetic filter fabric shall be a pervious sheet of propylene, nylon, polyester, or ethylene yarn and shall be certified by the manufacturer or supplier as conforming to the following requirements:

<u>PHYSICAL PROPERTY</u>	<u>REQUIREMENTS</u>
Filtering Efficiency	75% (minimum)
Tensile Strength at 20%	50 lbs./linear inch (minimum)
Flow Rate	0.3 gal./ sq. ft/ min. (minimum)

Synthetic filter fabric shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0°F to 120°F.

Posts for synthetic fabric silt fences shall be either 2-inch by 2-inch wood or 1.33 pounds per linear foot steel with a minimum length of 5 feet. Steel posts shall have projections for fastening wire to them.

Wire fence reinforcement for silt fences shall be a minimum of 36 inches in height, a minimum of 14 gauge and shall have a mesh spacing of no greater than 6 inches.

Construction Specifications

This section provides construction specifications for silt fences using synthetic fabric. See Figure 11-21 for an illustration and Figure 11-22 for general notes.

Posts shall be spaced a maximum of 10 feet apart at the barrier location and driven securely into the ground (minimum of 12 inches). When necessary because of rapid runoff, post spacing shall not exceed 6 feet.

A trench shall be excavated at least 6 inches wide and 6 inches deep along the line of posts and upslope from the barrier.

A wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1 inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of 2 inches and shall not extend more than 36 inches above the original ground surface.

The filter fabric shall be stapled or wired to the fence, and 12 inches of the fabric shall be extended into the trench. The fabric shall not extend more than 30 inches above the original ground surface. Filter fabric shall not be stapled to existing trees.

At joints, filter fabric should be lapped with terminating posts with a minimum overlap of 3 feet.

The trench shall be backfilled and soil compacted over the filter fabric.

Silt fences shall be removed when they have served their useful purpose and the upslope area has been permanently stabilized.

Maintenance

Silt fences and filter barriers shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Any required repairs shall be made immediately. Knocked down fences shall be repaired at the end of each day.

Should the fabric on a silt fence or filter barrier decompose or become ineffective prior to the end of the expected usable life and the barrier is still necessary, the fabric shall be replaced promptly.

Sediment deposits shall be removed after each storm event or when deposits reach approximately one-half the height of the barrier.

Any sediment deposits remaining in place after the silt fence or filter barrier is no longer required shall be dressed to conform with the existing grade, prepared, and seeded.

Silt fences shall be replaced every 6 months.

11.5.5 Storm Drain Inlet Protection

A sediment filter installed around a storm drain drop inlet or curb inlet is referred to as storm drain inlet protection. Its purpose is to prevent sediment from entering storm drainage systems prior to permanent stabilization of the disturbed area. This practice should be used when storm drain inlets are to be operational before permanent stabilization of disturbed areas in the watershed. Curb inlet protection is not required if other soil stabilization and sediment control measures are in place to prevent sediment from entering the street.

Design Criteria

The drainage area shall be no greater than 1 acre.

The inlet protection device shall be constructed in a manner that will facilitate cleanout and disposal of trapped sediment and minimize interference with construction activities.

Inlet protection devices shall be constructed in such a manner that any resultant ponding of stormwater will not cause excessive inconvenience or damage to adjacent areas or structures.

Specifications-Drop Inlet Filters

For silt fence inlet protection (illustrated in Figure 11-23), the following specifications apply:

For stakes, use 2 x 4-inch wood (preferred) or equivalent metal with a minimum length of 3 feet.

Space stakes evenly around the perimeter of the inlet a maximum of 3 feet apart and securely drive them into the ground, approximately 18 inches deep.

To provide needed stability to the installation, frame with 2 x 4-inch woodstrips around the crest of the overflow area at a maximum of 1.5 feet above the drop inlet crest and brace diagonally.

Place the bottom 12 inches of the fabric in a trench and backfill the trench with at least 4 inches of crushed stone or 12 inches of compacted soil.

Fasten fabric securely to the stakes and frame. Joints must be overlapped to the next stake.

For sod drop inlet protection, sod shall be placed to form a turf mat covering the soil for a distance of 4 feet from each side of the inlet structure. Soil preparation and sod placement shall be in accordance with the section entitled Sodding.

Specifications-Curb Inlet Filters

For gravel curb inlet protection (shown in Figure 11-24), the following specifications apply:

- Wire mesh with ½-inch openings shall be placed over the curb inlet opening so that at least 12 inches of wire extends across the concrete gutter from the inlet opening.
- KTC No. 2 Coarse Aggregate shall be piled against the wire so as to anchor it against the gutter and inlet cover and to cover the inlet opening completely.

A gravel filtering device has no overflow mechanism, therefore, ponding is likely. This type of device must never be used where overflow may endanger an exposed fill slope. Consideration should also be given to the possible effects of ponding on traffic movement, nearby structures, working areas, and adjacent property.

For block and gravel curb inlet protection (illustrated in Figure 11-25), the following specifications apply:

- Two concrete blocks shall be placed on their sides abutting the curb at either side of the inlet opening to act as spacer blocks.
- A 2-inch by 4-inch stud shall be cut and placed through the outer holes of each spacer block to help keep the front blocks in place.

- Concrete blocks shall be placed on their sides across the front of the inlet and abutting the spacer blocks.
- Wire mesh shall be placed over the outside of the concrete blocks to prevent stone from being washed through the holes in the blocks. Wire with ½-inch openings shall be used.
- KTC No. 2 Coarse Aggregate shall be piled against the wire to the top of the barrier.

Maintenance

The structure shall be inspected after each rain, and repairs made Inlet as needed. Sediment shall be removed and the device restored to its original dimensions when the sediment has accumulated to one-half the design depth of the filter. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

If a stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks and replaced.

Structures shall be removed after the drainage area has been properly stabilized.

11.5.6 Filter Strips

A filter strip is a strip of vegetation for removing sediment and related pollutants from runoff. Filter strips are also called vegetative filters. This practice uses infiltration, deposition, absorption, and decomposition to reduce pollution in runoff. Filter strips are applicable to land undergoing development where this practice can reduce sediment damage to adjacent property, streams, or wetlands.

Design Criteria

Filter strips shall only be used to remove sediment from overland flow. Filter strips are not effective in removing sediment from concentrated flows.

Vegetative filters cannot be expected to remove all sediment or adequately protect adjacent areas from sediment damage when used alone. Vegetative filters should only be considered as one component of the erosion and sediment control system.

If vegetative filters are proposed as a sediment control device and they do not already exist, they shall be planned and established prior to initiating land disturbing activities.

Minimum filter strip width shall be 50 feet for streams and wetlands. The minimum filter strip width shall be ten feet for constructed waterways. See Figure 11-26.

Where a post development floodplain or wet weather conveyance is being protected, filter strips shall be provided on each side. When a wetland is being protected, filter strips shall be provided around the perimeter.

Plans shall show the location, width, and length of filter strips. The type of vegetation and specifications for soil preparation and seeding shall be included. If existing vegetation is to be used, plans for protecting or improving it shall be provided.

Material Specifications

Existing grass or grass/legume mixtures used as filter strips shall be dense and well established, with no bare spots. When establishing new seeding, consideration shall be given to wildlife needs and soil conditions on the site. The following chart provides a list of alternative grass and grass/legume mixtures:

SEEDING MIXTURE AND SITE SUITABILITY CHART		
Seeding Mixture	Rate Lbs./Acre	Soil Suitability
1. Alfalfa or Red Clover Plus Timothy or Orchardgrass or Bromegrass	10 10 4 6 6	Well Drained
2. Ladino Clover Plus Timothy or Orchardgrass or Bromegrass	½ 4 6 8	Wet or Well Drained

Notes:

- 1.) All seeding shall be in accordance with the seeding sections of this manual
- 2.) Well drained sites include sites that are drained with tile as well as naturally well drained and droughty sites. Wet sites include sites that are excessively wet only a portion of the growing season.

Construction Specifications

When planting filter strips, prepare seedbed, incorporate fertilizer, and apply mulch consistent with the seeding sections of this manual. Filter strips using areas of existing vegetation shall be over seeded, as necessary, with the above mixtures to obtain an equivalent density of vegetation. The over seeding shall be accomplished prior to the land disturbing activity.

Maintenance

Filter strips shall be inspected regularly to ensure that a healthy vegetative growth is maintained. Any bare spots or spots where sediment deposition could lead to the destruction of vegetation shall be repaired.

Filter strips shall be fertilized once each year in the fall. Irrigation shall be used as necessary to maintain the growth of the vegetation in the filter strip.

Sediment shall be removed when it becomes visible in the filter.

Construction traffic shall not be permitted to drive upon filter strips.

11.5.7 Temporary Stream Crossing

A temporary stream crossing is a temporary structural span installed across a flowing water course for use by construction traffic. Structures may include bridges, round pipes, or pipe arches. The purpose of a temporary stream crossing is to provide a means for construction traffic to cross flowing streams without damaging the channel or banks and to keep sediment generated by construction traffic out of the stream.

Design Criteria

Temporary stream crossings are applicable to flowing streams with drainage areas less than one square mile. Structures that must handle flow from larger drainage areas shall be designed as permanent structures by a professional engineer.

Temporary stream crossings shall be planned to be in service for the shortest practical period of time and to be removed as soon as their function is completed.

Such structures are subject to the rules and regulations of the U.S. Army Corps of Engineers for in-stream modifications (404 permits) and the Kentucky Natural Resources and Environmental Protection Cabinet, Division of Water (401 certification).

The span shall be designed to withstand the expected loads from heavy construction equipment that will cross the structure.

The structure shall be large enough to convey the peak flow expected from a 1-year storm without appreciably altering the stream flow characteristics. The structure may be a span, a culvert, or multiple culverts.

The minimum-sized culvert shall be 18 inches.

Where culverts are installed, compacted soil or rock shall be used to form the crossing. The depth of soil or rock cover over the culvert shall be equal to one-half the diameter of the culvert or 12 inches, whichever is greater. The sides of the fill shall be protected from erosion using the mulching and seeding erosion control measures specified in this manual.

The slope of the culvert shall be at least 0.25 inches per foot.

Material Specifications

When using a culvert crossing, the top of a compacted earth fill shall be covered with six inches of KTC No. 57 stone. No. 57 stone shall also be used for the stone pads forming the crossing approaches.

Construction Specifications

Clearing and excavation of the streambed and banks shall be kept to a minimum.

The structure shall be removed as soon as it is no longer necessary for project construction.

Upon removal of the structure, the stream shall immediately be reshaped to its original cross section and properly stabilized.

The approaches to the structure shall consist of stone pads with a minimum thickness of 6 inches, a minimum width equal to the width of the structure, and a minimum approach length of 25 feet on each side.

Maintenance

The structure shall be inspected after every rainfall and at least once a week and all damages repaired immediately.

11.5.8 Pump-Around Flow Diversion

Pump-around flow diversions must be used to divert flow during excavation operations in streams. Pump-around flow diversions provide dry working conditions during construction in streams. Diverting stream flow around the work area prevents suspension of sediment in stream flow by construction activities. See Figure 11-27 for an illustration of a pump-around flow diversion.

Design Criteria

Size the diversion pump based on normal stream flow. Dewatering pump should be sized based on the size of the work area, the time allowed for dewatering, and the expected rate of groundwater flow into the excavation.

The check dams to form the diversion shall span the banks of the stream. Maintain 1-foot freeboard (minimum) on the upstream and downstream checks.

Check dams may be constructed of sandbags or may be a water-filled bladder, such as an Aqua-Barrier.

The dewatering flow from the work area must be treated in a sediment-trapping device prior to discharge to the stream.

Material Specifications

Sandbags shall be woven polypropylene bags with approximate dimensions of 18-1/2 inches by 28 inches. Tie the ends of filled bags closed using either draw strings or wire ties.

Construction Procedures and Specifications

Schedule operations such that diversion installation, in-stream excavation, instream construction, stream restoration, and diversion removal are completed as quickly as possible. Do not construct in a stream when rainfall is expected during the time excavation will be occurring in the stream.

Install check dams across the stream during low flow conditions.

Pump stream flow around the check dams. Install outlet protection as required at the discharge.

Dewater the work area and pump into a sediment trapping device.

Complete construction activities across the stream.

Restore the streambed and banks.

Remove sandbags and shut down pumping operation. (Salvage Pump-Around sandbags for future use if multiple stream crossings are required on the project.) Remove all sandbags from the stream, including damaged and empty bags.

Pumps shall be manned around-the-clock when the pump-around diversion is in the stream.

Maintenance

This control provides short-term diversion of stream flow (typically 1 day to 3 days). Additional sandbags or pumps may be required to maintain 1-foot freeboard on the sandbag checks if flow conditions change.

Add sandbags as required to seal leaks in checks.

11.6 EROSION CONTROL REQUIREMENTS FOR HOME BUILDERS

Soil erosion from construction sites causes problems in many ways. Construction site erosion:

- Impairs water quality of streams,
- Increases road maintenance costs,
- Clogs pipes,
- Degrades land surfaces and streams,
- Contributes to flooding, and
- Increases dusty conditions when eroded materials dry on streets.

Significant erosion results from rainfall and water running over unprotected soil. The effects of erosion are increased by heavy rains, long slopes, steep slopes, and lack of plant life stabilizing the soil. Improper construction, grading, or excavation resulting in the removal of natural ground cover can contribute to erosion control problems.

11.6.1 Performance Standards

The performance standards required of the home builder on single family, two family, or townhouse lots follow:

- No soil in public streets,
- No soil washed off the building lot or into drainageways on the lot by rainfall, and
- No used building material, packaging, or litter blown or washed off the lot.

The required practices described in this section are:

- Silt fence and gravel driveway installed before any disturbance on the lot,
- All disturbed areas seeded and mulched within 14 days after final grading,
- Waste building material and litter cleaned up each day,
- Dirt pads can not be used to protect sidewalks from earth moving equipment; gravel pads must be used instead, and
- Other measures may be required by the City of Danville inspector to meet the performance objectives.

Home builders in the City of Danville are required to comply with the practices described in this section.

11.6.2 Multiple Lots

Builders who have multiple lots that are adjacent to one another may treat them as one lot when installing erosion controls.

11.6.3 Practices to be Installed

Silt Fence

A silt fence shall be installed along the perimeter of the building lot that is down-slope of areas to be disturbed prior to clearing and grading. The silt fence is not required around the entire perimeter of the lot but must be installed down-slope of all disturbed areas. To install silt fence:

1. Excavate a 4-inch x 4-inch trench along the contour.
2. Stake the silt fence on the downslope side of trench. Extend 8 inches of fabric into the trench.
3. When joints are necessary, overlap ends at least three feet and provide a post at each end of the overlap.
4. Backfill and compact the excavated soil.

