CITY OF RICHMOND
STORMWATER DEVELOPMENT MANUAL

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Purpose of the Stormwater Development Standards

It is recognized that smaller streams and drainage channels serving the City of Richmond may not have sufficient capacity to receive and convey additional stormwater runoff, as a result of development. Development is the changing of open or agricultural land to urban uses. It is further recognized that deposits of sediment from development during and after construction can reduce capacities of storm sewers and drainage systems and result in damages to receiving lakes and streams. This Stormwater Development Manual was developed to ensure the proper treatment, pollution prevention, storage, and conveyance of stormwater within the City of Richmond, as required by the EPA's Phase II Final Rule and the State of Indiana's 327-IAC 15-13 and 327 IAC 15-5.

EPA's Phase II Final Rule was published in December 1999. The objectives of the Phase II regulations are to reduce the discharge of pollutants to the "maximum extent practicable" and to protect the quality of the Nation's waters. Included in this rule are permit requirements for designated small municipalities and certain facilities that maintain control of a separate storm sewer system. The City of Richmond is one of these municipalities. They are referred to as a Municipal Separate Storm Sewer System (MS4) community.

The intent of this Stormwater Development Manual is to create a development process that is easily understood and consistently applied for all stormwater projects and improvements within the City of Richmond. The Richmond Stormwater Management Board has coordinated the process to be used, the implementation of the rules and procedures, and the intent of the regulations and ordinances all of which manage the development of stormwater improvements. The developer, engineering consultants, architects, and municipality can be guided through the process so that each stakeholder knows the permit requirements, standards, and details associated with the design criteria.

The Stormwater Development Manual is comprised of the following sections:

- Stormwater Construction Permit Process
- Stormwater Construction Permit Application Components
- Hydrology
- Stormwater Conveyance
- Erosion and Sediment Control
- Post-Construction Stormwater Control

1.2 Stormwater Management Board Description

The Richmond Department of Stormwater Management was formed in 1999. The department is controlled by three appointed Directors.

The three main objectives of the board are as follows:

- To allow the local government to respond to stormwater problems,
- To establish a plan for collecting and disposing of stormwater, and
- To create finance alternatives.

1.3 Stormwater Related Ordinances

The following sections describe the stormwater related ordinances for the City of Richmond. The following ordinances can be found in **Appendix A**, Stormwater Related Ordinances.

1.3.1 Erosion and Sediment Control

The purpose of the Erosion and Sediment Control Ordinance is to minimize the amount of sediment and other pollutants resulting from soil erosion during land disturbing activities. These pollutants are often transported off-site to adjacent public or private lands including ditches, streams, lakes, wetlands, reservoirs, storm sewers and MS4 conveyances without proper erosion and sediment control.

1.3.2 Post-Construction Stormwater Runoff Control

The purpose of the Post-Construction Stormwater Runoff Control Ordinance is to establish minimum stormwater management requirements during the design process in order to reduce, non-point source pollution and the rate and volume of surface water run-off once the construction phase has been completed.

2.0 STORMWATER CONSTRUCTION PERMIT PROCESS

The following sections describe the stormwater construction permit process for the City of Richmond.

2.1 Review of Stormwater Development Standards

The applicant should review this manual and familiarize themselves with the permit process, the forms, specifications, construction details, etc. It is also advised that the applicant review the Erosion and Sediment Control Ordinance and the Post-Construction Stormwater Run-off Control Ordinance. Once the applicant is familiar with all three, the manual and ordinances may then be used as reference documents.

2.2 Kickoff Meeting

The applicant shall request a meeting with a City representative to review permit requirements. The applicant is encouraged to submit a sketch or concept plan of the proposed stormwater improvements with the initial meeting request. There are no fees associated with this submittal.

2.3 Project Development

The applicant shall incorporate stormwater improvements (stormwater quantity control and quality control) into the design of their project and submit their proposed development for review to the City. Appropriate stormwater control measures are discussed in greater detail in Chapters 6 and 7.

2.4 Permit Application

The applicant shall submit the permit application to the Stormwater Management Board through the City Engineer at 50 North 5th Street, Richmond, Indiana 47374, the following items:

- The Stormwater Construction Permit Application form;
- Submittal Package Checklist;
- Plans;
- Specifications; and
- Design documentation.

The Stormwater Construction Permit Application form and the Submittal Package Checklist can be found in **Appendix B**, Permit Forms. Please note that there are three separate categories of applications. They are: **Category 1**, land disturbing activities covering one or more acres, **Category 2**, single family residential development consisting of four or fewer lots or a single-family residential strip development where the developer offers for sale or

lease without land improvements, and the project is not part of a larger common plan of development or sale, and **Category 3,** land disturbing activities for individual lots of any size within a permitted project that is over one acre. There is one common permit application, but there are three separate checklists. A filing fee will be required in order to initiate the application review process. The components of the permit application are discussed further in Chapter 3.

2.5 Maintenance Agreement

Maintenance of all stormwater management facilities will be ensured through the establishment of a formal maintenance agreement. The applicant shall submit, along with the permit application, a completed Maintenance Agreement form. The Maintenance Agreement form can be found in **Appendix B**, Permit Forms.

2.6 Review for Compliance

Upon receipt of the Stormwater Construction Permit Application and attachments, the proposed development will be reviewed by a representative of Richmond's Stormwater Management Board or its designee. The proposed development will be reviewed to ensure that the requirements of this Stormwater Development Manual have been incorporated into the project.

2.7 Submittal Response

Once the Stormwater Management Board has reviewed the proposed development and determined whether or not it is in full compliance with the requirements of this manual, the board will issue a Submittal Response to the applicant. The Submittal Response form can be found in **Appendix B**, Permit Forms. The response will indicate if the required information has been provided for the proposed development to be reviewed for content or if additional information is required before the comprehensive review process can begin. If the required information has been provided, the proposed development is ready for the comprehensive review process which results in a construction permit.

2.8 Issuance of a Construction Permit

The proposed development will be reviewed against the design criteria set forth in this manual. Upon completion of the comprehensive review process, the project will be issued a Stormwater Construction Permit. The Construction Permit Form can be found in **Appendix B - Permit Forms**. Should the applicant receive a stormwater construction permit, he/she must then submit the required Notice of Intent (NOI) to IDEM. (Individual lots within

a permitted project do not have to submit a NOI.)

2.9 Inspection

Construction Inspections

The City will conduct regular inspections of construction sites during land-disturbing activities, in accordance with the Erosion and Sediment Control Ordinance, to ensure compliance with a Stormwater Construction Permit.

All inspections will be documented in writing. These reports will contain the following information when applicable:

- The date and location of the inspection;
- Whether construction is in compliance with the approved stormwater management plan;
- Variations from the approve construction specifications; and
- Any violations that exist.

Post-Construction Inspections

Post-construction stormwater runoff inspections may also be conducted by the City, in accordance with the requirements of the Post-Construction Stormwater Runoff Control Ordinance, to ensure compliance with a Stormwater Construction Permit.

All inspections will be documented in writing. These reports will contain the following information when applicable:

- The date and location of the inspection;
- Whether or not the stormwater BMP is being properly maintained
- Whether or not the stormwater BMP is operating properly
- Any violations that exist.

Project Completion Review

When the construction phase of a project has been completed, the person holding the permit shall request, in writing, City approval of the permanent erosion and sediment control measures constructed. The City will then evaluate the adequacy of the constructed control measures.

In the event that the permanent erosion control measures are approved, any surety bonds and/or letters of credit shall be released. However, all maintenance responsibilities shall remain with the person owning the land.

In the event that the erosion control measures are not approved because

they are not in accordance with the Erosion and Sediment Control Plan, the City shall notify, in writing, the person holding the permit of unacceptable features.

3.0 PERMIT APPLICATION COMPONENTS

3.1 Introduction

This chapter describes the permit application components for the submittal of a stormwater permit application for proposed developments within the City of Richmond.

3.2 Project Information

The following information for development and redevelopment on real estate located within the MS4 Area shall be submitted to the Richmond Stormwater Management Board at the time of application. This includes data certified by an Indiana licensed professional engineer or land surveyor engaged in storm drainage design. The following information requirements apply to: **Category 1** - land disturbing activities covering one or more acres, **Category 2 -** single family residential development consisting of four or fewer lots or a single-family residential strip development where the developer offers for sale or lease without land improvements, and the project is not part of a larger common plan of development or sale and **Category 3** - Land disturbing activities for individual lots of any size within a permitted project that is over one acre.

3.2.1 Project Narrative (Category 1 and Category 2)

The applicant shall provide a project narrative which includes at a minimum the following:

- The scope of the project;
- The purpose of the project;
- A legal description of the project location;
- Existing soil conditions;
- The construction sequence;
- A project site map or plat;
- The Hydrologic Unit Code; and
- Identification of other State of Federal Water Quality Permits required.

3.2.2 Vicinity Map (Category 1 and Category 2)

The applicant shall provide a map illustrating the location and vicinity with their submittal for a stormwater construction permit. The vicinity map shall include roads, railroads, water features and other relevant landmarks.

3.2.3 General Plan Requirements (Category 1 and Category 2)

The plans shall include, in general, the following:

- North arrows, graphic and written scale, legend for symbols;
- Location and elevation of property benchmark;
- Professional seal, signature, and date; and
- Table of revisions.

3.2.4 Existing Project Site Layout (Category 1 and Category 2)

The existing project site layout shall include the existing site conditions. This project site layout will require much more site specific detail than the vicinity map described above. The project site map shall contain, at a minimum, the following:

- Site location;
- Site boundaries;
- Immediately adjacent sites;
- Lakes, streams, channels, ditches, wetlands and other water courses on or adjacent to the site;
- 100-year floodplains, floodway fringes and floodways;
- Location of the predominant soil types. Soil types may be determined by the SCS County Soil Survey, by an equivalent publication, or as determined by a certified professional soil scientist;
- Location and delineation of vegetative cover such as grass, weeds, brush, and trees, and any vegetation areas that will not be disturbed during construction;

- Location of natural drainage patterns on and immediately adjacent to the site, and the location and approximate dimensions of any structural drainage systems;

- Locations and approximate dimensions of existing utilities, structures, roads, highways and paving;

- Site and adjacent topography, both existing and planned, at a minimum of 2 foot contour interval to indicate drainage patterns

3.2.5 Final Project Site Layout (Category 1 and Category 2)

The final project site layout shall include the existing site conditions. This project site layout will require much more site specific detail than the vicinity map described above. The project site map shall contain, at a minimum, the following:

- The location of all proposed site improvements including roads, utilities, lot delineation, structures and common areas.

3.2.6 Grading Plan (Category 1 and Category 2)

The grading plan shall include, at a minimum:

- A delineation of proposed land disturbing activities, including those off-site;

- Soil stockpiles and borrow areas;

- Information regarding off-site borrow, stockpile and disposal areas that are under the control of the project site owner; and

- Existing and proposed topographic information.