General specifications for silt fence include:

1. Filter fabric shall be purchased in a continuous roll and cut to the length of the barrier. When joints cannot be avoided, filter fabric shall be spliced together only at a post with 3-foot minimum overlap, and securely sealed.
2. Posts shall be a minimum of 5 feet in height.
3. Steel posts shall have projections for fastening wire and fabric.
4. Wood posts shall be 2-inch by 2-inch wood or equivalent.
5. Posts shall be spaced 6 feet on center.
6. Turn silt fence upslope at ends.

Gravel Driveway

Gravel driveway shall be constructed where vehicles leave the building lot to enter a public street. Vehicle access to enter into or exit from the building lot shall be restricted to one driveway. Providing a gravel surface on a single access point will allow all weather access, will reduce the amount of soil carried off the site by vehicles, and will provide a permanent base for the driveway.

General requirements for gravel driveway include:

1. A stabilized entrance pad of crushed stone shall be located at a single access point from or to the public street.

2. The entrance shall be maintained in a condition, which will prevent tracking or flowing of sediment onto public streets or existing pavement. This may require periodic top dressing with additional stone as conditions warrant and repair or cleanout of any measures used to trap sediment.

Seeding, Sodding, and Mulching

Requirements for seeding, sodding, and mulching include:

1. Seeding and mulching or sod placement must be made within 14 days after final grading.
2. Sodding must be used for disturbed areas in defined drainageways that require immediate vegetative cover.
3. Mulch without seed may be applied during December, January, and February.
4. Any area of the lot left undisturbed for longer than 14 days shall be seeded and mulched.

Waste Building Material and Litter Disposal

All waste building materials and packaging products must be hauled off-site or placed in an on-site dumpster after use and not allowed to be carried off-site by runoff or wind. Waste materials include, but are not limited to; food packaging, cans, bottles, other paper products, debris, and cleaning wastes.

Drainage Inlet and Drainage Way Protection

A silt fence must be used to keep soil from being washed into drainage inlets and drainageways.

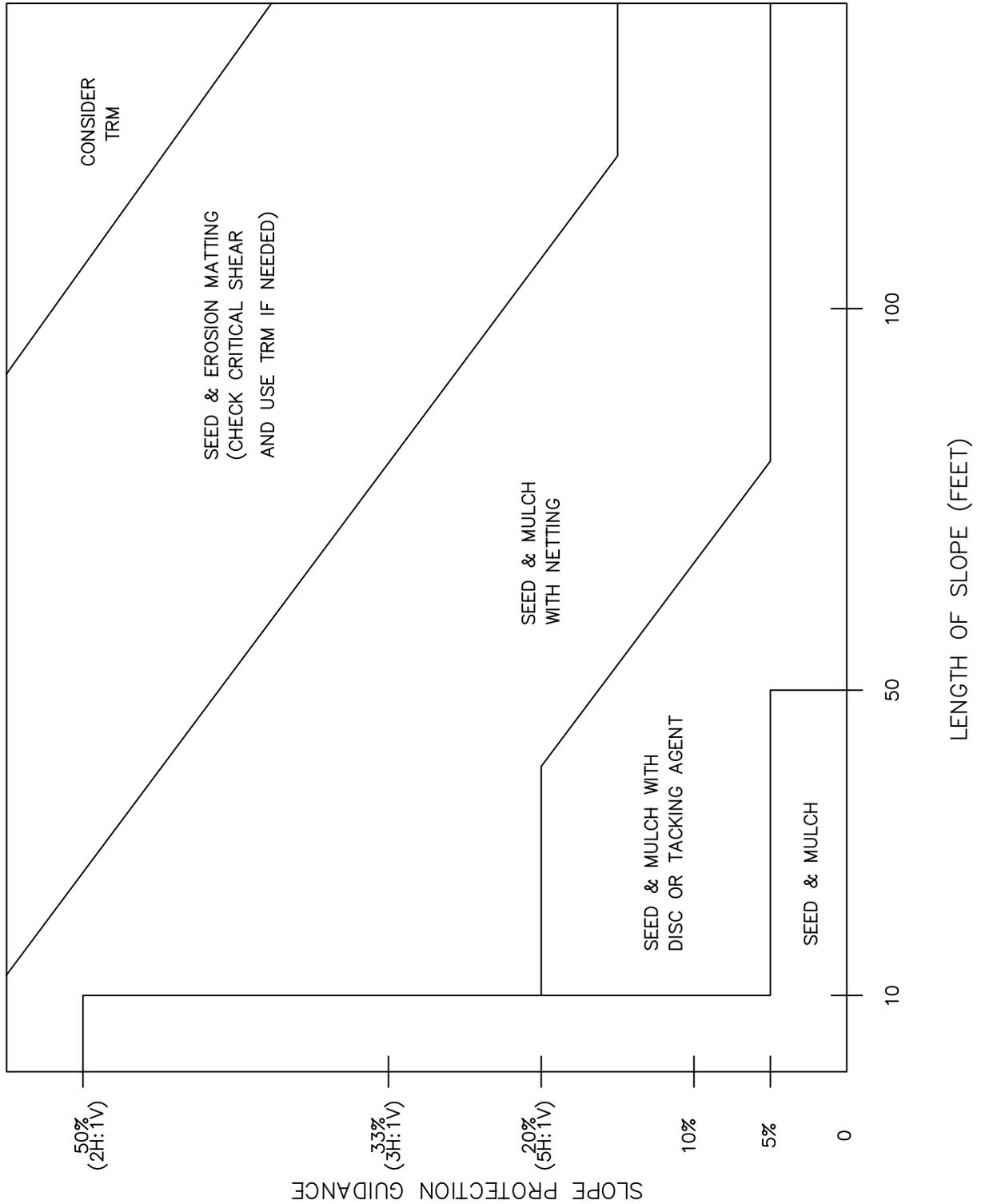
Alteration of Drainage System

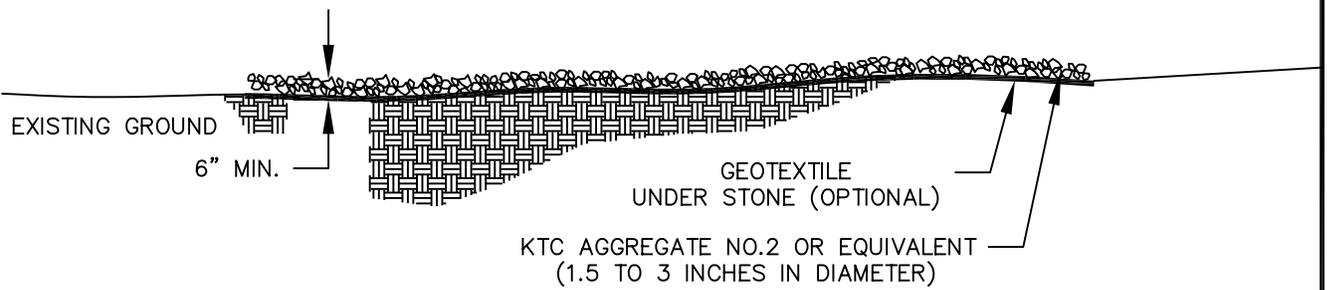
A home builder may not alter the drainage conditions existing on a lot. The home builder may not regrade the lot to move a creek, ditch, or drainage way on or off a lot. The home builder may not fill in a floodplain, detention/retention pond, swale, or other drainage way.

Inspections of Erosion Control Measures

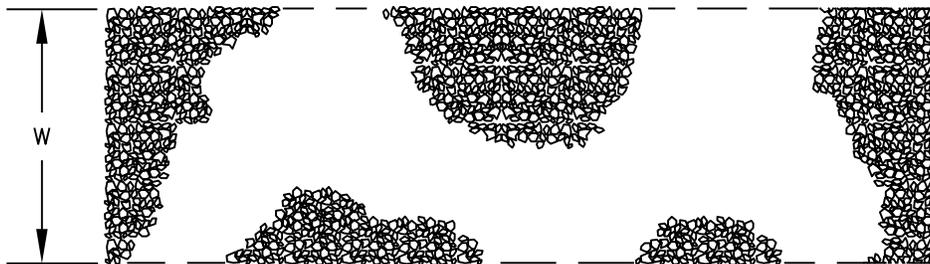
A home builder shall perform a routine inspection each working day. Practices shall be repaired as needed.

During the period of construction at a site, all erosion control procedures necessary to meet the performance standards of this chapter shall be properly implemented, installed, and maintained by the building permit applicant or subsequent landowner.



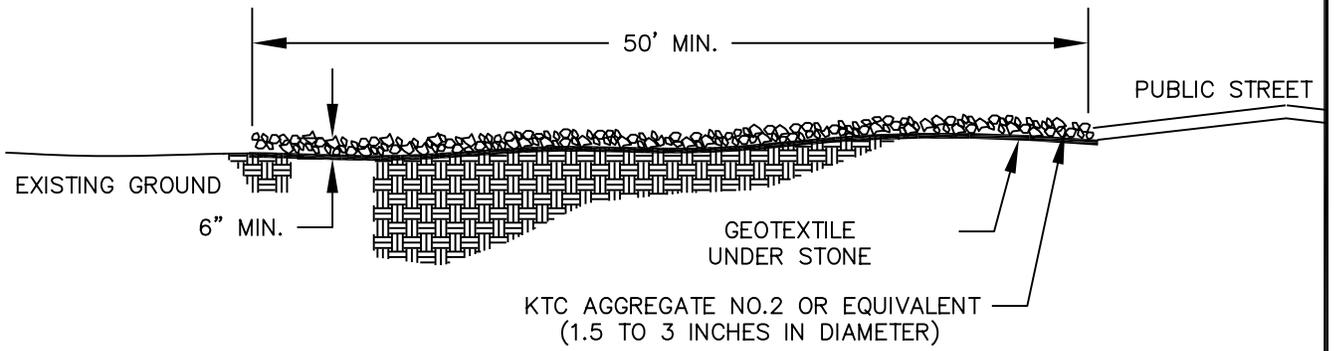


CROSS SECTION

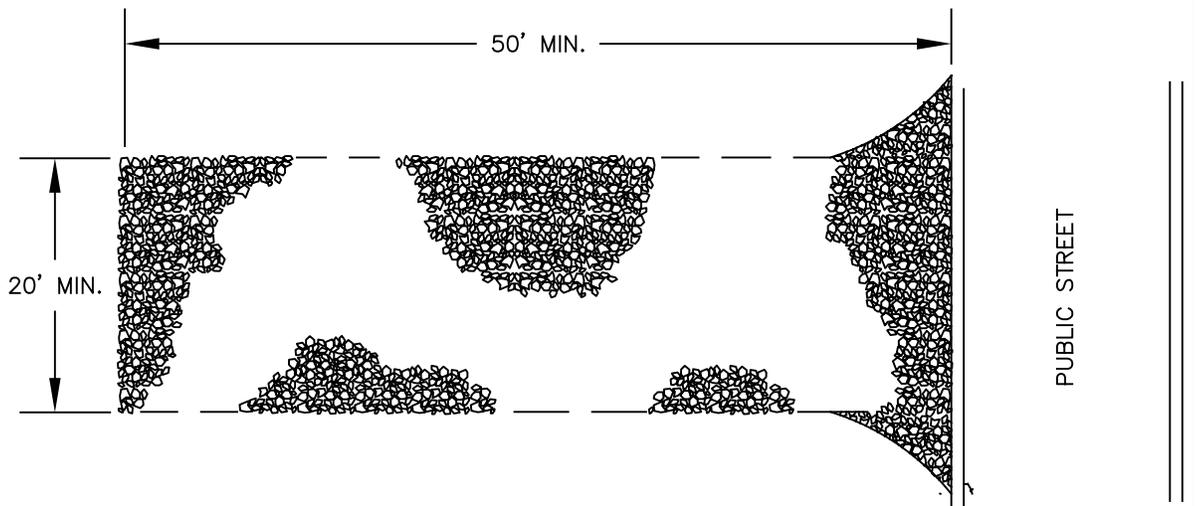


PLAN VIEW

W = 14' MIN. FOR ONE WAY TRAFFIC
20' MIN. FOR TWO WAY TRAFFIC



CROSS SECTION



PLAN VIEW

SPECIFICATIONS FOR GEOTEXTILE FABRIC

GRAB TENSILE STRENGTH	220 LBS. (MIN.) (ASTM D1682)
ELONGATION FAILURE	60% (MIN.) (ASTM D1682)
MULLEN BURST STRENGTH	430 LBS. (MIN.) (ASTM D3768)
PUNCTURE STRENGTH	125 LBS. (MIN.) (ASTM D751) (MODIFIED)
EQUIVALENT OPENING	SIZE 40-80 (US STD SIEVE) (CW-02215)

NOTES

1. A STABILIZED ENTRANCE PAD OF CRUSHED STONE SHALL BE LOCATED WHERE TRAFFIC WILL ENTER OR LEAVE THE CONSTRUCTION SITE ONTO A PUBLIC STREET.
2. SOIL STABILIZATION FABRIC SHALL BE USED AS A BASE FOR THE CONSTRUCTION ENTRANCE.
3. THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION WHICH WILL PREVENT TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC STREETS OR EXISTING PAVEMENT. THIS MAY REQUIRE PERIODIC TOP DRESSING WITH ADDITIONAL STONE AS CONDITIONS WARRANT AND REPAIR OR CLEAN OUT OF ANY MEASURES USED TO TRAP SEDIMENT.
4. ANY SEDIMENT SPILLED, DROPPED, WASHED, OR TRACKED ONTO PUBLIC STREETS OR INTO STORM DRAINS MUST BE REMOVED IMMEDIATELY.
5. WHEN APPROPRIATE, WHEELS MUST BE CLEANED TO REMOVE SEDIMENT PRIOR TO ENTERING A PUBLIC STREET. WHEN WASHING IS REQUIRED, IT SHALL BE DONE IN AN AREA STABILIZED WITH CRUSHED STONE WHICH DRAINS INTO AN APPROVED SEDIMENT BASIN.

SLOPES UP TO 1.5H:1V

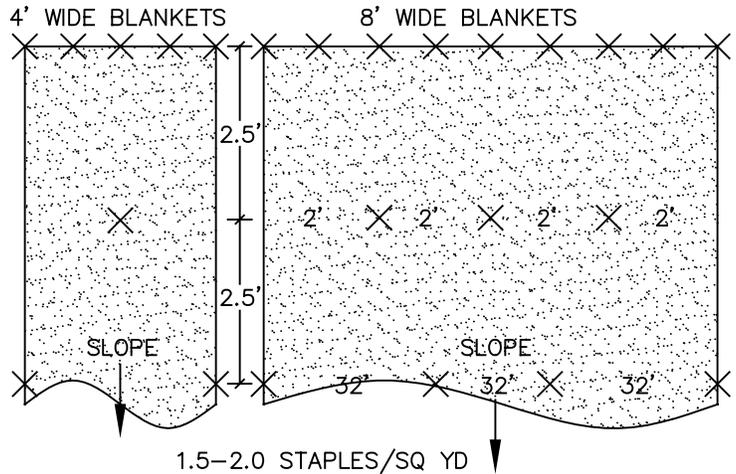
- INSTALL BLANKET VERTICALLY OR HORIZONTALLY
- USE 12" STAPLE SPACING ON STARTER ROW.

COHESIVE SOILS:

- NO OVERLAP REQUIRED ON SIDE SEAMS
- USE 6" STAPLE LENGTH

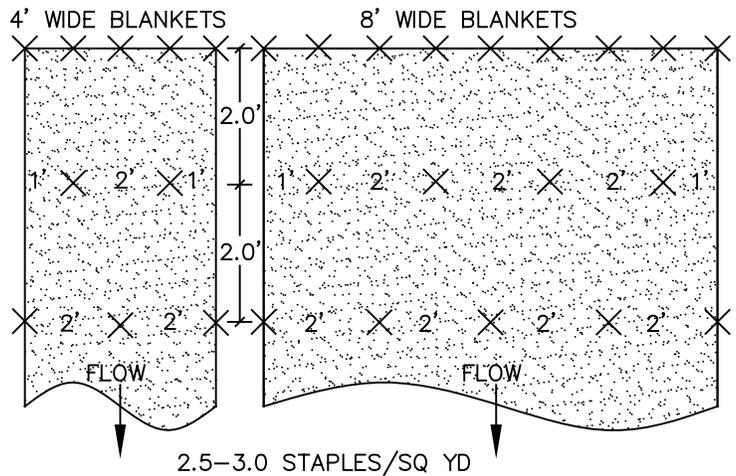
NON-COHESIVE SOILS:

- USE 6" SIDE SEAM OVERLAP
- USE 8" STAPLE LENGTH
- USE 6" ANCHOR TRENCH AT TOP OF SLOPE



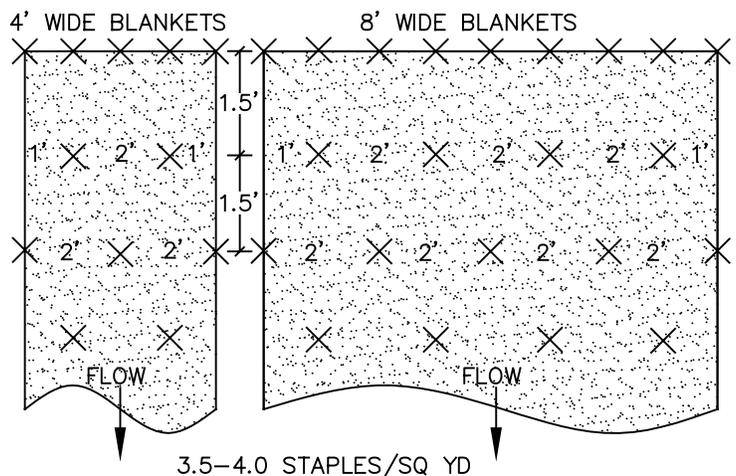
CHANNELS IN COHESIVE SOILS

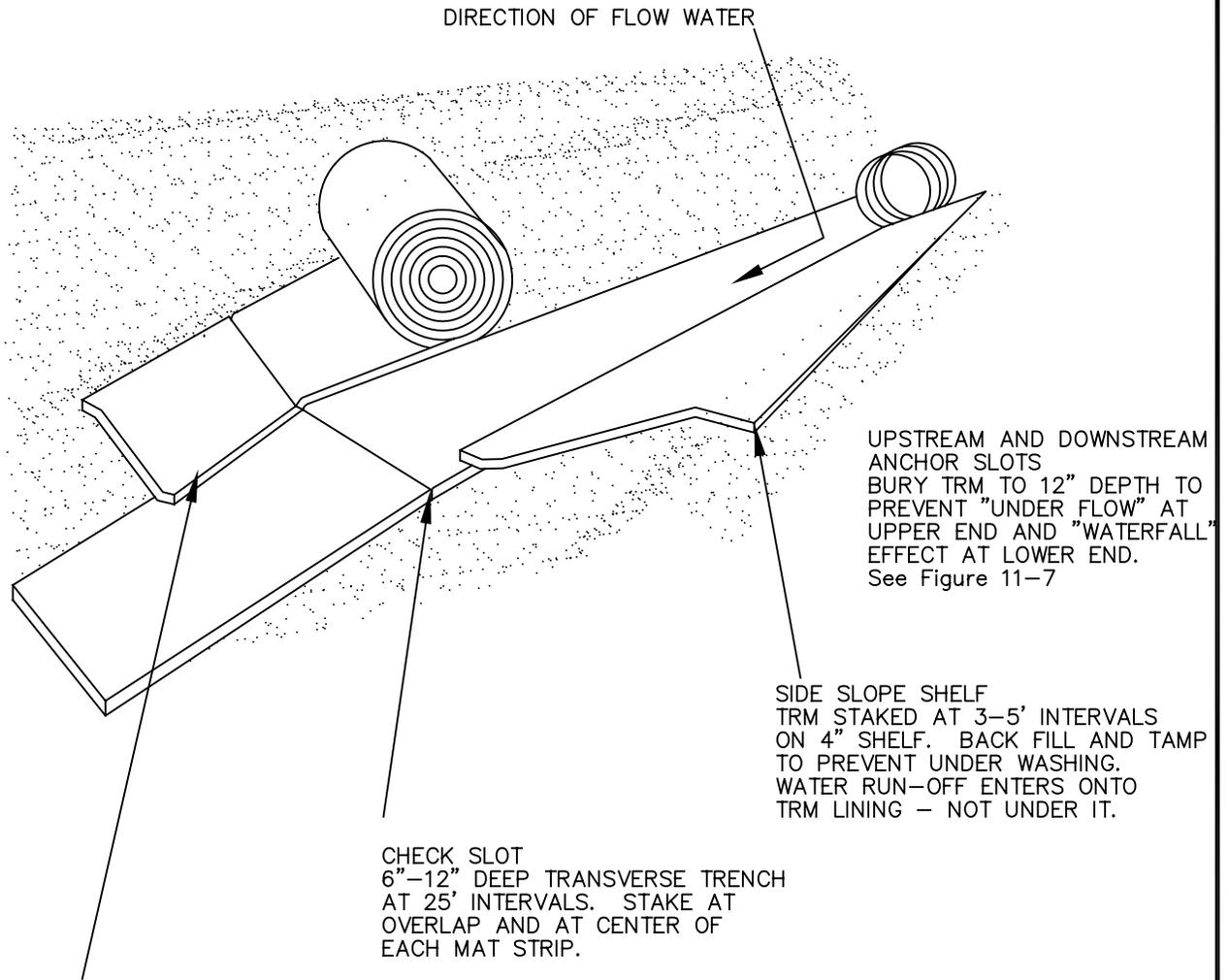
- USE 6" SIDE SEAM OVERLAP
- USE 6" STAPLE LENGTH
- USE 6" TRANSVERSE ANCHOR TRENCH AT 100-FT. INTERVALS
- USE 12" STAPLE SPACING ON STARTER ROW.
- UPSTREAM BLANKET SHOULD OVERLAP DOWNSTREAM BLANKET A DISTANCE OF 12" IN A "SHINGLE" FASHION AND BURY THE FINISHED TOE AT LEAST 6".



CHANNELS IN NON-COHESIVE SOILS

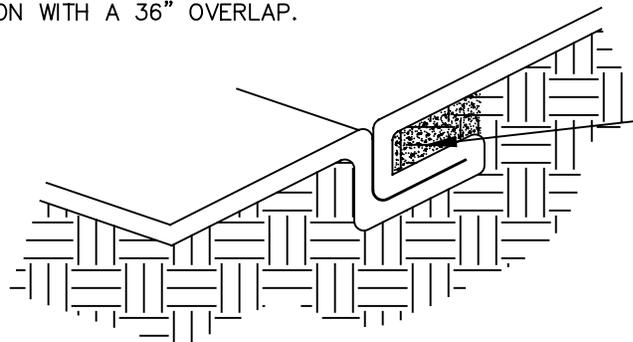
- USE 6" SIDE SEAM OVERLAP
- USE 8" STAPLE LENGTH
- USE 6" TRANSVERSE ANCHOR TRENCH AT 50-FT. INTERVALS
- USE 12" STAPLE SPACING ON STARTER ROW.
- UPSTREAM BLANKET SHOULD OVERLAP DOWNSTREAM BLANKET A DISTANCE OF 12" IN A "SHINGLE" FASHION AND BURY THE FINISHED TOE AT LEAST 6".



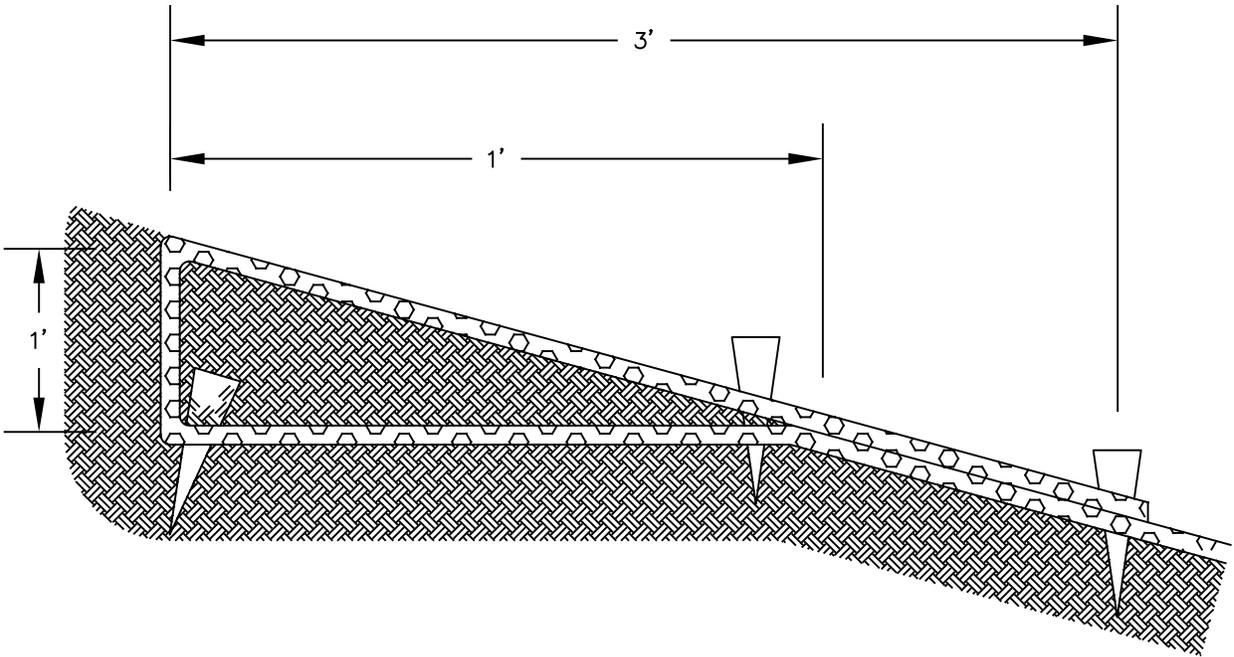


OVERLAP IN A SHINGLE FASHION
4" OVERLAP STAKED AT 3-5' INTERVALS

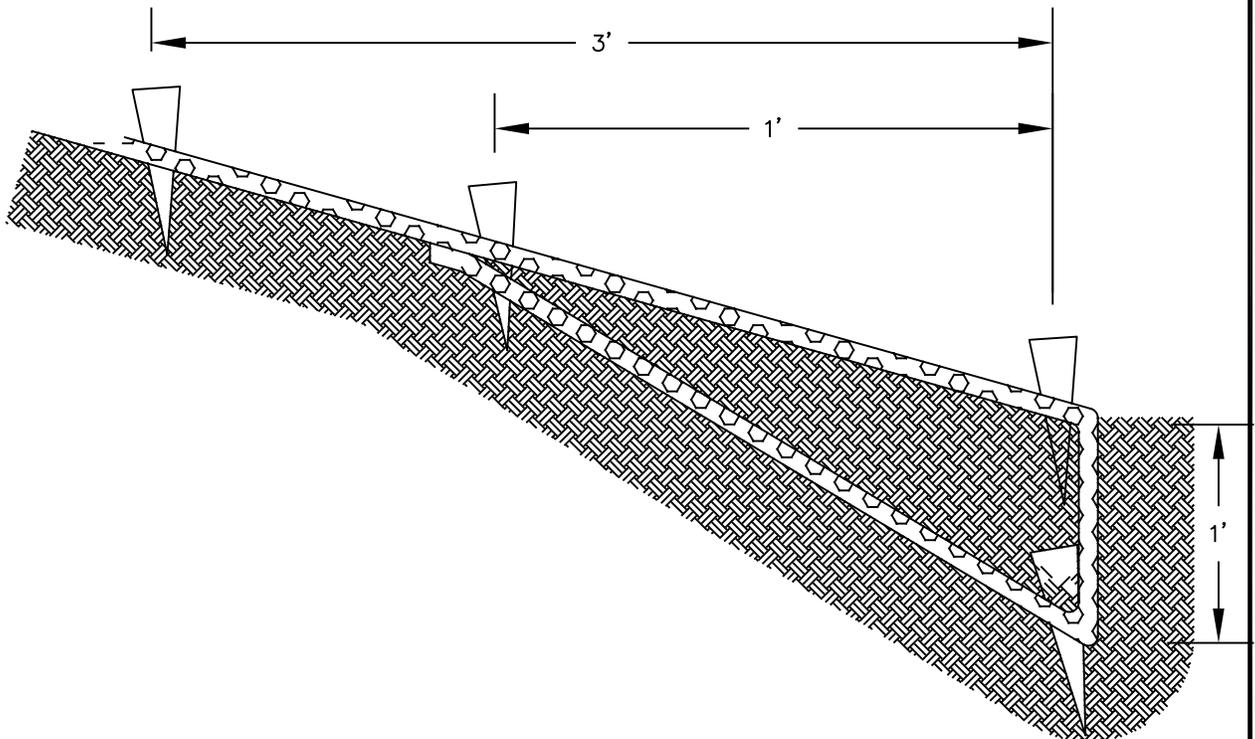
WHEN ROLL TERMINATES, IT IS STAKED OVER THE ROLL WHICH EXTENDS DOWNSTREAM IN A SHINGLE FASHION WITH A 36" OVERLAP.