3.2.7 Drainage Plan (Category 1 and Category 2)

The drainage plan shall include, at a minimum, the following:

- The peak discharge of a 10-year storm event, one for pre-development and one for post-development;

- The location, size, dimension, slope, and the direction of flow of all natural and structural stormwater drainage systems. These shall be prepared as both plan and profile views.

- When applicable, areas where point source stormwater discharges have the potential to enter ground water.

- All stormwater discharge points in which stormwater will leave the site. In addition, if the discharge point is to a receiving stream, the stream must be labeled by name. If the discharge point is to a conveyance system, the name of the receiving stream in which the conveyance system discharges must be identified.

- The location, size and dimensions of site features used for stormwater management. Examples of such features include detention and retention ponds.

- Off-site bypass flow route for detention and retention ponds, if applicable;

- Bottom pond slope for detention and retention ponds, if applicable; and

- Flood protection grades for detention and retention ponds, if applicable.

3.2.8 Erosion and Sediment Control Plan (Category 1 and Category 2)

The Erosion and Sediment Control Plan shall clearly portray the methods and means whereby erosion and sediment control measures are implemented. The plan shall include, at a minimum, the following site development information.

- A description of potential pollutant sources associated with construction activities that may be expected to add a significant amount of pollution to the developments stormwater discharges;

- The location, dimensions, detailed specifications and construction details of all temporary and permanent stormwater quality measures;

- Temporary and permanent stabilization measures including: the sequence of implementation; specifications and application rates for soil amendments and seed mixtures; and the type and application rate for anchored mulch;

- The construction sequence describing the relationship between implementation of stormwater quality measures and the stages of construction activities; and

- A self monitoring program including procedures and an on-going maintenance plan for each stormwater quality measure.

The person, or persons, responsible for the installation and maintenance of erosion and sediment control practices, their business address, and daytime phone number shall be included. This person must be identified prior to the commencement of any land disturbing activities.

3.2.9 Post-Construction Stormwater Management Plan (Category 1 only)

The Post-Construction Stormwater Management Plan shall clearly portray the methods and means whereby stormwater quality measures are implemented. The plan shall include, at a minimum, the following information.

- A description of potential pollutant sources associated with the proposed land use that may be expected to add a significant amount of pollution to the developments stormwater discharges.

- The location, dimensions, detailed specifications, construction details, and sequence of installation of all post-construction stormwater quality measures. These measures must remove or minimize pollutants from stormwater run-off and prevent or minimize adverse impacts to stream and riparian habitats.

- A self monitoring program including procedures and an on-going maintenance plan for each stormwater quality measure.

3.2.10 Technical Report (Category 1 and Category 2)

The applicant shall submit a technical report providing all calculations.

3.2.10.1 Existing and Proposed Stormwater Runoff Calculations

The existing and proposed stormwater runoff calculations must include, at a minimum, the following:

- Drainage area computations;
- Weighted curve number or run-off coefficient computations; and
- Time of concentration computations.

3.2.10.2 Closed Conduit and Open Channel Design Calculations

The closed conduit and open channel design calculations must include, at a minimum, the following:

- The size of pipe or channel shown as a cross-section;
- The pipe or channel inverts slope as a percentage and as invert elevations;
- Material and roughness coefficient;
- Flow velocities in feet per second;
- Pipe length, type, and class;
- Design capacity in cubic feet per second;
- Design run-off of component sheds; and
- Inlet spacing calculations.

3.2.10.3 Detention and Retention Pond Calculations

The detention and retention pond calculations must include, at a minimum, the following:

- Shed maps, both pre-development and post-development;
- Time of concentration, both pre-development and post-development;
- Overland flow route to pond;
- Peak design discharge;
- Time to peak discharge;
- Total design storm runoff;
- Inflow hydrograph;
- Spillway peak outflow rate;
- Emergency spillway capacity calculations;
- Description of off-site bypass flow route;
- Bottom pond slope; and
- Flood protection grades.

3.2.11 Requirements for Category 3

The following items must be submitted for a Category 3 activity:

- Post-Construction Stormwater Management Plan from original Category 1 project;
- General layout of lot including position of building;
- North arrow, graphic and written scale, date; and
- Stable construction site access and appropriate perimeter erosion and sediment control measures.

3.3 Permits for Construction in the Floodway

It is a requirement that the Department of Natural Resources (DNR) approve all construction activities being proposed in a floodway, as well as all works for flood control. This includes bridges, dams, levees, floodwalls, wharves, piers, booms, weirs, bulkheads, jetties, groins, excavations, fills, or deposits of any kind, utility lies, or any other building, structure, or obstruction. This also includes any ditch work (new construction, deepening or modification) within one-half mile of a public freshwater lake of 10 acres or more.

The approval of the DNR, in writing, must be obtained before land disturbing activities can begin. Applications for approval shall be submitted to:

Indiana Department of Natural Resources
Division of Water
402 West Washington St., Room W264
Indianapolis, IN 46204

All applications shall be sent to the DNR on their standard application form. Similar to this manual's filing requirements, the DNR's application form shall be accompanied by plans, profiles, specifications, and other data necessary for the DNR to determine the effect of the proposed development on the floodway.

It should be noted that an application made to and approved by the DNR does not in any way relieve the owner of the necessity of securing easements or other property rights, and permits and/or approvals from affected property owners and local, State, and Federal agencies.

The engineering staff of the DNR Division of Water is available to discuss and offer suggestions regarding requirements in the design of structures in floodways. High water marks have been set on many of the streams in the state, and information is available from the Division of Water on actual and/or potential flooding. Information regarding benchmarks set to Mean Sea Level Datum, General Adjustment of 1929, is available from the Division of Water, Surveying, and Mapping Section.

4.0 HYDROLOGY

4.1 Introduction

This chapter describes the policies and procedures which must be applied during a hydrologic analysis performed within the City of Richmond.

4.2 Calculating the Peak Discharge

Runoff quantities shall be computed for the area of the parcel under development, including runoff that flows to the proposed development's site from the site's surrounding watershed. The calculation should be done based on pre-development conditions and again with the proposed post-development conditions. The peak discharge which is generated as a result of a given rainfall intensity may be calculated as follows:

Areas up to and Including 200 Acres

For areas up to and including 200 acres, the Rational Method may be used, to determine the peak discharge rate

$$Q = CiA$$

Where:

C = runoff coefficient, representing the characteristics of the drainage area and defined as the ratio of runoff to rainfall.

i = average intensity of rainfall in inches per hour for a duration equal to the time of concentration (t_c) for a selected rainfall frequency.

A = tributary drainage area in acres.

The following tables provide guidance to selection of the runoff coefficient "C" for different types of surface and soil characteristics. The composite "C" value used for a given drainage area with various surface types shall be the weighted average for the total area calculated from a breakdown of the individual areas having different surface types.

Rainfall intensity shall be determined from rainfall frequency curves.

TABLE 4-1	
Urban Runoff Coefficients	
Type of Surface	**Runoff Coefficient "C"**
Asphalt	0.82
Concrete	0.85
Roof	0.85
Lawns (Sandy)	
Flat (0-2% slope)	0.07
Rolling (2-7% slope)	0.12
Steep (>7% slope)	0.17
Lawns (Clay)	
Flat (0-2% slope)	0.16
Rolling (2-7% slope)	0.21
Steep (>7% slope)	0.30

TABLE 4-2	
Rural Runoff Coefficients	
Type of Surface	**Runoff Coefficient "C"**
Woodland (Sandy)	
Flat (0-5% slope)	0.10
Rolling (5-10% slope)	0.25
Steep (>10% slope)	0.30
Woodland (Clay)	
Flat (0-5% slope)	0.30
Rolling (5-10% slope)	0.35
Steep (>10% slope)	0.50
Pasture (Sandy)	
Flat (0-5% slope)	0.10
Rolling (5-10% slope)	0.16
Steep (>10% slope)	0.22
Pasture (Clay)	
Flat (0-5% slope)	0.30
Rolling (5-10% slope)	0.36
Steep (>10% slope)	0.42
Cultivated (Sandy)	
Flat (0-5% slope)	0.30
Rolling (5-10% slope)	0.40
Steep (>10% slope)	0.52
Cultivated (Clay)	
Flat (0-5% slope)	0.50
Rolling (5-10% slope)	0.60
Steep (>10% slope)	0.72

TABLE 4-3				
Runoff Coefficients "C" by Land Use and Typical Inlet Times				
LAND USE	**RUNOFF COEFFICIENTS**			**INLET TIME (minutes)**
	FLAT (0-2% slope)	**ROLLING** (2-7% slope)	**STEEP** (>7% slope)	
Commercial (CBD)	0.75	0.83	0.91	5
Commercial (NHD)	0.54	0.60	0.66	5
Industrial	0.63	0.70	0.77	5-10
Garden Apartments	0.54	0.60	0.66	5-10
Churches	0.54	0.60	0.66	5-10
Schools	0.31	0.35	0.39	10-15
Semi-Detached Residence	0.45	0.50	0.55	10-15
Detached Residence	0.40	0.45	0.50	10-15
Quarter-Acre Lots	0.36	0.40	0.44	10-15
Half-Acre Lots	0.31	0.35	0.39	10-15
Parkland	0.18	0.20	0.22	To be determined

Interpolation, extrapolation, and adjustment for local conditions shall be based on engineering experience and judgment.

The coefficients of these tabulations are applicable to storms of 5- to 10-year frequencies. Coefficients for less frequent, higher intensity storms shall be modified as follows

Return Period (years)	Multiply "C" by
25	1.1
50	1.2
100	1.25

Areas Over 200 Acres

The peak discharge rate for areas in excess of 200 acres shall be determined by methods approved by the Stormwater Management Board. The procedures or methods used must receive the prior approval of the Board. The TR-20 and TR-55 models are approved by the Board for appropriate use in analysis of the runoff and routing of stormwater.

4.3 Design Storm Frequencies

Design storm frequencies shall be chosen based on the following criteria.

4.3.1 Minor Conveyance Systems

Minor conveyance system components such as inlets, catch basin inserts, street gutters, swales, sewers, and small channels which collect stormwater must accommodate peak runoff from a 10-year return period storm. Rainfall duration shall be less than or equal to the time of concentration for one hour, if the time of the concentration is less than or equal to one hour. A first quartile storm distribution shall be used for computer modeling.

4.3.2 Major Conveyance Systems

Major conveyance systems are defined as any drainage system carrying runoff from an area of one or more square miles and shall be designed in accordance with *Indiana Department of Natural Resources* standards.

4.3.3 Detention and Retention Facilities

If an adequate storm sewer outlet exists, all developments will have in-place stormwater structures capable of collecting the stormwater runoff from a post-development 10-year storm. This collection system shall be connected to the existing storm sewer system.

Where adequate storm sewers do not exist, all new developments must detain stormwater on their respective properties. The storage volume required is that to control the post-development 100-year storm. The outlet structure from the detention area will discharge no more flow than the pre-development 10-year storm. The outlet structure will consist of a pre-developed 2-year storm outlet to retain the lower flows of the 2 to 10 year storm in the staged detention area.

5.0 STORMWATER CONVEYANCE

5.1 Introduction

This chapter describes policies, design criteria and information for the construction of stormwater conveyances. Stormwater conveyance details are located in **Appendix C**, Stormwater Conveyance Details.

5.2 Hydraulic Capacity

The hydraulic capacity of all conveyances shall be determined using Manning's Equation:

$$v = (1.486/n) R^{2/3} S^{1/2}.$$

Where:

v = mean velocity in feet per second
R = the hydraulic radius in feet
S = the slope of the energy grade line in feet per foot
n = the roughness coefficient

The hydraulic radius, R, is defined as the cross-sectional area divided by the wetted flow surface or wetted perimeter.

The following table provides guidance to the selection of roughness coefficient (n) values for various materials. Roughness coefficient (n) values for materials can also be found in standard hydraulics texts and references.

TABLE 5-1		
Typical Values of Manning's (n) Roughness Coefficient		
MATERIAL	**MANNING'S (n)**	**DESIRABLE MAXIMUM VELOCITIES**
Closed Conduits		
Concrete	0.013	15 fps
Vitrified Clay	0.013	15 fps
Brick	0.015	15 fps
Cast Iron	0.013	15 fps
Circular Corrugated Metal, Annular Corrugations (2 2/3" x 1/2")		
Unpaved	0.024	7 fps
25% Paved	0.021	7 fps
50% Paved	0.018	7 fps
100% Paved	0.013	7 fps
C.C.M.P., Helical Corrugations, 2/3" x 1/2" Unpaved Corrugation		
12"	0.022	7 fps
18"	0.023	7 fps
24"	0.024	7 fps
36"	0.025	7 fps
48"	0.026	7 fps
60" or larger	0.027	7 fps
Corrugated polyethylene smooth interior pipe	0.012	15 fps
Concrete Culverts	0.013	7 fps
Open Channels		
Concrete, trowel finish	0.013	10 fps
Concrete, broom float	0.015	10 fps
Gunite	0.018	10 fps
Riprap, placed	0.030	7 fps
Riprap, dumped	0.035	7 fps
Gabion	0.028	10 fps
New earth (uniform sodded clay)	0.025	7 fps
Existing earth (fairly uniform, some weeds)	0.030	7 fps
Dense growth of weeds	0.040	7 fps
Dense weeds and brush	0.040	7 fps
Swale with grass	0.035	7 fps

5.3 Storm Sewers

Plans for all proposed storm sewer construction must be submitted to the Richmond Stormwater Management Board prior to the start of land disturbing activities.

The specifications for the construction of storm sewers shall not be less stringent than those set forth in the latest edition of the *Indiana Department of Transportation Standard Specifications*.

5.3.1 Sewer Pipe

Sewer pipe shall be designed and constructed using the following criteria.

5.3.1.1 General Specifications

Minimum Size
The minimum size of all storm sewers shall be 12 inches. The rate of release for detention storage shall be controlled by an orifice plate or other devices, subject to approval of the Board, where the 12-inch pipe will not limit the rate of release as required.

Grade
Sewer grade shall be such that, in general, a minimum of two feet of cover is maintained over the top of the pipe. Pipe cover less than the two foot minimum may be used with the approval of the Board. This approval must occur prior to land disturbing activities. Uniform slopes shall be maintained between inlets, manholes, and inlets to manholes. Final grade shall be set with the full consideration of the capacity required, sedimentation problems, and other design parameters. Minimum and maximum allowable slopes shall be those capable of producing velocities of two and one-half (2½) and fifteen (15) feet per second, respectively, when the sewer is full flowing.

Flexible Pipe
All flexible storm sewer pipe must meet a deflection of 7.5%.

5.3.1.2 Pipe Materials

Concrete Pipe, Plain and Reinforced
Concrete pipes, both plain and reinforced, shall conform in all respects with ASTM C14, AASHO M86, and Federal SS-P-

371 for Non-Reinforced Concrete Pipe, ASTM C76 AASHO M170 and Federal S-P-375 for Reinforced Concrete Pipe and ASTM 361 for Reinforced Low Head Concrete Pipe.

Corrugated Smooth Walled Interior PVC
Corrugated smooth walled interior PVC shall conform in all respects to the latest edition of ASTM F 794. Ribs shall be annular.

Truss Pipe
Truss pipes shall conform in all respects to the latest edition of ASTM D2680 (Non-pressure pipe).

Corrugated Smooth Walled Interior High Density Polyethylene Pipe (HDPE)
Corrugated HDPE pipe shall conform to AASHTO M294 Type S for sizes 12" and larger, and AASHTO M252 Type S for sizes smaller than 12". Joints shall be bell and spigot and shall be watertight. Rubber gasket for joints shall conform to ASTM F477.

Corrugated Metal Pipe
Corrugated metal pipe shall conform to the requirements of AASHTO Designation M-36 and Indiana Dept. of Transportation Specifications for Aluminized Steel Type.

In addition, the pipe shall be of full circle and shall be fabricated with helical corrugations and a welded seam extending from end to end of each length of pipe. Pipe made first by the lock-seam method with the seam welded later will not be acceptable. The welded seam shall be continuous, utilizing ultra-high frequency resistance equipment. Seams shall be welded in such a manner that they will develop the full strength of the pipe and not affect the shape or nominal diameter of the pipe. Each pipe end shall be fabricated with two annular corrugations for the purpose of joining pipes together with band couplers.

Polyvinyl Chloride (PVC) Pipe
PVC pipe shall be Type PSM conforming to the latest edition of ASTM D3034 for pipe sizes up to 15-inch and ASTM F679 for pipe sizes 18-inches and larger. HOWEVER, no reworked material shall be used and the material shall have a cell classification of 12454-B as defined in the latest edition of ASTM D1782 and shall have an SDR (Standard Dimension Ratio) of not greater than 35.

For depths of bury through fifteen (15) feet a minimum wall thickness of SDR 35 as defined in Section 7.4.1 of ASTM D-3034 is required. For depths of bury greater than fifteen (15) feet, a minimum wall thickness of SDR 26 is required.

5.3.1.3 Pipe Installation

Location

Locate pipes according to dimensions on the drawings. Where the sewer location is not located clearly by dimensions on the drawings, locate the sewer where concrete encasement is used, provide not less than 4-inch thickness including that of pipe joints.

Laying Pipe

All pipe shall be inspected for soundness and damage that may have occurred during transportation immediately before being lowered into the trench. Any pipe found to be unsound or damaged will be rejected and removed immediately from the work site.

All sound and intact pipe shall be laid accurately to the required line and grade in such a manner as to form a close, concentric joint with the adjoining pipe and to bring the invert of each section to the required grade. Bell holes shall be dug in advance of the pipe being laid as required. The supporting of any pipe on blocks will not be permitted.

Pipe laying shall proceed upgrade, beginning at the lower end of the sewer, unless otherwise approved by the Board.

Each length of section shall be properly pulled or shoved "home" with a winch or come-a-long against the section previously laid to make a proper joint. The pipe shall then be securely held in position during the backfill operations. Joints shall not be pulled or cramped more than the design of the joint will permit and so as not to injure the conduit.

All open ends of pipes and branches shall be sealed with plugs or bulkheads firmly held in place in a manner acceptable to the Board. No special payments will be made for the placement or removal of said plugs or bulkheads. At the end of each days work, the open ends of all pipes shall be satisfactorily protected against the entrance of animals, earth or other materials.

Dewatering

Dewatering sufficient to maintain the water level below the surface of the trench bottom shall be accomplished prior to pipe laying and jointing, if not done prior to excavation and placement of the bedding as called for. The dewatering operation, however accomplished, shall be carried out so that it does not destroy or weaken the strength of the soil under or alongside the trench. When the dewatering operation is complete, the trench shall be replaced in such a manner so as not to disturb the pipe and its foundation.

Abandoning Pipe or Structures

Where called for on the plans to be abandoned, said sewers or structures shall be permanently plugged or bulkheaded. Where standard "plugs" are available, they shall be employed. For other pipes or structures, the use of brick and mortar or concrete may be used in a manner suitable to the Board.

Bedding, Rigid Pipe

The following terms apply to all classifications of rigid pipe bedding.

Definition of Terms for Bedding:
Bc = Outside diameter of pipe, in inches
D = Inside diameter of pipe, in inches
d = Depth of bedding material below the pipe bell, in inches

The values of "d", depth of bedding material below the bell of the pipe shall be as follows:

"D" (inside diameter of pipe)	"d" (depth of bedding material) Minimum Requirements
27" and smaller	3"
30" to 60"	4"
66" and larger	6"

Class "A" bedding is that method of bedding in which the conduit is set on "d" inches of concrete in an earthen foundation and encased in concrete up to ¼" of "Bc" to fit the lower part of the conduit's exterior breadth. The remainder of the conduit is to be surrounded to a height of at least (12) inches above its top by densely compacted granular backfill material carefully placed by hand to completely fill all spaces under and adjacent to the conduit.

The fill is to be tamped thoroughly on each side of the conduit, as far as practicable, shall be in layers not to exceed six (6) inches in thickness.

The concrete used for Class “A” bedding shall be plain concrete with a 28-day compressive strength of 3,000 psi, unless otherwise specified. Refer to “Bedding and Backfill Details” located in **Appendix C**, Stormwater Conveyance Details for further details on Class “A” bedding.

Class “B” bedding is that method of bedding in which the conduit is set on “d” inches of a fine granular material (sand cushion) in an earth foundation, carefully shaped to fit the lower part of the conduit exterior for a width of at least 60% of the conduit’s breadth. The remainder of the conduit is to be surrounded to a height of at least twelve (12) inches above its top by densely compacted granular backfill material carefully placed by hand to completely fill all spaces under and adjacent to the conduit. The fill shall be tamped thoroughly on each side and under the conduit, as far as practicable, in layers not to exceed six (6) inches in thickness. Bell excavation is to be provided. Refer to “Bedding and Backfill Details” located in **Appendix C**, Stormwater Conveyance Details for further details on Class “B” bedding.

Class “B” bedding material shall meet the gradation as set forth in the Indiana Dept. of Transportation Standard Specifications, current edition, Section 211, Special Fill and Backfill (“B” Borrow), except that no more than 12% or less than 5% shall pass the No. 200 sieve (silt or clay).

Each pipe shall be laid in Class "B" bedding unless specifically noted otherwise, as shown on the plans and the construction standard drawings.

Class “C” bedding is that method of bedding in which the conduit is set on an earth foundation, carefully shaped to fit the lower part of the conduit exterior for a width of at least 50% of the conduit’s breadth. The remainder of the conduit is to be surrounded to a height of twelve (12) inches above its top by lightly compacted granular backfill material carefully around the exterior of the conduit. Bell excavation is to be provided. Refer to “Bedding and Backfill Details” located in **Appendix C**, Stormwater Conveyance Details for further details on Class “C” bedding.

Bedding, Flexible Pipe

Each pipe shall be laid in a Class I or Class II bedding, as shown in **Appendix C**, Stormwater Conveyance Details. Pipe bedding installation shall conform to ASTM D 2321.