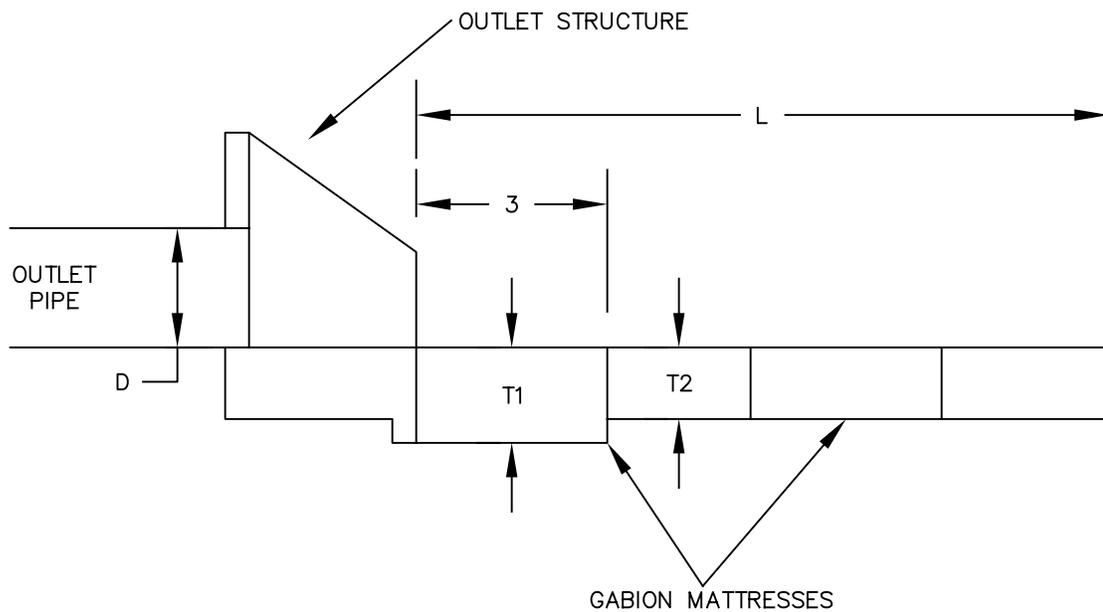


UPSTREAM ANCHOR SLOT DETAIL



DOWNSTREAM ANCHOR SLOT DETAIL



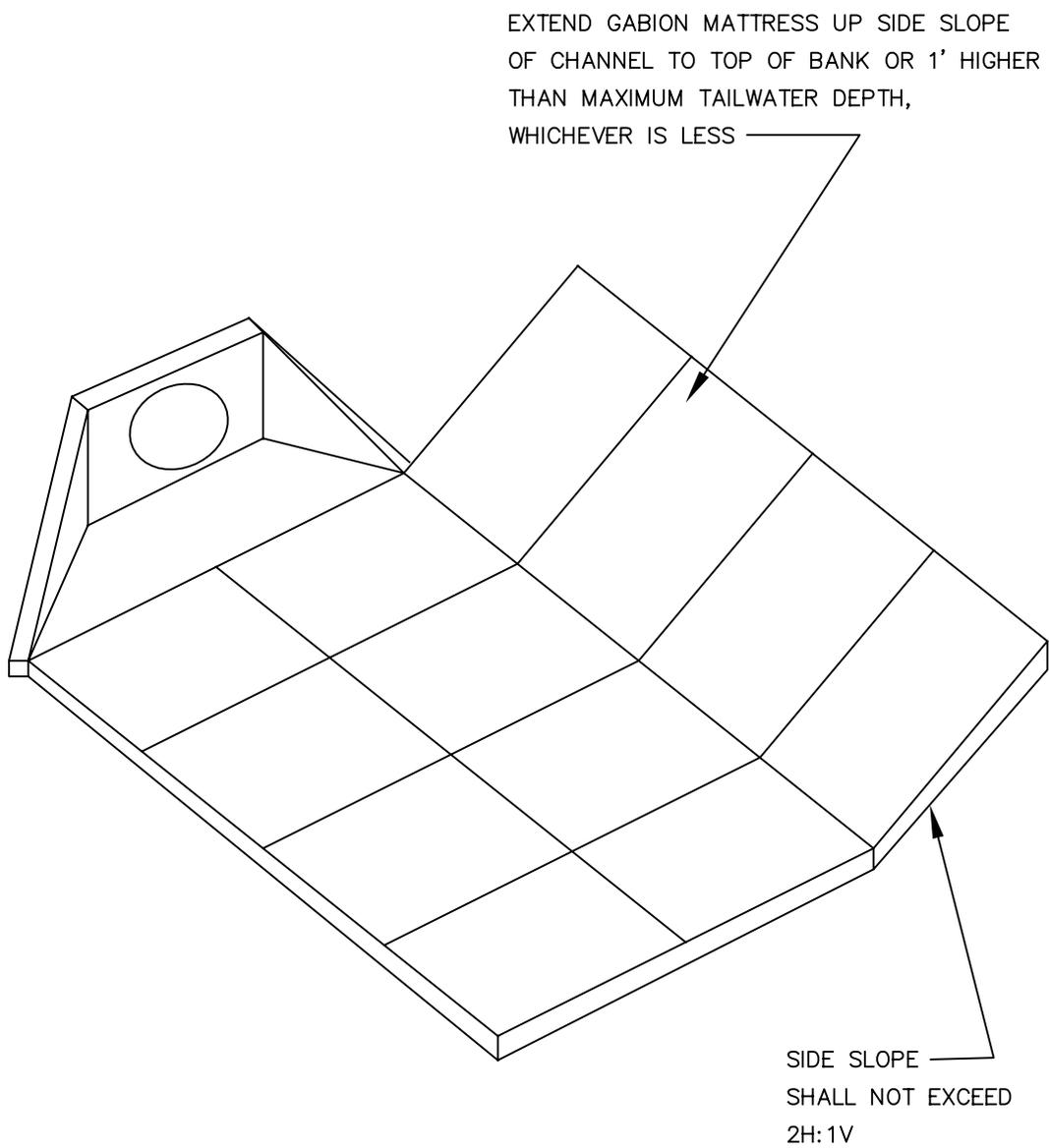


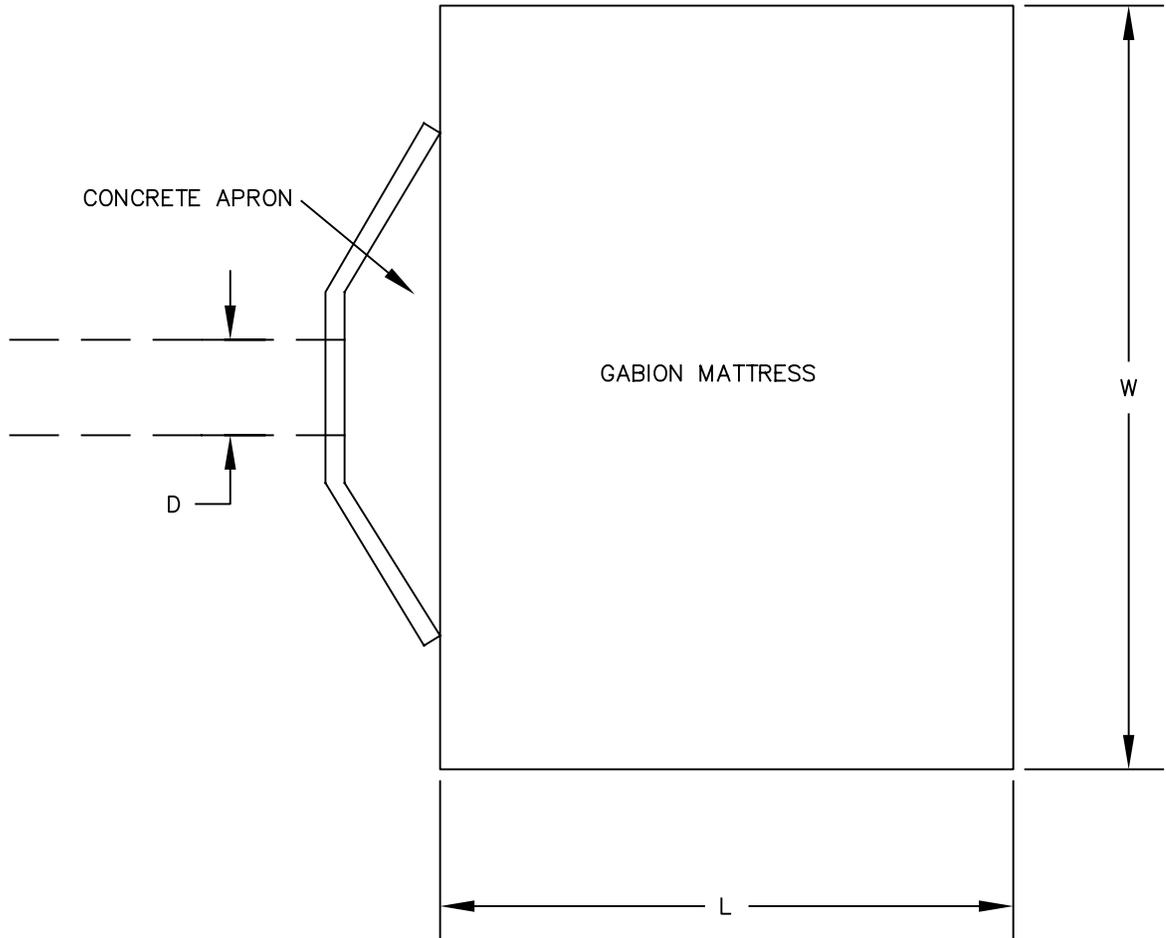
- T1 = THICKNESS OF FIRST 3 FEET OF GABION MATTRESS TO MATCH DEPTH OF OUTLET STRUCTURE FOUNDATION
- T2 = THICKNESS OF REMAINING GABION MATTRESS, 12 INCHES MINIMUM AND 18 INCHES MINIMUM FOR CALCULATED OUTLET VELOCITIES OF 10 TO 15 FEET PER SECOND.

FOR $D < 36$ INCHES, $L = 12$ FEET

FOR $D > 36$ INCHES, $L = 4 \times D$ FEET

D = HEIGHT OR WIDTH OF OUTLET, WHICHEVER IS GREATER





D = HEIGHT OR WIDTH OF OUTLET, WHICHEVER IS GREATER

FOR $D \leq 36$ INCHES:

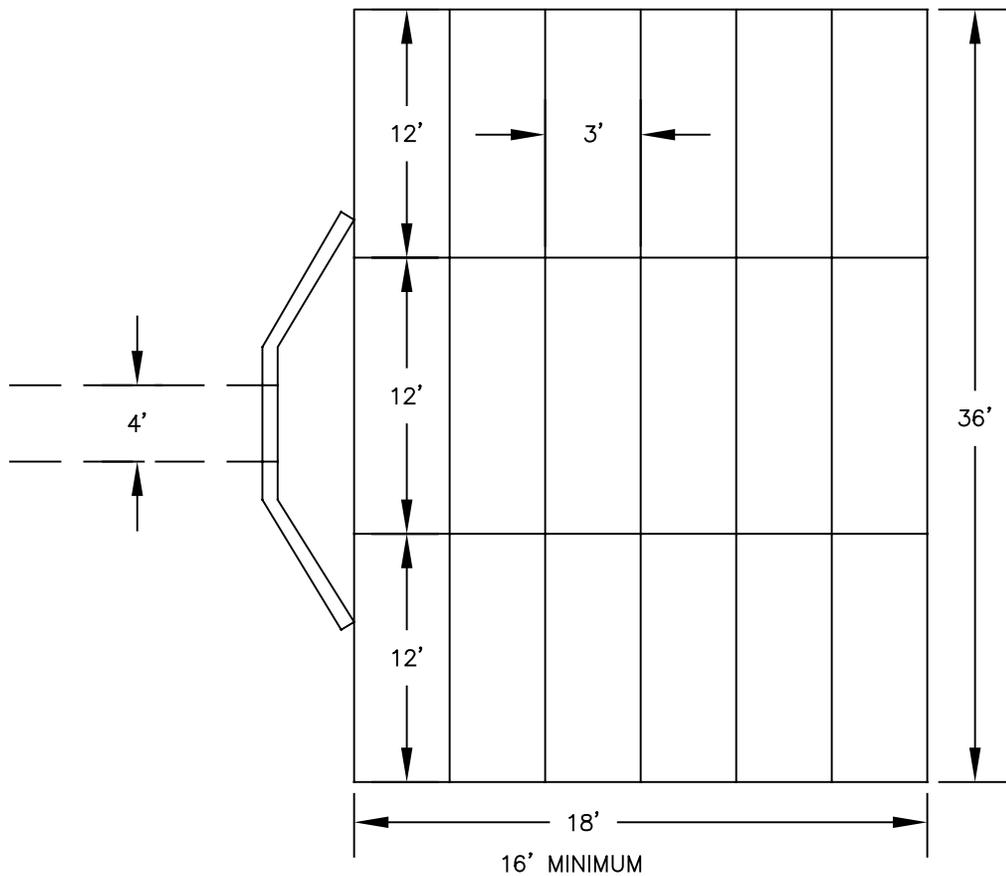
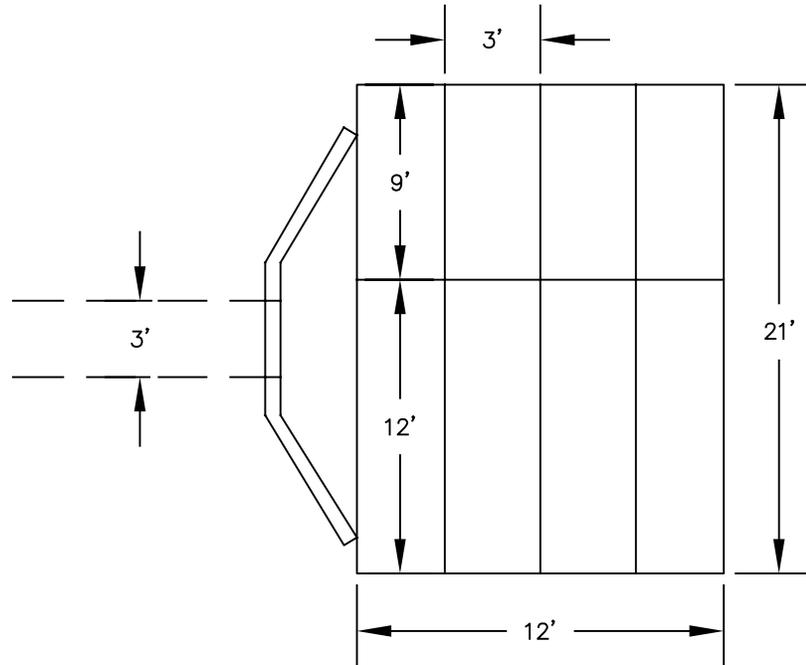
L = 12 FEET MINIMUM