Existing Sewer Removal and Replacement

When applicable, existing sewer lines shall be completely removed and replaced with new sewer lines. The contractor shall be required to maintain service during said removal and replacement, which may entail bypass pumping. The contractor shall inform the engineer of the method proposed for maintaining service.

Sheet Piling

Permanent or temporary sheet piling shall be provided in the following circumstances: for construction in areas where wide excavations cannot be permitted; for an excavation that is open for an extended period; or where soil conditions dictate to protect adjacent structures, roadways, and utilities.

The section modulus of piling sections shall be as required to function properly as intended.

Piling sections shall be marked for length and sorted and stacked at the job site to prevent distortion and to facilitate proper sequence of setting and driving.

Interlocks shall be protected from becoming obstructed by sand, gravel, mud or other materials.

Pile tips are approved for use at the contractor's discretion.

5.3.2 Structures

Structures shall be designed and constructed using the following criteria.

5.3.2.1 General Specifications

Manholes

Manholes shall be installed to provide access to continuous underground storm sewers for the purpose of inspection and maintenance. Manholes shall be provided at the following locations:

- Where two or more storm sewers converge;

- At the point of beginning or at the end of a curve, and at the point of reverse curvature (PC, PT, PRC);
- Where pipe size changes;
- Where an abrupt change in alignment occurs;
- Where a change in grade occurs; and
- At suitable intervals in straight sections of sewer.

The maximum distance between storm sewer manholes shall be as follows:

Size of Pipe (inches)	Maximum Distance (feet)
12 to 42	400
48 and larger	600

Inlets

Inlets or drainage structures shall be utilized to collect surface water through grated openings and convey the surface water into storm sewers, channels, or culverts. Inlet design and spacing shall be in accordance with Section 7-400 of the *Indiana Department of Transportation Road Design Manual - Volume 1* or other approved design procedures as determined by the Board prior to any land disturbing activities. The inlet grate opening must be adequate to accommodate a 10-year flood event with 50% of the sag inlet areas clogged. An overloaded channel from the sag inlets to the overflow channel, or basin, shall be provided at sag inlets. This will prevent the maximum depth of water ponding in the street sag from exceeding 7 inches.

Culverts

Culverts shall be capable of accommodating peak runoff from a 50-year flood event when crossing under a road which is part of the *Indiana Department of Transportation* rural functional classification system and are classified as principal or minor arterial, or minor collector roads.

Special Hydraulic Structures

The use of special hydraulic structures shall be limited to those locations justified by prudent planning and by careful and thorough hydraulic engineering analysis. Special

hydraulic structures control the flow of water in storm runoff drainage systems. They include: junction chambers, drop manholes, inverted siphons, stilling basins, and other special structures.

5.3.2.2 Materials

Reinforced Concrete Manholes

Reinforced concrete manholes shall be erected of precast, or cast in place, reinforced concrete sections to the shape of the manhole. Steps shall be cast in place in accordance with the standards as shown in **Appendix C**, Stormwater Conveyance Details. All concrete, reinforcing and wall thickness shall be in accordance with the latest edition of ASTM Designation C-478. All structure joints shall be watertight and constructed in accordance with the latest edition of ASTM Specification C-443. The bottom of the structures shall be of either precast, poured in place, or monolithic bottom stack, with 3,000 psi concrete to conform to the plans. They shall be at least eight (8) inches thick and reinforced as shown in **Appendix C**, Stormwater Conveyance Details.

Precast Manhole Components

Precast manhole components shall conform to the latest edition of ASTM C-478, and to the design dimensions indicated by the approved plans. All precast manhole components shall be manufactured by an experienced and reputable manufacturer whose precast manhole components have been used commercially for at least three (3) years. Cones and sections shall be substantially free from fractures, large or deep cracks and surface roughness. Slabs shall be sound and free from gravel pockets.

Monolithic Concrete Manholes

Monolithic concrete manholes shall conform to the contract drawings and the Stormwater Conveyance Details located in **Appendix C**. Walls and base dimensions shall be of approved thickness and the maximum step spacing shall be sixteen (16) inches.

Manhole Joints

Storm sewer manhole joints shall be neatly joined by flexible rubber gasket or approved bitumastic material.

Cast Iron Frames and Covers

Cast iron frames and covers shall conform to the requirements of the latest edition of ASTM A48 for Gray Cast Iron. The dimensions, weights and finish preparation shall conform to the appropriate construction standards.

Ductile Cast Iron Frames, Covers and Grates

Ductile cast iron frames, covers and grates shall conform to the requirements of the latest edition of ASTM A536 for Ductile Cast Iron. The dimensions, weights and finish preparation shall conform to the appropriate construction standards.

5.3.2.3 Installation

Dewatering

Dewatering sufficient to maintain the water level below the surface of the trench bottom shall be accomplished prior to pipe laying and jointing, if not done prior to excavation and placement of the bedding as called for. The dewatering operation, however accomplished, shall be carried out so that it does not destroy or weaken the strength of the soil under or alongside the trench. When the dewatering operation is complete, the trench shall be replaced in such a manner so as not to disturb the pipe and its foundation.

Sheet Piling

Permanent of temporary sheet piling shall be provided in the following circumstances: for construction in areas where wide excavations cannot be permitted; for an excavation that is open for an extended period; or where soil conditions dictate to protect adjacent structures, roadways, and utilities.

The section modulus of piling sections shall be as required to function properly as intended.

Piling sections shall be marked for length and sorted and stacked at the job site to prevent distortion and to facilitate proper sequence of setting and driving.

Interlocks shall be protected from becoming obstructed by sand, gravel, mud or other materials.

Pile tips are approved for use at the contractor's discretion.

Bedding for Structures

Precast base sections shall be placed on a well-graded granular bedding course conforming to the requirements for sewer bedding, but not less than four (4) inches in thickness and extending to the limits of the excavation. The bedding course shall be firmly tamped and made smooth and level to assure uniform contact and support of the precast element.

Cast-in-Place Bases

Unless otherwise specified, cast-in-place bases shall be at least eight (8) inches in thickness and shall extend at least six (6) inches radially outside of the outside dimensions of the manhole section. The cast-in-place base shall be made of 3,000 psi concrete, 28-day compression test, and shall be reinforced as shown on the construction standards.

Lift Holes

All lift holes in precast elements shall be thoroughly wetted and be completely filled with non-shrinking concrete grout, smoothed and painted both inside and out, to ensure water tightness.

Placing Precast Sections

Precast sections shall be placed and aligned to provide vertical sides and vertical alignment of the ladder rungs. The completed manhole shall be rigid, true to dimensions and watertight.

Placing of Castings

Castings placed on a concrete surface shall be set in full grout beds. The grout shall be mixed in proportion of one (1) part Portland Cement to three (3) parts sand, by volume, based on dry materials. Castings shall be set accurately to the finished elevation so that no subsequent adjustment will be necessary, or unless otherwise specified by the licensed Engineer.

After grout has cured, use an approved bitumastic material around the outside of casting to ensure water tightness.

When working in paved streets or areas which have been brought to grade, not more than fifteen (15) inches shall be provided between the top of the cone or slab and the underside of the manhole casting for adjustment of the casting to street grade.

When working in an unimproved street or alley, not less than twelve (12) inches of adjusting rings shall be provided between the top of the cone or slab and the underside of the manhole casting for adjustment of the casting to finished grade. The top of the manhole casting shall be flush with the finished grade, unless otherwise shown in the plans.

When working in cultivated areas, the top of the manhole casting shall be buried three (3) feet. In non-cultivated areas, the casting shall be flush with the finished grade, unless otherwise directed by the licensed Engineer.

In the event that the last manhole section is a reducing cone set to final grade by the licensed Engineer and if it becomes necessary to lower them below the cone, compensation to the contractor will be allowed for said adjustment and changing of the manhole stacks.

When concrete adjusting rings are used to set the castings to grade, they shall be pointed up and a grout bed placed between each ring and casting; and made watertight with a heavy coating of an approved bitumastic material on the outside of the structure. The casting is flush with the surrounding pavement.

When rubber adjustment rings are used to set castings to grade, they shall be positioned so that the casting is flush with surrounding pavement.

Channels and Inverts

Channels and inverts shall be made to conform accurately to the sewer characteristics and grades, and shall be brought together smoothly with well-rounded junctions, satisfactory to the licensed Engineer and in conformance with the Stormwater Conveyance Details in **Appendix C**.

Pipe Connections

Pipes shall be firmly full of jointing material at entrance to manhole to ensure water tightness. The pipes shall not protrude farther than three (3) inches into the inside face of the manhole, measured along the horizontal center of the pipe. Special care shall be taken to see that the opening through which pipes enter the structure have all pipe ends sawed and smoothed completely.

Rubber water stops, “O”-Ring gaskets, or poured-in-place pipe sleeves shall be used for water tightness between the pipe and the manhole for all sidewall pipes.

When new holes are required in the manhole, they shall be core drilled, or star drilled, in a circle of the required diameter and then knocked out. In no instance shall new holes be sledge-hammered out.

5.3.2.4 Grade Adjustment of Existing Structures

When adjusting castings to grade or reconstructing structures, the applicant shall conform to the applicable provisions of the Indiana Department of Transportation Standard Specifications, current edition.

5.3.3 Joints, Fittings and Appurtenances

Joints, fittings and appurtenances shall be designed and constructed using the following criteria.

Joints
Elastomeric seals for gasketed joints for corrugated and spiral wound PVC shall meet ASTM F477 and ASTM D3212.

Flexible rubber gasket joints for concrete sewer pipe shall conform to the requirements of ASTM Designation C-443, joints for circular concrete sewer and culvert pipe, using flexible watertight, rubber gaskets. Storm sewer pipe larger than 24-inch diameter may be tongue and groove plain joint unless the sewer is under a pavement or the plans specifically say otherwise. If plain joint is used, an approved bitumastic material shall be applied to each joint.

Coupling bands for use with corrugated metal pipe shall be “hugger” type with “O” rings.

The PVC joint shall conform to ASTM D3212 “push on” type with a confined rubber gasket conforming to ASTM F477.

Fittings
PVC sewer fittings shall conform to the requirements of ASTM D-3034 specifications. Four, six, and eight-inch fittings shall be molded in one piece, with elastomeric joints and minimum socket depths as specified in Section 6.2 and 7.3.2 of the D-3034 specification. Fittings 10 inches and larger shall be molded or fabricated from pipe meeting ASTM D-3034 with standard pipe bells and gaskets identified by the

manufacturer.

The PVC fittings for corrugated and spiral wound pipe shall conform to the latest edition of ASTM F 794.

Plugs
All fittings shall be capped with a plug of the same material as the pipe, and gasketed with the same gasket material as the pipe joint, or be of material approved by the Board. The plug shall be able to withstand all test pressures involved without leakage.

5.3.4 Construction Requirements

The following construction requirements must be addressed prior to any land disturbing activities.

5.3.4.1 Surface Conditions

The applicant shall examine the areas and conditions under which work of this section will be performed. Conditions detrimental to timely and proper completion of the work to be done shall be corrected. Work may not be done until unsatisfactory conditions are corrected.

5.3.4.2 Field Measurements

The applicant shall make necessary measurements in the field to assure precise fit of items in accordance with the approved design.

5.4 Open Channels

Open channels shall be designed and constructed using the following criteria.

5.4.1 Channel Cross-Section and Grade

The required channel cross-section and grade are determined by the design capacity. A minimum depth may be required to provide adequate outlets for subsurface drains, tributary ditches, or streams. The channel grade shall be such that the velocity in the channel is high enough to prevent siltation from occurring and ultimately reducing the channel cross-section. The maximum permissible velocities in vegetal-lined channels to be constructed must be considered in design of the channel section.

5.4.2 Side Slopes

Earthen channel side slopes shall be no steeper than 2 to 1. Flatter slopes may be required to prevent erosion and for ease of maintenance. Where channels will be lined, side slopes shall be no steeper than 1 ½ to 1 with adequate provisions made for weep holes. Side slopes steeper than 1 ½ to 1 may be used for lined channels, provided that the side lining and structural retaining wall are designed and constructed with provisions for live and dead load surcharge.

5.4.3 Peak Flows

Open channels carrying peak flows greater than thirty (30) cubic feet per second shall be capable of accommodating peak runoff for a 50-year flood event within the drainage easement.

5.4.4 Channel Stability

The following characteristics are indicative of a stable channel:

- It neither aggrades nor degrades beyond tolerable limits;
- The channel banks to not erode to the extent that the channel cross-section changes appreciably;
- Excessive sediment bars do not develop;
- Excessive erosion does not occur around culverts, bridges, or elsewhere; and
- Gullies do not form or enlarge due to the entry of uncontrolled surface flow to the channel.

Channel stability shall be determined for an aged condition, and the velocity shall be based on the design flow or the bank full flow, whichever is greater, using “n” values for various channel linings. In no case, is it necessary to check channel stability for discharges greater than that from a 100-year flood event.

Channel stability must be checked for conditions immediately after construction. For this stability analysis, the velocity shall be calculated for the expected flow from a 10-year flood event on the watershed, or the bank full flow, whichever is smaller. The “n” value for newly constructed channels in fine-grained soils and sands may be determined in accordance with the National Engineering Handbook 5, Supplement B, Soil Conservation Service, and shall not exceed

channel 0.025.

The allowable velocities for newly constructed channels may be increased by a maximum of 20 percent to reflect the effects of vegetation to be established under the following conditions:

- The soil and site in which the channel is to be constructed are suitable for rapid establishment and support of erosion-controlling vegetation;

- Species of erosion-controlling vegetation adapted to the area and proven methods of establishment are shown; and

- The channel design includes detailed plans for establishment of vegetation on the channel side slopes.

5.4.5 Drainage of Waterways

Vegetated waterways that are subject to low flows of long duration or where wet conditions prevail shall be drained with a tile system or by other means such as paved gutters. Tile lines may be outlet through a standard tile outlet.

5.4.6 Appurtenant Structures

The design of channels shall provide all structures required for the proper functioning of the channel and the laterals thereto, and travelways for operation and maintenance. Recessed inlets and structures needed for entry of surface and subsurface flow into channels without significant erosion or degradation shall be included in the design of channel improvements. The design is also to provide the necessary flood gates, water level control devices, and any other appurtenances affecting the functioning of the channels and attainment of the purpose for which they are built.

The effect of channel improvements on existing culverts, bridges, buried cables, pipelines, and inlet structures for surface and subsurface drainage on the channel being improved and laterals thereto shall be evaluated to determine the need for modification or replacement. Culverts and bridges which are modified or added as part of channel improvement projects shall meet reasonable standards for the type of structure, and shall have a minimum capacity equal to the design discharge or governmental agency design requirements; whichever is greater.

5.4.7 Disposition of Spoils

Spoil material resulting from clearing, grubbing, and channel excavation shall be disposed of in such a manner which will:

- Minimize overbank wash;
- Provide for the free flow of water between the channel and flood plain unless the valley routing and water surface profile are based on continuous dikes being installed;
- Not hinder the development of travelways for maintenance;
- Leave the right-of-way in the best condition feasible, consistent with the project purposes for productive use by the owner;
- Improve the aesthetic appearance of the site to the extent feasible; and
- Be approved by the IDNR or the U.S. Army Corps of Engineers (whichever is applicable), if deposited in floodway.

5.4.8 Materials

Materials acceptable for use as channel lining are:

- Grass;
- Revetment riprap;
- Concrete;
- Hand-laid riprap;
- Pre-cast cement concrete riprap;
- Grouted riprap;
- Gabions;
- Coir logs;
- Mesh matting; or
- Cellular walls.

6.0 EROSION AND SEDIMENT CONTROL

6.1 Introduction

This chapter describes policies, design criteria and information for erosion and sediment control best management practices (BMPs).

6.1.1 Background and Purpose

Land development necessitates the removal of natural ground cover, creating the potential for erosion to occur. Erosion from a construction site negatively impacts water quality, and the ability of stormwater facilities to continue functioning properly.

This chapter is intended to establish minimum standards for the design and construction of erosion and sedimentation control BMPs.

6.1.2 Design Principles

The Indiana Handbook for Erosion Control in Developing Areas has identified ten general principles of erosion and sediment control. They are as follows:

- Fit the development to the existing terrain and soil;
- Develop an erosion and sediment control plan before land-disturbing activities begin, and then fully implement the plan during construction;
- Retain existing vegetation on the construction site wherever possible;
- Minimize the extent and duration that bare soil is exposed to erosion by wind and water;
- Retain sediment on-site as much as possible;
- If possible, divert off-site runoff away from disturbed areas;
- Minimize the length and steepness of slopes;
- Stabilize disturbed areas as soon as possible;
- Keep velocity of runoff leaving site low;
- Inspect and maintain erosion control measures regularly.

These general principles shall be used along with specific erosion and sediment control measures during construction activities.

6.2 Details on Specific Practices

In addition to the following practices, the applicant should also consult *The Indiana Stormwater Quality Manual* (formerly *The Indiana Handbook for Erosion Control in Developing Areas)* for detailed design, construction and maintenance criteria for all erosion and sediment control practices

6.2.1 Temporary Sediment Basin

A temporary sediment basin is a temporary impoundment built to retain sediment and debris. Sediment basins prevent off-site sedimentation by retaining sediment on the construction site.

A schematic example of a temporary sediment basin can be found in **Appendix D**, Erosion and Sediment Control Details.

6.2.1.1 Site and Design Considerations

The following design and site considerations must be followed when designing a temporary sediment basin:

- The basin shall have a depth of at least 3 feet with sufficient surface area to trap the sediment;
- The site shall be of large enough size for the sedimentation basin to have at least one percent of its drainage area with 30 acres being the maximum drainage area;
- The basin shall be able to maintain a three foot minimum depth; and
- The basin shall not create a condition in which the discharge rate from a sedimentation basin would cause scouring in the receiving channel.

6.2.1.2 Materials

Temporary sediment basin design and material selection is site specific. Materials used must ensure that all design considerations are met.

6.2.1.3 Installation

The following installation procedures must be followed when installing a temporary sediment basin:

- Locate the sediment basin as close to the sediment source as possible, considering soil type, pool area, dam length, and spillway conditions;
- Clear, grub, and strip the dam location, removing all woody vegetation, rocks and other objectionable material;
- Excavate the area (outlet apron first), stockpiling any surface soil having high amounts of organic matter for later use; and
- Clear the sediment pool to facilitate sediment cleanout.

6.2.1.4 Maintenance

The developer is responsible for maintenance and inspections of all temporary sediment basins. The maintenance plan must include, but is not limited to:

- Inspection of the sediment basin after each storm event;
- The removal and proper disposal of sediment that has accumulate to one-half the design volume;
- The removal of trash and other debris from the riser, emergency spillway, and pool area; and
- The removal of the basin after the drainage area has been permanently stabilized, inspected, and approved. This may be done by draining any water, removing the sediment to a designated disposal area, smoothing the site to blend with the surrounding area, and permanent stabilization.

6.2.2 Rock Check Dam

A rock check dam is a small temporary barrier, grade control structure, or dam constructed across a swale, drainage ditch, or area of concentrated flow. The purpose of this structure is to minimize the

erosion rate by reducing the velocity of stormwater and to capture larger soil particles.

A schematic example of a rock check dam can be found in **Appendix D**, Erosion and Sediment Control Details.

6.2.2.1 Site and Design Considerations

The following design and site considerations must be followed when designing a rock check dam:

- The contributing drainage area for a rock check dam shall not exceed two acres;
- Two or more check dams in series shall be used for drainage areas greater than two acres;
- The maximum spacing between dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam;
- The dam height shall be 2 feet maximum, measured at the center of the check dam, but at least 9 inches lower in center than the outer edges at natural ground elevation; and
- The side slopes of the check dam shall be 2:1 or less.

6.2.2.2 Materials

The developer shall use Revetment Riprap, per INDOT Standards, for the construction of a rock check dam.

6.2.2.3 Installation

The following installation procedures must be followed when installing a rock check dam:

- Excavate a cutoff trench into the ditch banks, and extend it a minimum of 18 inches beyond the abutments;
- Place the rock in the cutoff trench and channel; and

- Extend the rock at least 18 inches beyond the channel banks to keep overflow water from undercutting the dam.

6.2.2.4 Maintenance

The developer is responsible for the inspection and maintenance of the rock check dam. The maintenance plan must include, but is not limited to:

- The inspection of the dam and channel after each storm event;
- Repairs as a result of damage from a storm event, which are to be performed immediately following the event;
- The installation of a riprap liner in the event that there is significant erosion between dams;
- The removal of sediment accumulated behind each dam as needed to maintain channel capacity, allow drainage through the dam, and to prevent large flows from displacing sediment;
- The addition of rock to the dams, as necessary, to maintain the height and cross section; and
- The removal of rock and stabilized channel, using an erosion resistant lining when necessary, shall the dam no longer be needed.

6.2.3 Temporary Stone Construction Entrance

The purpose of a temporary stone construction entrance is to provide a stable entrance and exit condition from the construction site and to keep mud and sediment off public roads.

A schematic example of a temporary stone construction entrance can be found in **Appendix D**, Erosion and Sediment Control Details.

6.2.3.1 Site and Design Consideration

The following design and site considerations must be followed when designing a temporary stone construction entrance:

- The temporary entrance must be at least 12-feet wide and 50-feet long or the distance to the foundation;

- If wet conditions are expected, geotextile fabric is required for stabilization; and

- Six inches of clean depth must be maintained.

6.2.3.2 Materials

Materials required for the use of a temporary stone construction entrance include:

- 2 to 3-inch size washed stone (per INDOT standards); and

- Geotextile fabric if wet conditions are expected.

6.2.3.3 Installation

The following installation procedures must be followed when installing a temporary stone construction entrance:

- Avoid locating the entrance on a steep slope or at a curve in a public roads;

- Remove all vegetation and other objectionable material from the foundation area, then grade and crown for positive drainage;

- If slope towards the road exceeds 2%, construct a 6-8 inch high water ridge with 3:1 side slopes across the foundation area about 15 feet from the entrance to divert runoff away from the road; and

- Install a temporary culvert under pad to maintain proper public road drainage, as necessary.