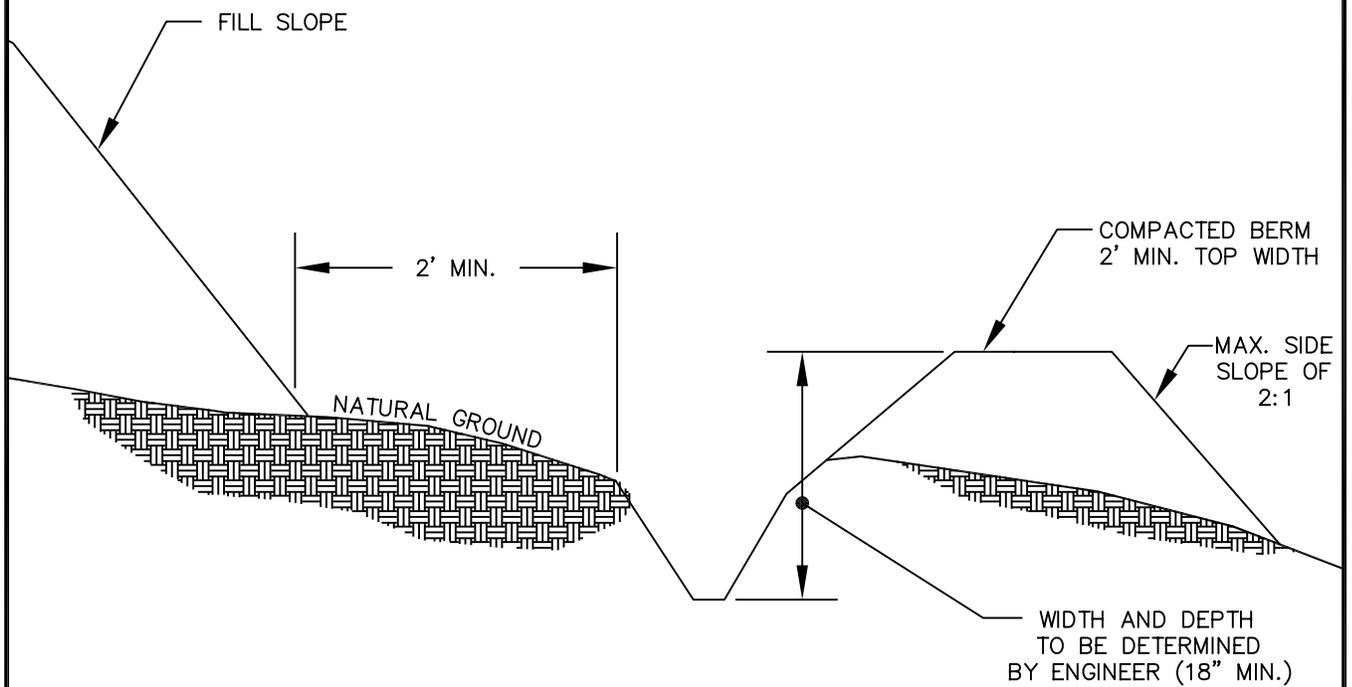
W = (18 + D) FEET MINIMUM

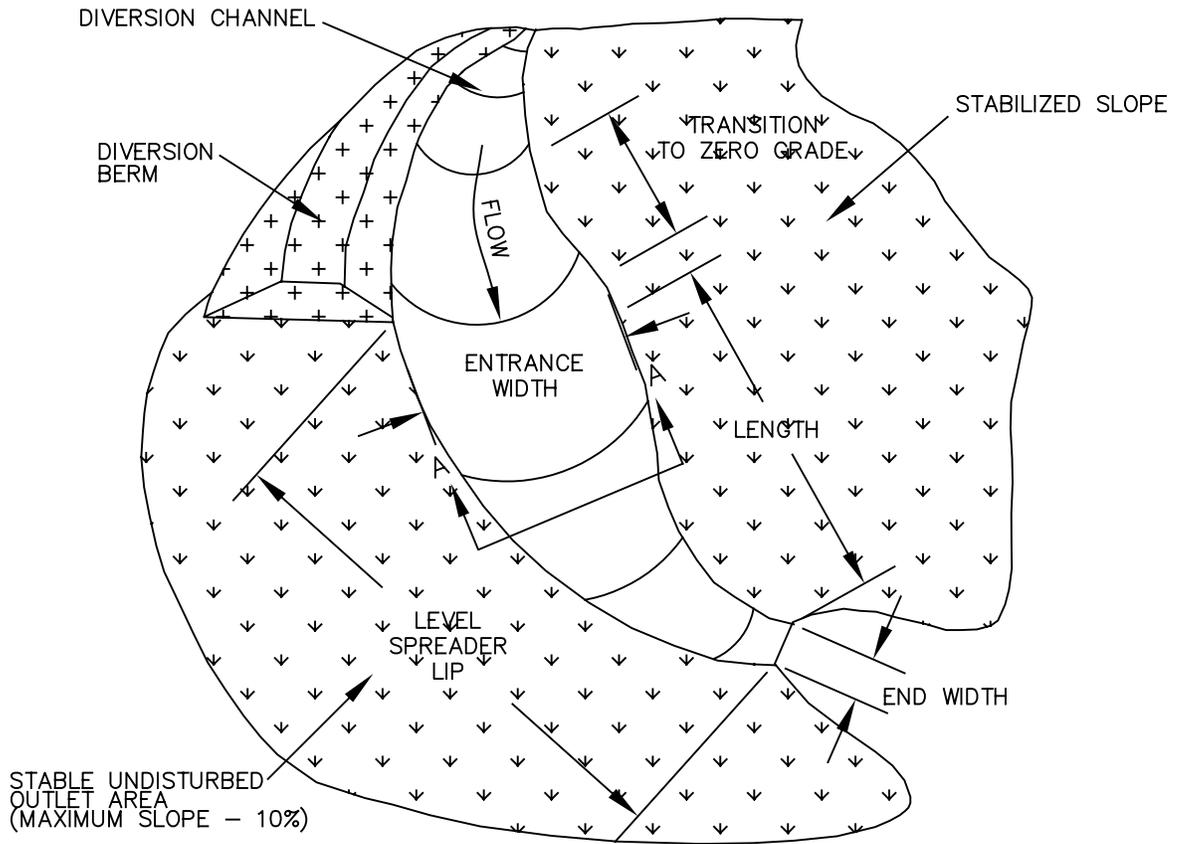
FOR $D > 36$ INCHES:

L = 4 x D FEET MINIMUM

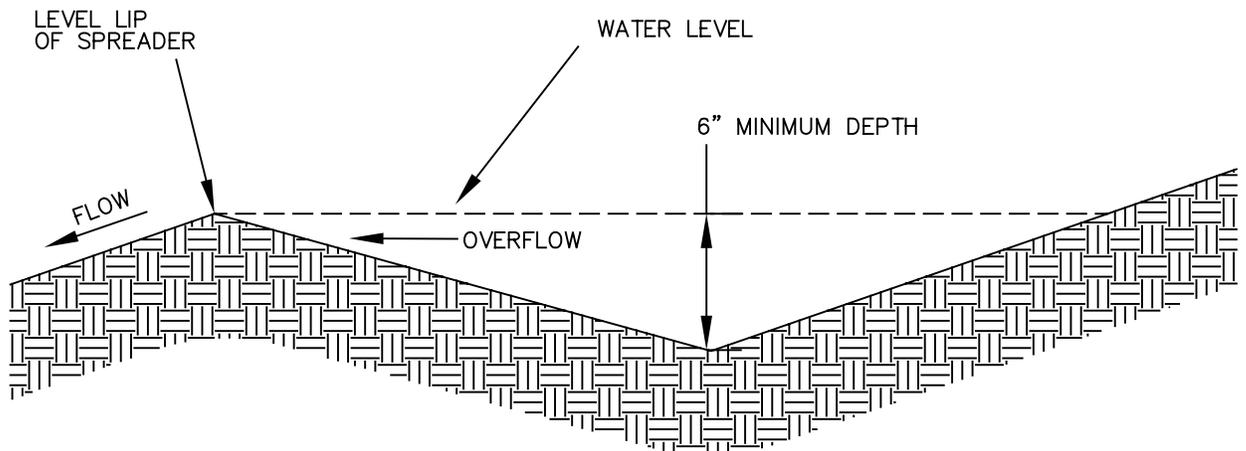
W = (2 L + D) FEET MINIMUM



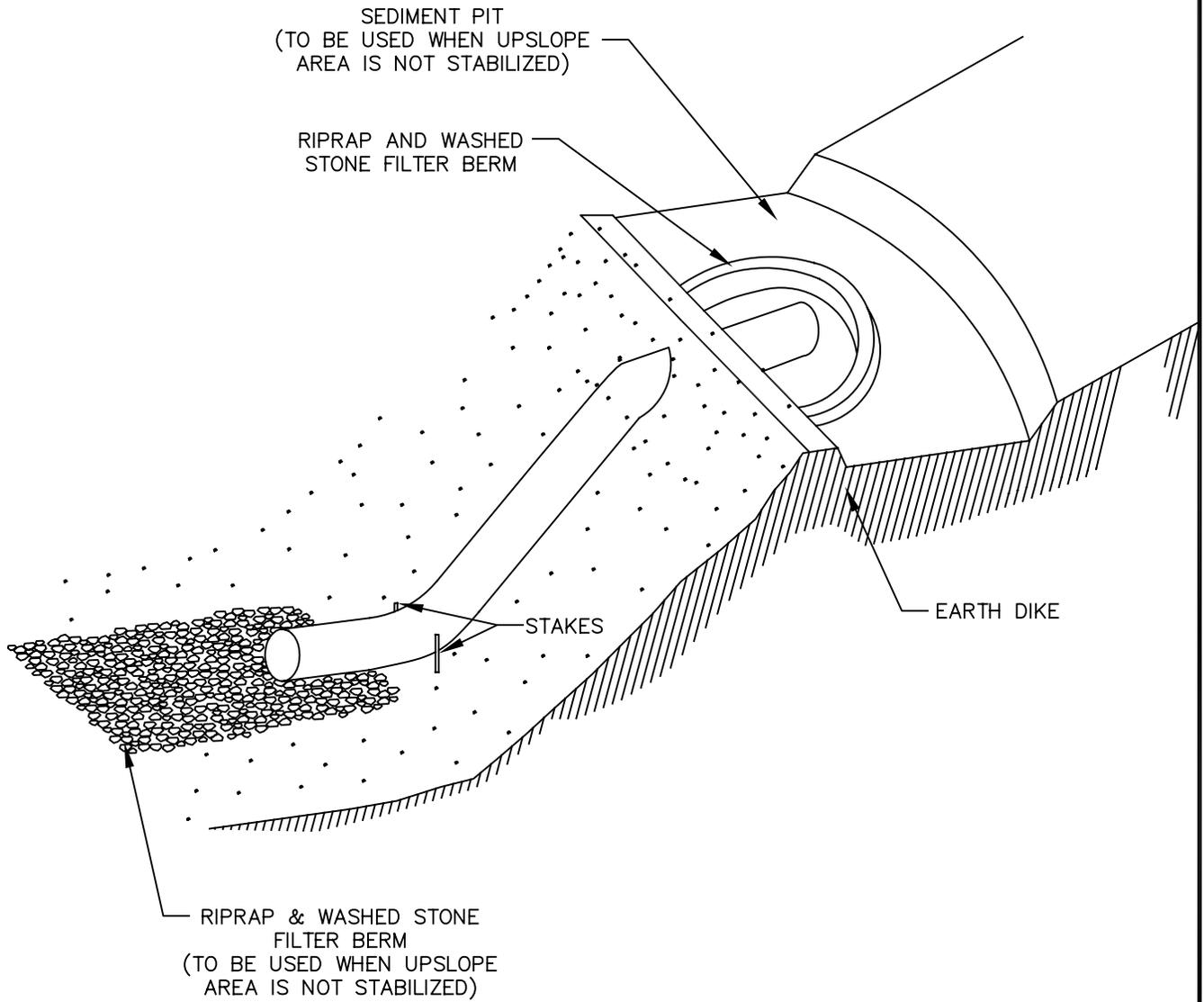


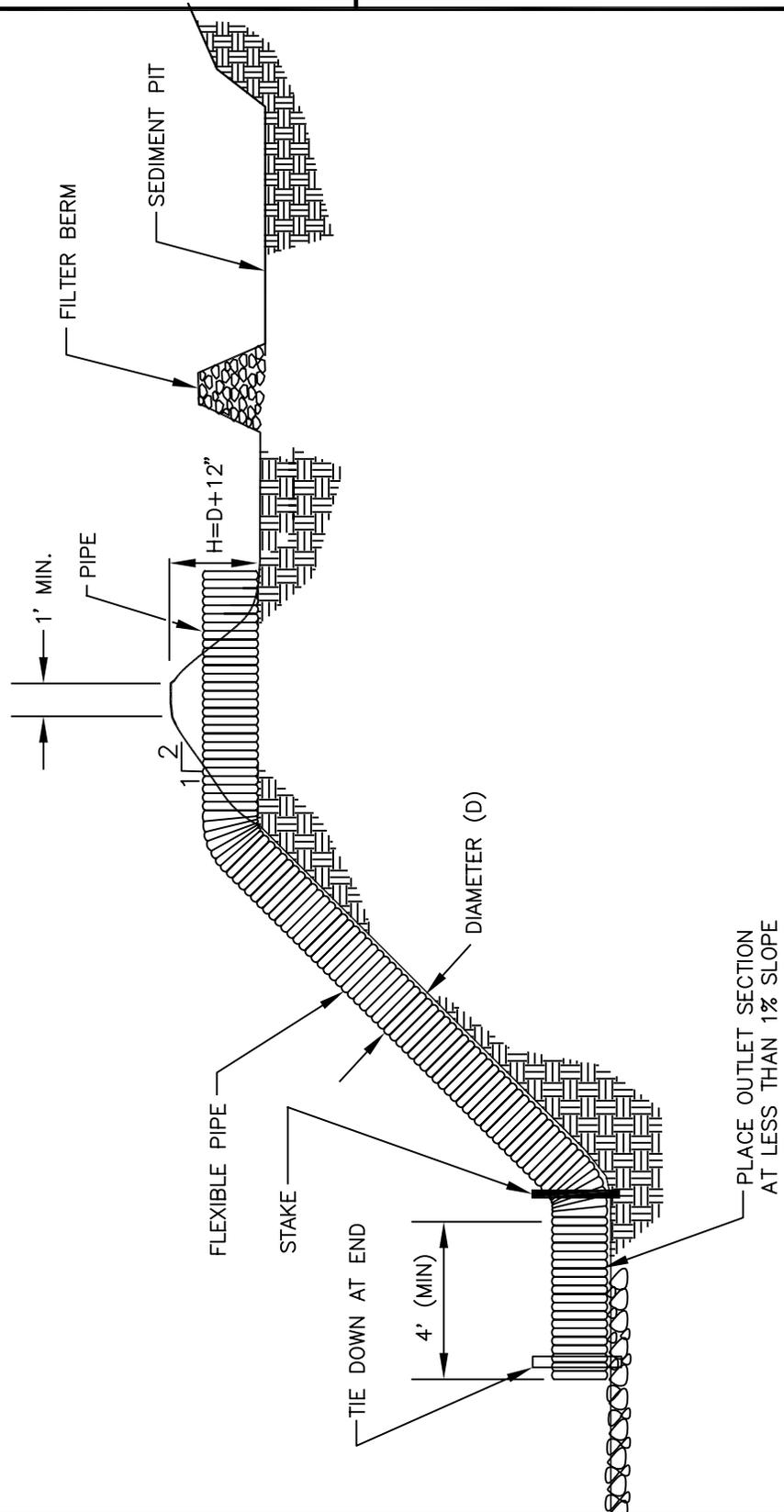


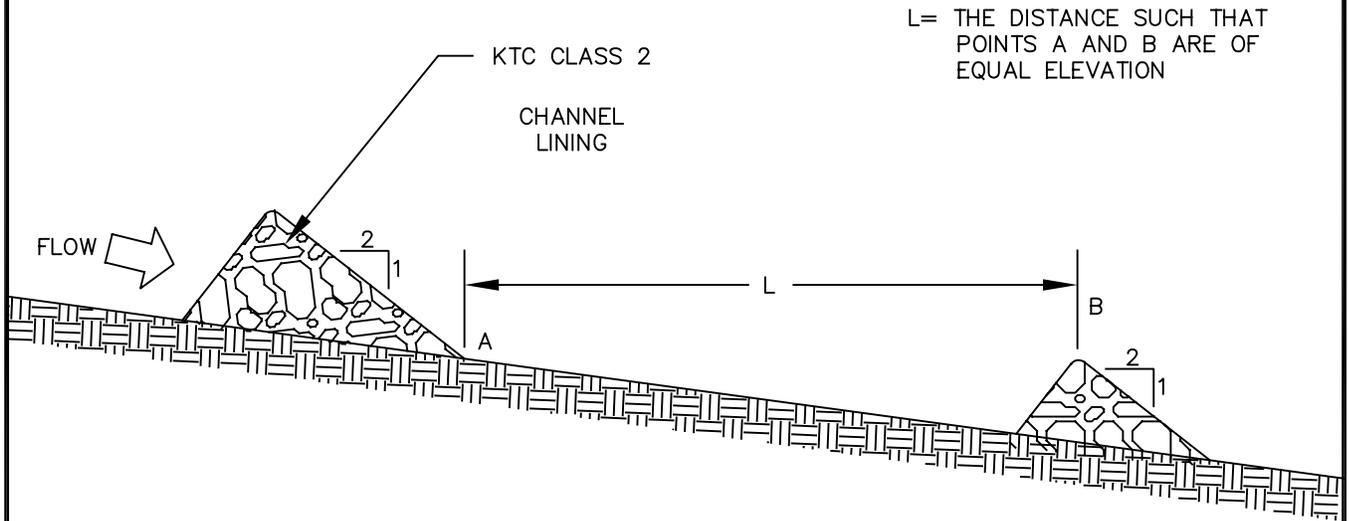
PERSPECTIVE



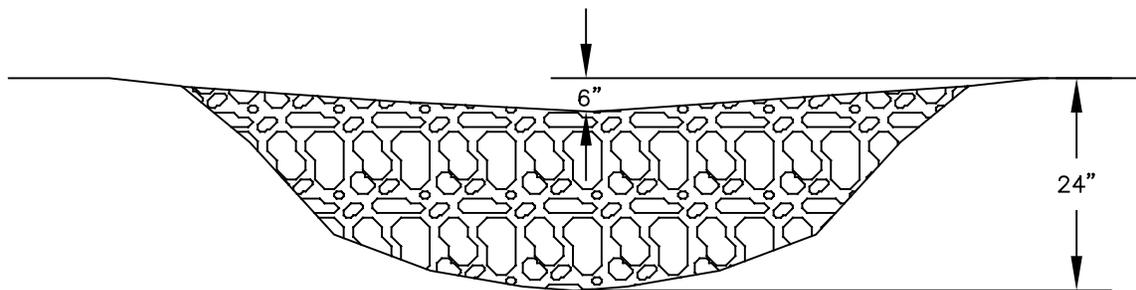
SECTION A-A



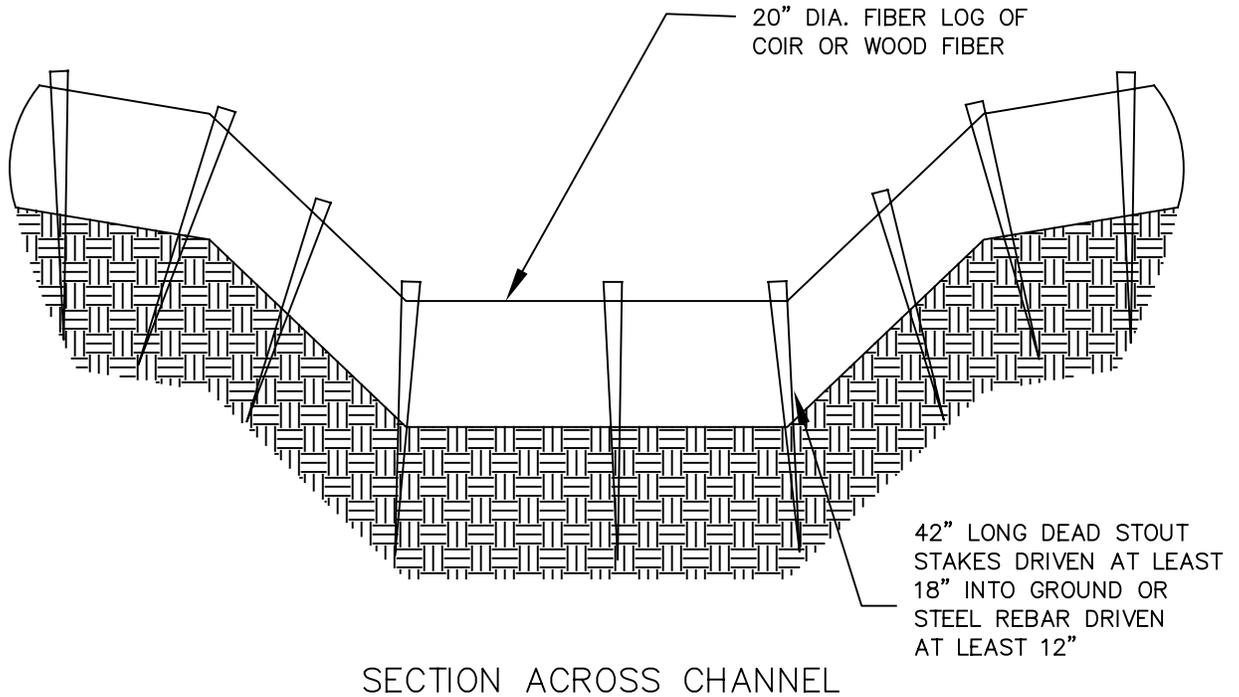




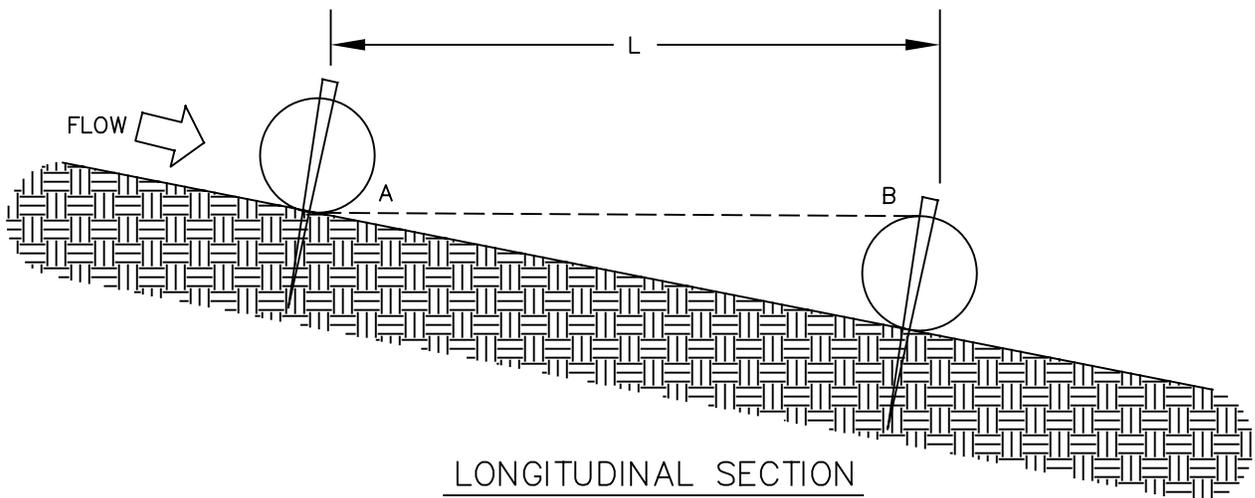
LONGITUDINAL SECTION SHOWING
SPACING BETWEEN CHECK DAMS



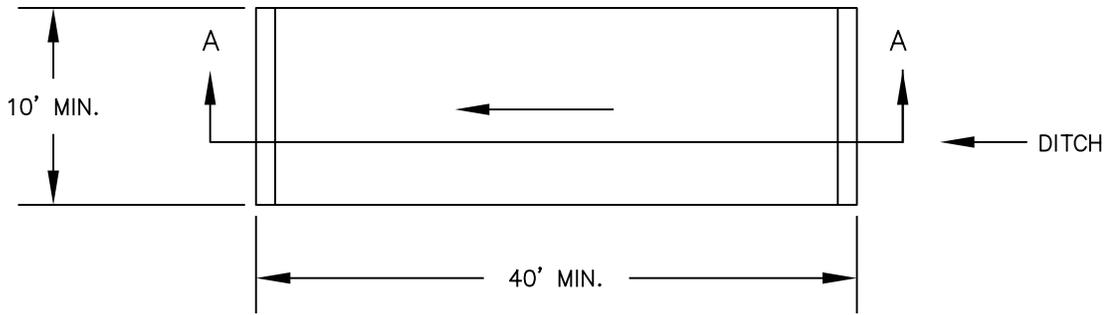
SECTION ACROSS CHANNEL



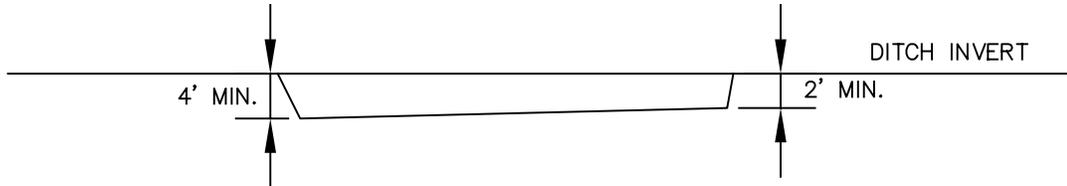
STAKES SHALL BE SPACED NO FURTHER
THAN 24" AND SHALL BE DRIVEN AT EACH
SIGNIFICANT SLOPE BREAK AND WITHIN 6" OF EACH END.