6.2.3.4 Maintenance

The developer is responsible for the inspection and maintenance of the temporary stone construction entrance. The maintenance plan must include, but is not limited to:

- Inspection of the entrance pad and sediment disposal area on a weekly basis, but also following storm events or heavy use;

- Reshaping of the pad for drainage and runoff control, as necessary.

- Topdressing the entrance with clean stone as necessary;

- The immediate removal of mud and sediment tracked or washed onto public roads. This shall be performed by brushing or sweeping; and

- The immediate repair of any broken road pavement.

6.2.4 Silt Fence

A silt fence is a temporary barrier constructed of geotextile fabric, posts, and depending upon the strength of the fabric used, wire fence for support. The purpose of a silt fence is to retain sediment on-site by reducing the velocity of sheet flow.

A schematic example of a silt fence can be found in **Appendix D**, Erosion and Sediment Control Details.

6.2.4.1 Site and Design Considerations

The following design and site considerations must be followed when designing a silt fence:

- The contributing drainage area for a silt fence shall be limited to ¼ acre per 100 ft of fence and further limited by slope steepness as shown in the following table;

Land Slope	Max Distance Above Fence
< 2%	100 ft
2 – 5%	75 ft
5 – 10%	50 ft
10 – 20%	25 ft
> 20%	15 ft

- The fabric must be buried at an 8 inch minimum depth;

- The fence shall be placed on the contour to avoid channelization; and

- The spacing of the posts shall be 8 foot maximum if supported by wire and 6 foot maximum if no supporting wire is used.

6.2.4.2 Materials

Materials required for the installation of a silt fence include:

- 2-inch x 2-inch hardwood posts or steel fence posts;

- Woven or non-woven geotextile fabric;

- When applicable, a 14 gauge, 6-inch mesh wire fence.

6.2.4.3 Installation

The following installation procedures must be followed when installing a silt fence:

- Install fence parallel to the contour of the land;

- Dig an 8-inch deep flat bottomed or V-trench along the entire fence line;

- Extend ends upslope into the trench to allow water to pond behind fence;

- Install fence with posts on the down slope side;

- Join silt fence sections using a wrap joint; and

- Backfill the trench with compacted earth or gravel.

6.2.4.4 Maintenance

The developer is responsible for the inspection and maintenance of all silt fences. The maintenance plan must include, but is not limited to:

- The frequency of inspections;

- The requirement for repairs and replacements as necessary;

- The removal of sediment deposits when they reach one half the fence height or in the event that they cause the fabric to bulge; and

- The removal and proper disposal of all fences. Once removed, the depressions shall be filled, compacted, and seeded.

6.2.5 Straw Dam

A straw dam is a temporary sediment barrier constructed of straw bales across small drainages. The purpose of a straw dam is to retain sediment on-site by reducing the velocity of sheet flow.

A schematic example of a straw dam can be found in **Appendix D**, Erosion and Sediment Control Details.

6.2.5.1 Site and Design Considerations

The following design and site considerations must be followed when designing a straw dam:

- The contributing drainage area for a straw dam shall be limited to ¼ acre per 100 ft of dam and further limited by slope steepness as shown in the following table.

Land Slope	Maximum Spacing
Less than 2%	100 ft
2 – 5%	75 ft
5 – 10%	50 ft
10 – 20%	25 ft
Greater than 20%	15 ft

- The dam shall be located on the contour to prevent channelization; and

- The straw dam shall be anchored to prevent movement.

6.2.5.2 Materials

Materials required for the installation of a straw dam include:

- New, firm, and well compacted straw bales bound with wire or nylon. Minimum size for bales shall be 14" x 18" x 36"; and
- 2-inch x 2-inch hardwood stakes.

6.2.5.3 Installation

The following installation procedures must be followed when installing a straw dam:

- Excavate trench at least 4 inches deep, a bale's width, and long enough that the end bales are somewhat upslope of the sediment pool;
- Place each bale in the trench so the bindings are oriented around the sides rather than top and bottom;
- Anchor the dam by driving stakes through each bale until nearly flush with the top;
- Insert straw into any gaps between bales to prevent sediment-laden water from running through; and
- Backfill and compact the excavated soil against the bales to the ground level on the down-slope side and to 4 inches above ground level on the up-slope side.

6.2.5.4 Maintenance

The developer is responsible for the inspection and maintenance of all straw dams. The maintenance plan must include, but is not limited to:

- The frequency of inspections of the dams;
- The requirement for repairs and replacements when necessary;
- The removal of sediment deposits not to undermine the entrenched bales.

- The removal and proper disposal of all dams. Once removed, the depressions shall be filled, compacted, and seeded.

6.2.6 Fabric Drop Inlet Protection

Fabric drop inlet protection is a temporary woven geotextile barrier placed around a drop inlet to prevent sediment from entering the storm drains during construction operations.

A schematic example of fabric drop inlet protection can be found in **Appendix D**, Erosion and Sediment Control Details.

6.2.6.1 Site and Design Considerations

The following design and site considerations must be followed when designing fabric drop inlet protection:

- The height of the fabric shall be a maximum of 1.5 feet and a minimum of 1 foot;
- The base of the fabric shall be buried at least 6 inches below the ground surface;
- The support posts shall have a minimum length of 3 feet;
- The maximum spacing of the support posts shall be 3 feet;
- Framing shall be used to connect tops of posts to stabilize the structure; and
- The maximum contributing drainage area for fabric drop inlet protection is 1 acre.

6.2.6.2 Materials

Materials required for the installation of fabric drop inlet protection include:

- Steel fence posts or 2-inch x 4-inch wooden posts; and
- Durable, high-strength synthetic woven fabric.

6.2.6.3 Installation

The following installation procedures must be followed when installing fabric drop inlet protection:

- Set the top of the fabric at least 6 inches below the downslope ground elevation;
- Cut the fabric from a single roll to eliminate joints if possible. If joints are needed, a wrap joint shall be used;
- Bury the bottom of the fabric at least 1 foot deep, backfill, and compact the backfill; and
- Space the support posts evenly against the inlet perimeter a maximum of 3 feet apart and drive them about 1.5 feet into the ground.

6.2.6.4 Maintenance

The developer is responsible for the inspection and maintenance of all fabric drop inlet protection sites. The maintenance plan must include, but is not limited to:

- Inspection of the fabric barrier after storm events and making the needed repairs at that time;
- The removal of sediment from the pool area to provide storage for the next storm, while avoiding damage or undercutting of the fabric during sediment removal.
- The removal and proper disposal of all construction material and sediment. The area shall then be graded to the elevation of the top of the inlet, and stabilized.

6.2.7 Sandbag Curb Inlet Protection

The purpose of sandbag curb inlet protection is to trap sediment on paved streets that receive relatively small runoff flows, preventing the sediment from being transported further down the street or into an inlet.

A schematic example of a sandbag curb inlet protection can be found in **Appendix D**, Erosion and Sediment Control Details.

6.2.7.1 Site and Design Considerations

The following design and site considerations must be followed when designing a sandbag curb inlet protection:

- 1 to 3 layers of sandbags shall be used;
- The length of the inlet protection structure shall be a minimum of 3 feet; and
- The maximum contributing drainage area is 1 acre.

6.2.7.2 Materials

All sandbags used for curb inlet protection shall be filled half full with sand or fine gravel.

6.2.7.3 Installation

The following installation procedures must be followed when installing sandbag curb inlet protection:

- Lay the bags tightly end to end in a row curving from the curb and away from the inlet, upslope from the curb inlet;
- Overlap the barrier onto the curb, and extend it into the street to intercept the runoff;
- If using more than one row, overlap the bags with the row beneath, and leave a one-bag gap in the middle of the top row to serve as a spillway.

6.2.7.4 Maintenance

The developer is responsible for the inspection and maintenance of all sandbag curb inlet protection sites. The maintenance plan must include, but is not limited to:

- The frequency of inspection for damage by vehicular traffic and following each storm event;
- The repair and replacement procedures when necessary; and

- The removal of sediment when it reaches half the height of the barrier.

6.2.8 Riprap Chute Outfall Protection

Riprap chute outfall protection is a pad or apron of rock placed at the outlet end of culverts or chutes. They are used to reduce velocity and prevent erosion at the outlet of a channel or culvert.

A schematic example of riprap chute outfall protection can be found in **Appendix D**, Erosion and Sediment Control Details.

6.2.8.1 Site and Design Considerations

The following design and site considerations must be followed when designing riprap chute outfall protection:

- The maximum contributing drainage area shall be 100 acres;
- The minimum thickness shall be 12 inches with a geotextile foundation and
- Ensure that the apron size is proportional to the pipe diameter size.

6.2.8.2 Materials

Riprap chute outfall protection materials shall be hard, angular, and highly weather resistant riprap stone of size and gradation that will withstand the velocities of the chute.

6.2.8.3 Installation

The following installation procedures must be followed when installing riprap chute outfall protection:

- Excavate the apron area subgrade below design elevation to allow for thickness of the filter and riprap;
- Place fabric on compacted and smooth foundation and install the riprap;
- Make sure the top of the riprap apron is level with or slightly below the receiving stream;

- Blend the riprap smoothly to the surrounding grade; and

- Stabilize all disturbed areas immediately following installation.

6.2.8.4 Maintenance

The developer is responsible for the inspection and maintenance of all riprap chute outfall protection sites. The maintenance plan must include, but is not limited to:

- The inspection of rock chutes after storm events for stone displacement and for erosion at the sides and ends of the apron; and

- Making needed repairs immediately using the appropriately sized stone, while placing them at or below the finished grade.

7.0 POST-CONSTRUCTION STORMWATER QUALITY

7.1 Introduction

This chapter describes policies, design criteria and information for water quality best management practices (BMPs) as required by the City of Richmond's National Pollutant Discharge Elimination System (NPDES) permit.

7.1.1 Background and Purpose

Best management practices (BMPs), both structural and non-structural, can reduce the amount of pollutants in stormwater. This section of the manual establishes minimum standards for the design, maintenance, application, and construction of water quality BMPs. The information provided in this chapter establishes performance criteria for stormwater quality management and procedures to be followed when preparing a BMP plan that must be in compliance with this manual.

BMPs noted in this chapter refer to post-construction BMPs, to be used after construction has been completed and the site has been stabilized. The installation of certain BMPs, such as bioretention areas and sand filters, prior to stabilization can cause failure of the measure due to clogging from sediment caused during land disturbing activities. Nonetheless, with a strict construction sequence, detention ponds and other BMPs can be installed initially during construction and used as sediment control measures. In those instances, the construction sequence must require that the pond is cleaned out with pertinent elevations and storage and treatment capacities re-established as noted in the approved post-construction stormwater management plan.

7.1.2 Stormwater Quality Control Requirements

The City of Richmond has adopted a policy that city-wide control of stormwater runoff quality will be based on the management of total suspended solids (TSS). The target TSS removal rate is 80%.

In addition to TSS removal, BMPs must also be designed to treat the water quality volume (WQv) or the first flush of runoff.

7.1.3 Water Quality Volume

The storage needed to capture and treat the runoff from the first one inch of rainfall is referred to as Water Quality Volume (WQv). In numerical terms, it is equivalent to an inch of rainfall multiplied by the volumetric runoff coefficient (Rv) and the site area.

The following equation is used to calculate WQv (in acre-feet):

$$WQv = \frac{(P)\ (Rv)\ (A)}{12}$$

Where:

WQv = water quality volume (acre-feet)
P = 1 inch of rainfall
Rv = 0.05 + 0.009(I) where I is the percent impervious cover
A = area in acres

All new development projects requiring stormwater quality management (Category 1 Projects) shall be required to treat the first one inch of rainfall. Redevelopment projects will be required to obtain the same approval if the redevelopment is to disturb more than 1 acre.

7.1.4 Structural Best Management Practices

Table 7.1.4-A, at the end of section 7.1, identifies pre-approved structural BMPs that can be used in Richmond for water quality control when designed and constructed in the manner in which they are intended. Note that many of these measures can also be designed to meet the water quantity control requirements. Specific water quality design requirements are presented in the following sections.

Table 7.1.4-B, at the end of section 7.1, discusses BMP selection criteria based on current and planned use of the site. Note that other approved BMPs and combination of approved BMPs may be used on a specific site if the target TSS removal rate of 80% is met.

7.1.4.1 Innovative or Otherwise Unapproved BMPs

All plans for unapproved BMPs (BMPs not included in Table 7.1.4-A) must be certified by a professional engineer, land surveyor, or landscape architect and submitted to the Stormwater Management Board for approval prior to installation. ASTM standard methods must be followed when verifying performance of new measures. New BMPs must meet the 80% TSS removal rate and must have a low to medium maintenance requirement to be considered by the City.

7.1.4.2 Operation and Maintenance of Structural BMPs

Each BMP must have an operations and maintenance plan. The maintenance plan must be submitted with the post-construction stormwater management plan and approved by the City. The approved operations and maintenance plan will be returned to the BMP owner, who will then be required to implement the operations and maintenance plan.

The City must be notified of any changes in BMP ownership, major repairs or BMP failure in writing within 30 days.

In the event that the City finds a BMP in need of maintenance or repair, the City will notify the BMP owner of the necessary maintenance, or repairs, and give the landowner a timeframe for complying with their request. If the maintenance, or repairs, are not completed within the designated timeframe, the City shall perform the repairs or maintenance and bill the landowner for the actual costs for the work.

Table 7.1.4-A Pre-Approved BMPs

BMP Type	Description	Quantity Control	WQv and 80% TSS removal
Ponds • Wet Pond • Wet extended detention pond • Micropool extended detention pond • Multiple pond systems	Stormwater ponds are constructed stormwater retention basins with a permanent pool (or micropool) of water. Runoff from each rain event is captured and treated in the pool.	Yes	Yes
Detention Basins • Detention Basin	A dry detention basin is an area used to detain stormwater for a relatively short period of time. The area should be dry between storms. The basin allows particles and pollutants to settle.	Yes	No
Stormwater Wetlands • Shallow wetland • Extended detention wetland • Pond/wetland systems • Pocket wetland	Stormwater wetlands are constructed, artificial wetland systems used for stormwater management. They consist of a combination of shallow marsh areas, open water and semi-wet areas above the permanent pool.	Yes	Yes
Bioretention Areas	Bioretention areas are shallow stormwater basins or landscaped areas that utilize engineered soils and vegetation to capture and treat stormwater run-off.	No	Yes
Sand Filters • Surface sand filter • Perimeter sand filter	Sand filters are multi-chamber structures designed to treat stormwater run-off through filtration, using a sand bed as its primary filter media.	No	Yes
Water Quality Swales • Dry Swale	Water quality swales are vegetated open channels that are designed and constructed to capture and treat stormwater run-off within dry cells.	No	Yes
Biofilters • Filter strip • Grass channel	While biofilters provide some filtering of stormwater runoff, by themselves they cannot meet the 80% TSS removal performance goal. *These measures can only be used as pre-treatment measures or as part of a treatment train.*	No	No
Catch Basin Inserts • Various designs	Catch basin inserts are small filtering devices installed in each catch basin to trap suspended solids and other pollutants.	No	Yes

Table 7.1.4-B BMP Selection Criteria

Current Use	Planned Use	Approved BMPs
Open land	Commercial strip, light industrial, institutional (individual lots)	Bioretention, wet pond, detention basin, artificial wetland, sand filters, biofilter, water quality swale, catch basin insert
Open land	Commercial or industrial subdivision (regional stormwater plan)	Wet pond, detention basin, wetland
Open land	Residential	Bioretention, wet pond, detention basin, artificial wetland, biofilter, water quality swale
Commercial building or strip (medium imperviousness)	Commercial building or strip	Bioretention, sand filter, catch basin insert, wet pond, detention basin, wetland
Commercial building or strip (small lot, high imperviousness)	Commercial building or strip	Bioretention, sand filter, catch basin insert
Transportation infrastructure	Increased/expanded transportation infrastructure	Water quality swales, wet ponds, detention, basin, artificial wetlands, catch basin inserts

7.2 Pre-Approved BMPs

In addition to the following practices, the applicant should also consult *The Indiana Stormwater Quality Manual* (formerly *The Indiana Handbook for Erosion Control in Developing Areas*) for detailed design, construction and maintenance criteria for all post-construction stormwater management practices.

7.2.1 Stormwater Ponds

Wet stormwater ponds can be designed to meet both water quality and water quantity requirements. If the retention pond is to be designed for only water quality purposes, then the pond shall be designed to capture the water quality volumes as noted in Section 7.1.3.

A schematic example of stormwater ponds and variations can be found in **Appendix E**, Post-Construction Stormwater Quality Details.

7.2.1.1 Site and Design Considerations

The following design and site considerations must be followed when designing a stormwater pond:

- Design the pond with a minimum length to width ratio of 3:1, preferably expanding outward toward the outlet;

- Maximize flow length between the inlet and outlet structure. Use baffles if short-circuiting cannot be prevented with inlet-outlet placement. Long flow paths and irregular shapes are recommended;

- In areas where there is a contributing drainage area, one must design the BMP as if the entire upstream watershed is fully developed;

- In areas where flow from the upstream watershed bypasses the proposed development, the design of the BMP will only need to consider the drainage from the site;

- Provide a sediment forebay, or similar pretreatment, upstream from the BMP inlet;
  - The forebay must be sized to contain 0.1 inches of runoff per impervious acre of contributing drainage. The forebay storage volume counts toward the total water quality storage requirements.
  - Exit velocities from the forebay must be non-erosive.
  - Direct maintenance access for appropriate equipment must be provided to the forebay.
  - The bottom of the forebay may be hardened (e.g. using concrete, paver blocks, etc.) to make sediment removal easier.
  - A fixed vertical sediment depth marker must be installed in the forebay to measure sediment deposition over time.
  - Sediment removal in forebay shall occur when 50% of the total capacity has been lost.

- Side slopes shall be no greater than 3:1 if mowed;

- Rip-rap protection must be provided (or other suitable erosion control means) for the outlet and all inlet structures into the pond;

- The minimum drainage area, contributing or effective, for stormwater ponds is 25 acres. The minimum drainage area, contributing or effective, for a micro-pool extended detention facility is 10 acres;

- Anti-seep collars or filter diaphragms must be provided for the barrel of principal spillway;

- If reinforced concrete pipe is used for the principal spillway, “O”-ring gaskets (ASTM C361) shall be used to create watertight joints;

- Provide a one (1) foot minimum freeboard above the maximum anticipated flow depth through the emergency spillway;

- Design and install an emergency drain (i.e. sluice gate or drawdown pipe) capable of draining within 24 hours;

- Design an emergency spillway to pass 1.25 times the peak discharge and peak flow velocity from the 100-year storm event for the entire contributing drainage area (unless the site has been bypassed), assuming post-development conditions;

- Provide trash racks, filters, hoods or other debris control;

- Provide a permanent benchmark within the permanent pool and sediment forebay for sediment removal;

- The principal spillway/riser system must incorporate anti-floatation, antivortex, and trash-rack designs;

- To prevent drawdown of the permanent pool, an impervious soil boundary may be needed;

- Orifice-type outlets are not allowed below the permanent pool elevation of wet ponds and micropools;

- Construction debris cannot be disposed of within the facility or used as fill in the embankment; and

- If the pond is used as a sediment control measure during active construction, the sediment must be cleaned out of the pond and elevations and grades reestablished as noted in the approved post-construction stormwater management plan.

7.2.1.2 Performance Standards

Wet ponds and variations designed, constructed and maintained as noted above shall provide the following pollutant reductions:

Pollutant	Percent Reduction
BOD	30%
TSS	85%
Total P	50%
Total N	30%
Metals	30%

7.2.1.3 Variations

Wet extended detention ponds: A wet extended detention pond is a wet pond where the water quality volume is split evenly between the permanent pool and the extended detention storage provided above the permanent pool. During storm events, water is detained above the permanent pool and released over 12 - 48 hours. This design has similar pollutant removal to a traditional wet pond, but consumes less space.

Micropool extended detention pond: The micropool extended detention pond is a variation of the wet extended detention pond where only a small micropool is maintained at the outlet to the pond. The outlet is sized to detain the water quality volume for 24 hours. The micropool prevents resuspension of previously settled sediments.

Multiple pond systems: Multiple pond systems consist of constructed facilities that provide water quality and quantity volume storage in two or more cells. The additional cells can create longer pollutant removal pathways and improved downstream protection.

7.2.1.4 Advantages

The advantages of stormwater ponds are as follows:

- High pollutant removal;
- High community acceptance, if designed and maintained correctly;
- Opportunity for wildlife habitat; and

- Multi-objective use for water quality and quantity control.

7.2.1.5 Disadvantages

The disadvantages of stormwater ponds are as follows:

- Potential for thermal impacts downstream; and
- Dam height restrictions.

7.2.1.6 Maintenance

The developer is responsible for the inspection and maintenance of each stormwater pond. Each BMP must have an operations and maintenance plan. The BMP owner must maintain and update the BMP operations and maintenance plan, as needed. The operations and maintenance plan must include, but is not limited to:

- The removal of debris from inlet and outlet structures;
- The removal of invasive vegetation from all side slopes;
- The removal of sediment accumulation from forebay and permanent pool area when it is 50% full; and
- The removal of woody vegetation from the embankment.

7.2.2 Detention Basin

A dry detention basin is an area used to detain stormwater for a relatively short period of time. The area shall be dry between storms. The basin allows particles and pollutants to settle. However, the TSS removal provided is less than 80%. Therefore, dry detention basins must be used in a treatment train in order to provide the 80% TSS removal performance goal.

A schematic example of dry detention basins can be found in **Appendix E**, Post-Construction Stormwater Quality Details.