L = DISTANCE SUCH THAT POINTS A AND B ARE OF EQUAL ELEVATION



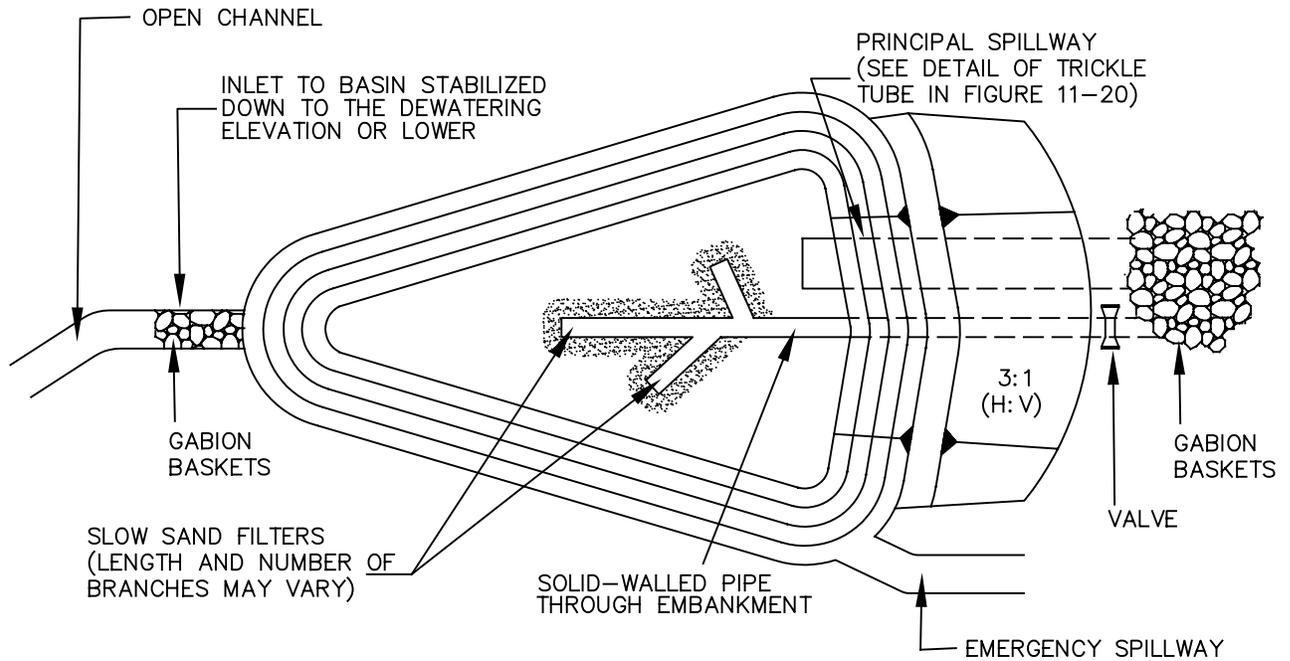
PLAN VIEW



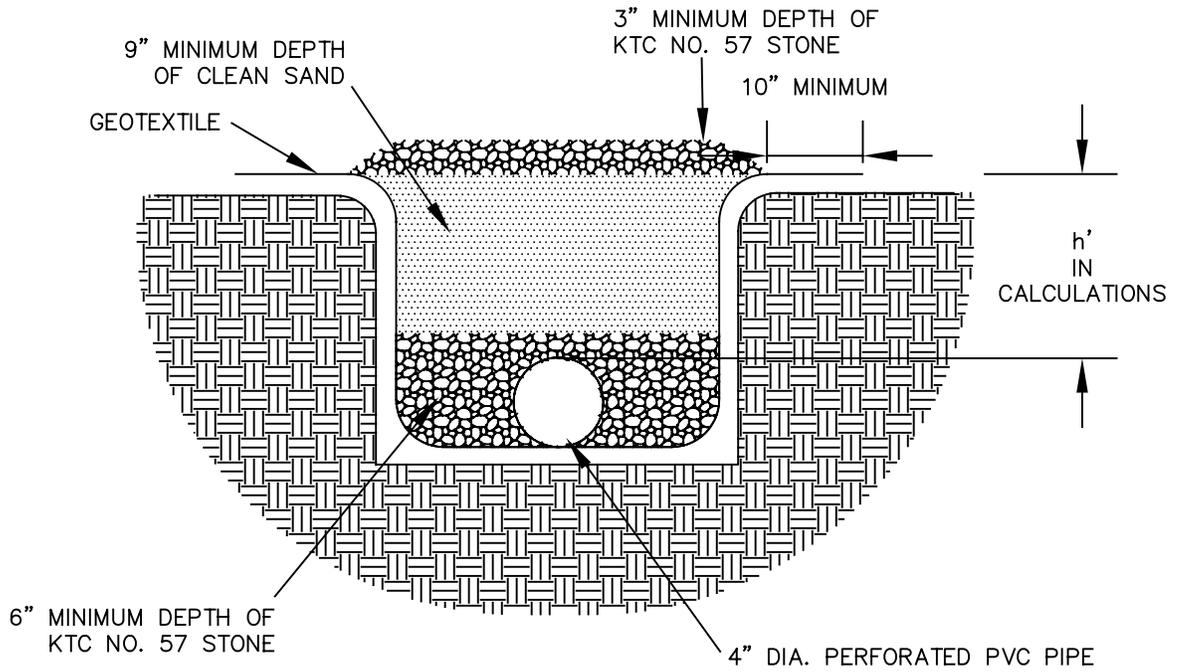
SECTION A-A

NOTES:

- 1) THE SIZE, SHAPE AND LOCATION OF TRAP MAY BE ADJUSTED FROM THAT SHOWN IN THE CONSTRUCTION PLANS, AS DIRECTED BY THE ENGINEER.
- 2) THE SEDIMENT TRAP MAY BE CONSTRUCTED AS DIRECTED BY THE ENGINEER AS LONG AS THE AREA AND DEPTH IS AT LEAST AS THAT INDICATED ON THE PLANS.
- 3) SEDIMENT TRAP SHALL BE CONSTRUCTED BY EXCAVATING THE BASIN IN NATURAL OR EXCAVATED CHANNELS. SEDIMENT DEPOSITS IN TRAP SHALL BE REMOVED EACH TIME THE TRAP IS APPROXIMATELY 50 PERCENT FILLED. WHEN THEIR USEFULNESS HAS ENDED, THE TRAPS SHALL BE REMOVED, SURPLUS MATERIAL DISPOSED OF AND THE ENTIRE DISTURBED AREA SHALL BE SEEDED AND PROTECTED, OR SODDED, AS DIRECTED. SEDIMENT TRAPS MAY REMAIN IN PLACE UPON COMPLETION OF THE PROJECT ONLY WHEN PERMITTED BY THE ENGINEER OR THE PLANS.

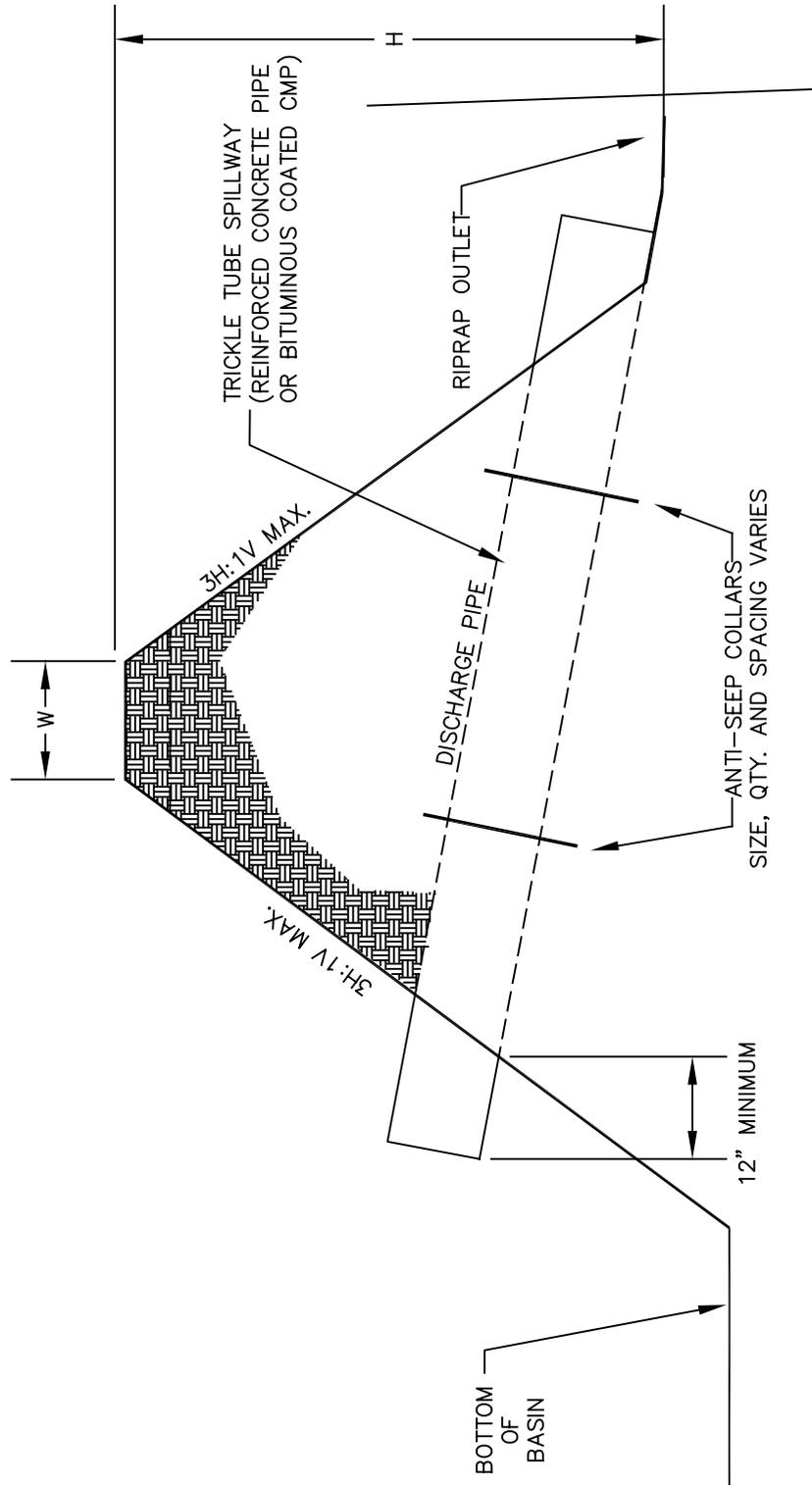


PLAN VIEW
N.T.S.



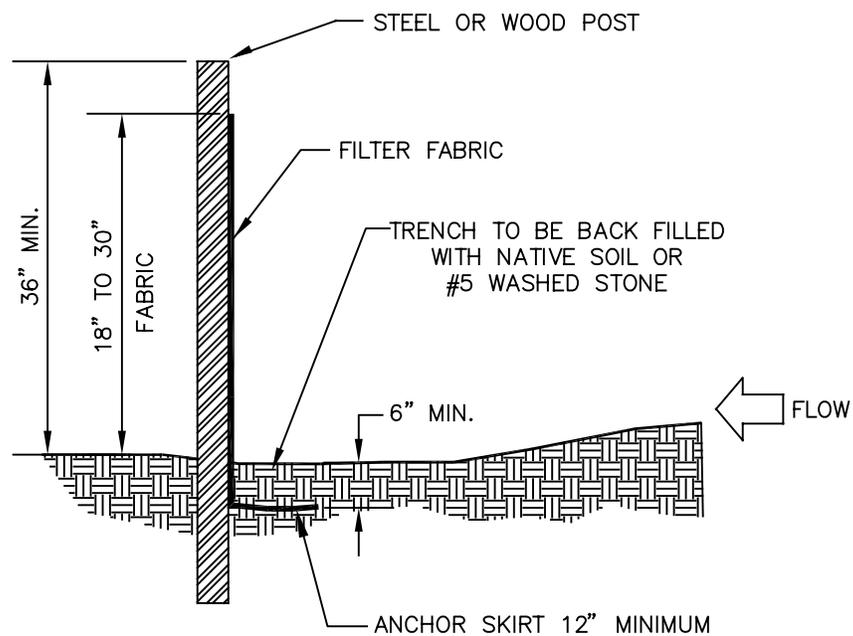
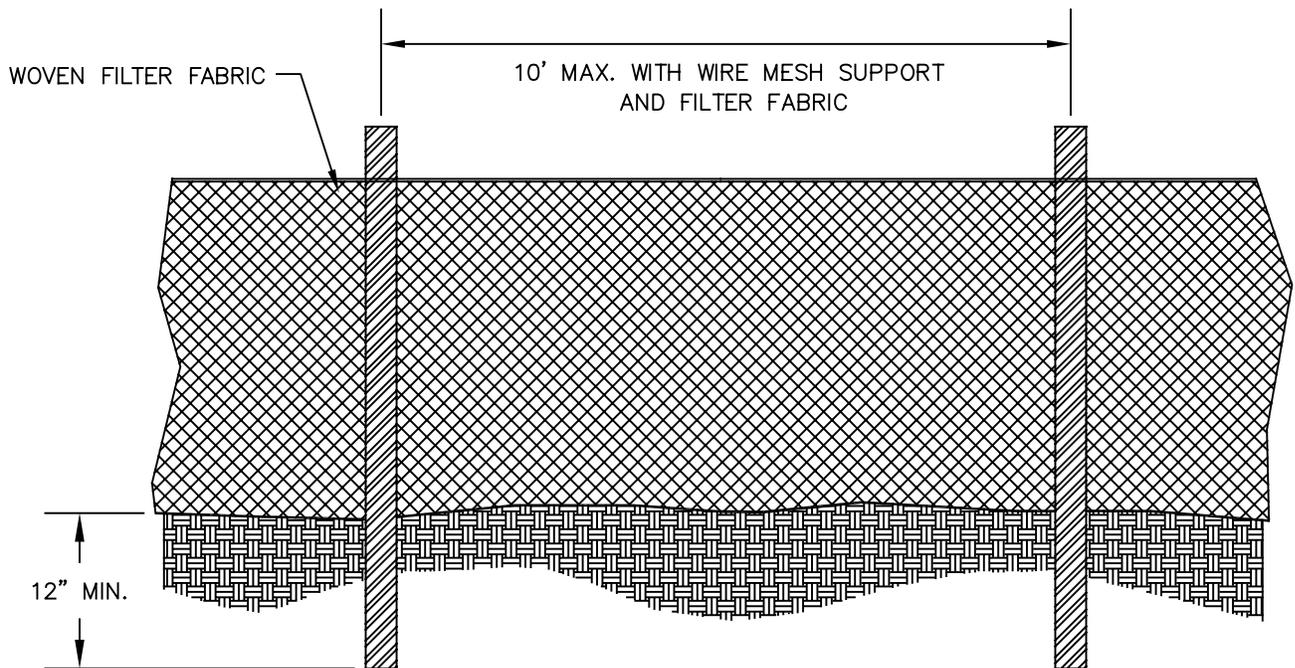
TYPICAL SECTION
N.T.S.

- NOTES:
- 1) MAXIMUM $H = 20'$
 - 2) FOR $H = 5'$ OR LESS, MINIMUM $W = 5'$
 - 3) FOR $H > 5'$, MINIMUM $W = 10'$



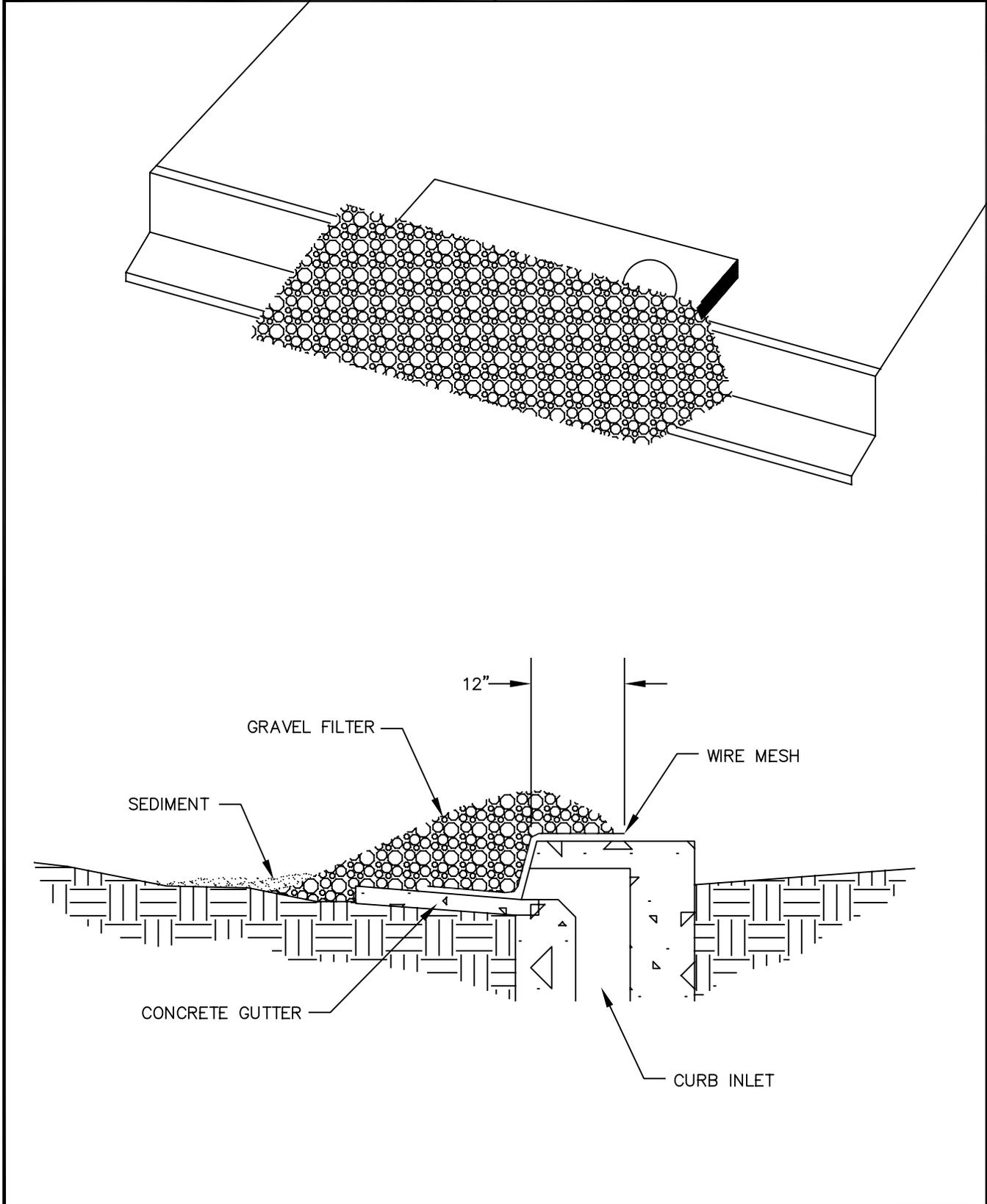
TYPICAL SECTION

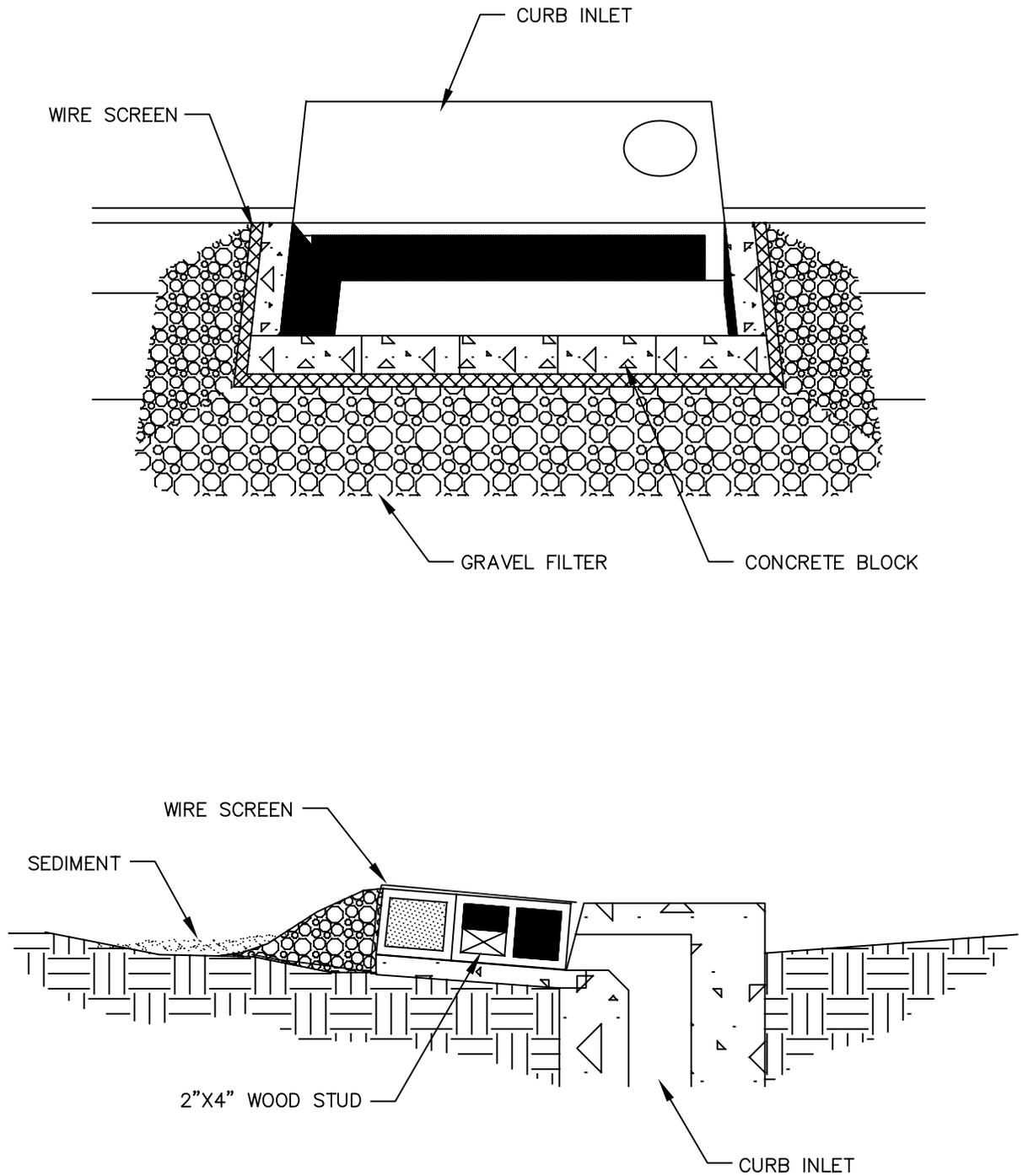
N.T.S.

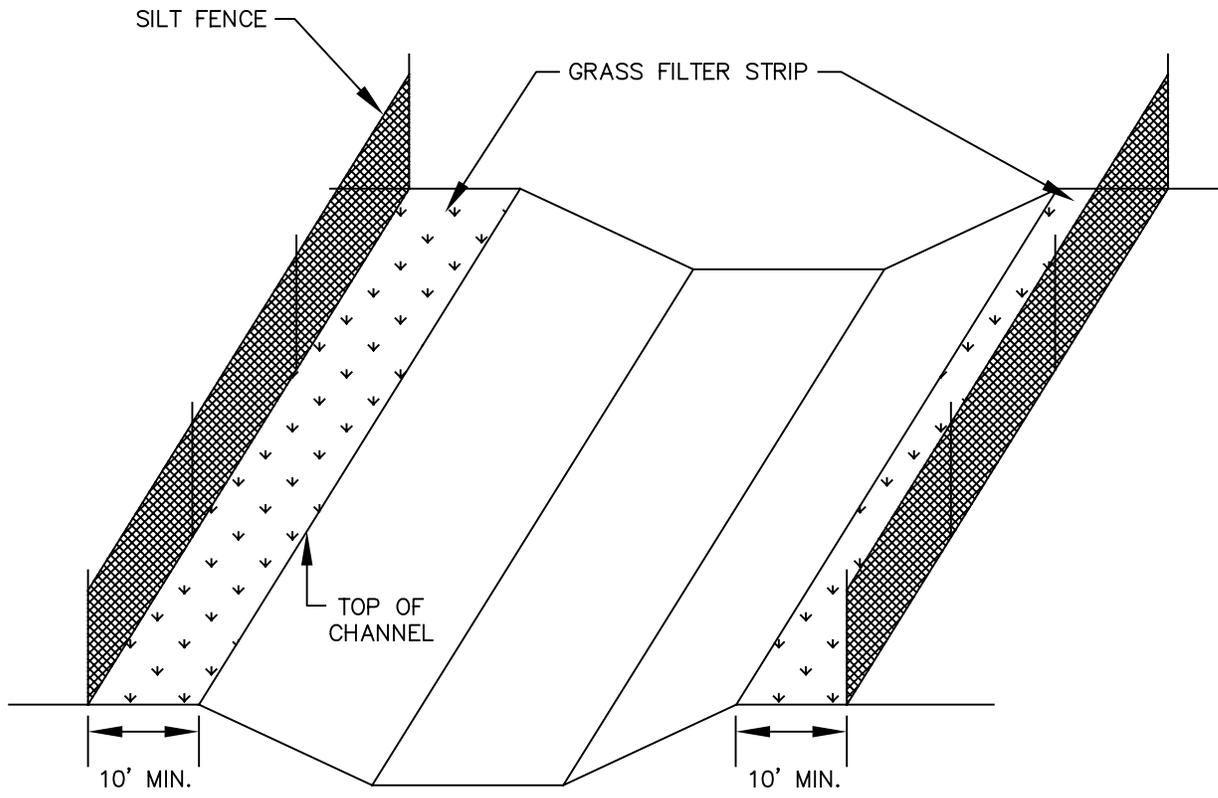


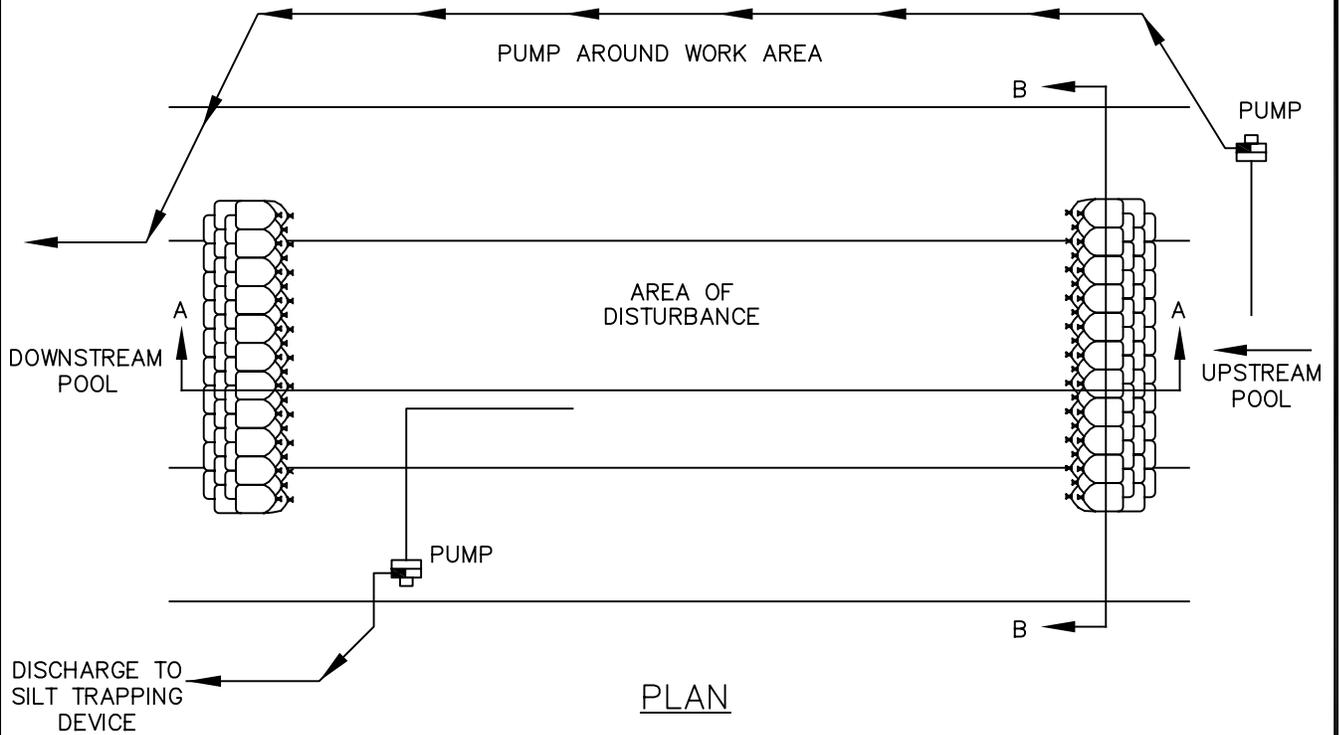
GENERAL NOTES

1. FILTER FABRIC SHALL BE PURCHASED IN A CONTINUOUS ROLL AND CUT TO THE LENGTH OF THE BARRIER. WHEN JOINTS CANNOT BE AVOIDED, FILTER FABRIC SHALL BE SPLICED TOGETHER ONLY AT A POST WITH 3 FOOT MIN. OVERLAP AND SECURELY SEALED.
2. POSTS SHALL BE SPACED AT 6 FOOT INTERVALS IN AREAS OF RAPID RUNOFF.
3. POSTS SHALL BE AT LEAST 5 FEET IN LENGTH.
4. STEEL POSTS SHALL HAVE PROJECTIONS FOR FASTENING WIRE AND FABRIC.
5. WOOD POSTS SHALL BE 2 INCHES BY 2 INCHES OR EQUIVALENT. STEEL POSTS SHALL BE 1.33 LBS PER LINEAR FOOT.
6. A WIRE MESH SUPPORT FENCE SHALL BE FASTENED SECURELY TO THE UPSLOPE SIDE OF THE POSTS USING HEAVY DUTY WIRE STAPLES AT LEAST 1 INCH IN LENGTH, WIRE TIES OR HOG RINGS. THE WIRE SHALL EXTEND INTO THE TRENCH A MINIMUM OF 2 INCHES AND SHALL NOT EXTEND MORE THAN 36 INCHES ABOVE THE ORIGINAL GROUND SURFACE.
7. WASHED STONE SHALL BE USED TO BURY SKIRT WHEN SILT FENCE IS USED ADJACENT TO A CHANNEL, CREEK, OR POND.
8. TURN SILT FENCE UP SLOPE AT ENDS.

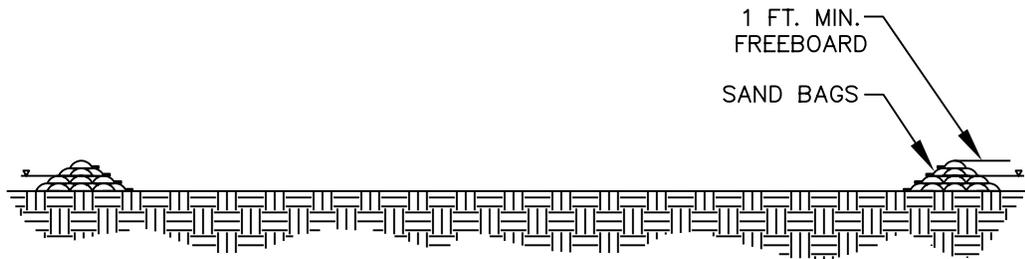




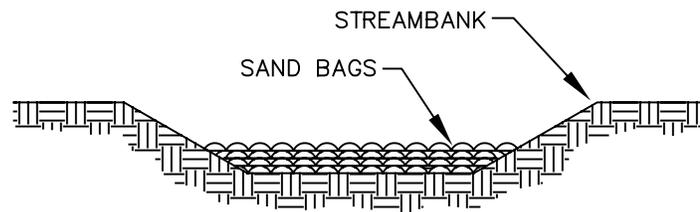




PLAN



SECTION A-A



SECTION B-B