7.2.2.1 Site and Design Considerations

The following design and site considerations must be followed when designing a detention basin:

- The seasonal high water table and bedrock shall be at least four feet beneath the bottom of the system to minimize the potential for ground water contamination and to assure that the bottom is dry;

- The maximum volume of water stored and subsequently released at the design release rate shall not result in storage duration in excess of 48 hours unless additional storms occur within that period;

- Use a sediment forebay at all inflow points to trap sediments and allow for easy removal;

- The length of the basin shall be at least three times the width, with the basin narrow at the inlet and wide at the outlet;

- Side slopes shall be at least 3:1 for safety and ease of mowing;

- The basin floor shall be flat with a 2% slope toward the outlet;

- The maximum planned depth of stormwater stored shall not exceed four feet; and

- If the basin is used as a sediment control measure during active construction, the sediment must be cleaned out of the basin and elevations and grades reestablished as noted in the approved post-construction stormwater management plan.

7.2.2.2 Performance Standards

Dry detention basins designed, constructed and maintained as noted above shall provide the following pollutant reductions:

Pollutant	Percent Reduction
TSS	60%
Total P	20%
Total N	20%
Metals	40%

7.2.2.3 Advantages

The primary advantage of detention basins is that thy may be used as secondary uses (e.g. Parks) because they are dry between storms.

7.2.2.4 Disadvantages

The disadvantages of detention basins are as follows:

- Poor stormwater treatment effectiveness;
- They have the potential to serve as mosquito breeding ground if they are not maintained properly; and
- They require a relatively high level of maintenance.

7.2.2.5 Maintenance

The developer is responsible for the inspection and maintenance of each detention basin. Each BMP must have an operations and maintenance plan. The BMP owner must maintain and update the BMP operations and maintenance plan, as necessary. The operations and maintenance plan must include, but is not limited to:

- The frequency of the removal of accumulated solids, debris, and litter from the detention area. As a general note, sediment shall be removed when it is dry in which case they will crack and are then able to be separated from the bottom and surrounding vegetation;
- The removal of debris from the control device, especially if it has a small orifice;
- The mowing and removal of excess vegetation; and
- The vegetative stabilization of eroding sides or bottom.

7.2.3 Stormwater Wetlands

Stormwater wetlands are artificial wetlands created for the purposes of stormwater pollutant removal and stormwater quantity control. It is the intent of the City to encourage regional stormwater wetlands and discourage artificial wetlands designed for individual sites. However,

BMP plans proposing stormwater wetlands will be reviewed on a case-by-case basis to determine their feasibility.

A schematic example of stormwater wetlands and variations can be found in **Appendix E**, Post-Construction Stormwater Quality Details.

7.2.3.1 Site and Design Considerations

Prior to the approval of a developments post-construction stormwater management plan, the following design and site considerations must be addressed:

- A water balance must be performed to demonstrate that a stormwater wetland could withstand a thirty-day drought at summer evaporation rates without completely drawing down. Also, inflow of water must be greater than that leaving the basin by infiltration or exfiltration. The following water balance equation shall be used in calculations:

  S = Qi + R + Inf - Qo - ET

  Where:
  S = net change in storage
  Qi = stormwater runoff inflow
  R = contribution from rainfall
  Inf = net infiltration (infiltration - exfiltration)
  Qo = surface outflow
  ET = evapotranspiration

- The wetland must be designed for an extended detention time of 48 hours for the water quality volume (WQv). WQv is addressed in Section 7.1.4. The orifices used for extended detention will be vulnerable to blockage from plant material or other debris that will enter the basin with stormwater runoff. Therefore, some form of protection against blockage (e.g. non-corrodible wire mesh) must be installed;

- The frequently flooded zone surrounding the wetland must be located within the permanent easement;

- The surface area of the wetland must account for a minimum of 1 percent of the area of the watershed draining into it. A minimum of 1.5 percent shall be

required for a shallow marsh design. The length to width ration must be at least 2:1;

- The design must incorporate long flow paths through the wetland, as appropriate;

- A forebay shall be established at the pond inflow points to capture larger sediments and be 4 to 6 feet deep. The depth of the forebay shall contain approximately 10 percent of the total volume of the normal pool. Direct maintenance access to the forebay must be provided with an access with a 25 foot minimum width and a maximum slope of 5:1. Permanent sediment depth markers must be provided;

- If high water velocity is a potential problem, some type of energy dissipation device must be installed;

- Site preparation: Soil types conducive to wetland vegetation shall be used during construction. The wetland must be designed to allow slow percolation of the runoff through the substrate. A layer of clay must be added for porous substrates. Ensure that the substrate, once flooded, is soft enough to permit relatively easy insertion of the plants;

- Surrounding slopes must be stabilized with vegetation to aid in trapping pollutants and preventing them from entering the wetland;

- Maintain the wetland to prevent loss of area of ponded water available for emergent vegetation due to sedimentation and/or accumulation of plant material;

- Obtain local assistance for specifications on plants to be used, planting schedule, soil requirements, mulch requirements, etc;
- Construction debris cannot be disposed of in the facility or used as fill in the embankment;

- If the wetland area or sediment forebay is used as a sediment control measure during active construction, the sediment must be cleaned out of the wetland or forebay and elevations and grades re-established as noted in the approved post-construction stormwater management plan;

- Stormwater wetlands must be designed with the recommended proportion of depths noted in Table 7.2.3-A.

  The four basic depths and descriptions are:
  - *Deepwater*: 1.5 - 6 feet below normal pool elevation. Includes the outlet micropool and deep water channels through the wetland. This zone supports little emergent wetland vegetation but may support floating or submerged vegetation.
  - *Low marsh*: 6-18 inches below normal pool elevation or water surface elevation. This zone is suitable for the growth of several emergent wetland species.
  - *High marsh*: 6 inches or less below normal pool elevation. This zone will support a greater density and diversity of wetland vegetation than the low marsh. The high marsh area shall have a greater surface area to volume ration than the low marsh area.
  - *Semi-wet zone*: Areas above normal pool elevation inundated by larger storm events. This area supports vegetation that can survive periodic flooding.

Table 7.2.3-A Minimum Required Design Configuration for Stormwater Wetlands

Design Criteria	Shallow Wetland	Pond/Wetland	Pocket Wetland
Length to width ratio (min)	2:1	2:1	2:1
Allocation of WQv (pool/marsh) in %	25/75	70/30 (includes pond volume)	25/70
Allocation of surface area (deepwater/low marsh/high marsh/semi-wet) in %	20/35/40/5	45/25/25/5 (includes pond surface area)	10/45/40/5
Forebay	Required	Required	Optional
Micropool	Required	Required	Required
Outlet configuration	Reverse-slope pipe or hooded broad crest weir	Reverse-slope pipe or hooded broad crest weir	Hooded broad crest weir

Modified from Massachusetts DEP, 1997; Schueler, 1992

7.2.3.2 Performance Standards

Artificial wetlands designed, constructed and maintained as noted above shall provide the following pollutant reductions:

Pollutant	Percent Reduction
BOD	55%
TSS	95%
Total P	55%
Total N	45%
Metals	80%

7.2.3.3 Maintenance

The developer is responsible for the inspection and maintenance of each artificial wetland. Each BMP must have an operations and maintenance plan. The BMP owner must maintain and update the BMP operations and maintenance plan, as necessary. The operations and maintenance plan must include, but is not limited to:

- The maintenance of the wetland to prevent loss of area of ponded water available for emergent vegetation due to sedimentation and accumulation of plant material;
- The cleaning of sediment forebays when they are 50% full. Pocket wetlands without forebays must be cleaned after a six-inch accumulation of sediment;
- The maintenance of the ponded water area by raising the elevation of the water level in the permanent pond, by raising the height of the orifice in the outlet structure, or by removing accumulated solids by excavation;
- Water levels may need to be supplemented or drained periodically until vegetation is fully established; and
- It may be desirable to remove contaminated sediment bottoms or to harvest above ground biomass and remove it from the site to permanently remove pollutants from the wetland.

7.2.4 Bioretention

Bioretention areas, or rain gardens, are structural stormwater controls that capture and temporarily store the WQv using soils and vegetation

in landscaped areas to remove pollutants from stormwater runoff. Bioretention areas are engineered facilities in which runoff is conveyed as sheet flow to the "treatment area," consisting of a grass buffer strip, ponding area, organic or mulch layer, planting soil, and vegetation. An optional sand bed can be included in the design to provide aeration and drainage of the planting soil. The filtered runoff is typically collected and returned to the conveyance system, though it can be exfiltrated into the surrounding soil in areas with porous soils though exfiltration may not be permitted in Wellfield Zoning Districts.

Bioretention areas are designed for intermittent flow and to drain and aerate between rainfall events. Sites with continuous flow from groundwater, sump pumps or other areas must be avoided.

A schematic example of a bioretention area can be found in **Appendix E**, Post-Construction Stormwater Quality Details.

Bioretention areas consist of:

- Grass filter strip between the contributing drainage area and the ponding area;
- Ponding areas containing vegetation with a planting soil bed;
- Organic/mulch layer; and
- Gravel and perforated pipe underdrain system to collect runoff that has filtered through the soil layers (bioretention areas can optionally be designed to infiltrate into the soil).

Optional design components include:

- Sand filter layer to spread flow, filter runoff and aid in aeration and drainage of the planting soil;
- Stone diaphragm at the beginning of the grass filter strip to reduce velocities and spread flow into the grass filter; and
- Inflow diversion or an overflow structure.

7.2.4.1 Site and Design Considerations

The following design and site considerations must be followed when designing bioretention areas:

- The drainage area (contributing or effective) must be 5 acres or less, though 0.5 to 2 acres is preferred;

- The minimum size for facility is 200 ft^2, with a length to width ratio of 2:1. Slope of the site may not exceed 6%;

- Soil filter beds must be sized using a Darcy's Law equation with a filter bed drain time of 48 hours and a coefficient of permeability (k) of 0.5 ft/day. The soil bed must be at least 4 feet deep. Planting soils must be sandy loam, loamy sand or loam texture with a clay content rating from 10 to 25 percent. The soil must have an infiltration rate of at least 0.5 inches per hour and a pH between 5.5 and 6.5. In addition, the planting soil shall have a 1.5 to 3 percent organic content and a maximum 500-ppm concentration of soluble salts;

- The maximum ponding depth in bioretention areas is 6 inches;

- Filter strip design for pre-treatment must follow the requirements outlined in Section 7.2.7;

- The mulch layer must consist of 2-4 inches of commercially available fine shredded hardwood mulch or shredded hardwood chips;

- The sand bed must be 12-18 inches thick. Sand must be clean and have less than 15% silt or clay content;

- Pea gravel for the diaphragm and curtain, where used, must be ASTM D 448 size No. 6 (1/8" to 1/4");

- The underdrain collection system must be equipped with a 6-inch perforated PVC pipe in an 8-inch gravel layer. The pipe must have 3/8-inch perforations, spaced on 6-inch centers with a minimum of 4 holes per row. The pipe is spaced at a maximum of 10 feet on center, and a minimum grade of 0.5% must be maintained. A permeable filter fabric is placed between the gravel layer and the planting soil bed;

- The required elevation difference needed from the inflow to the outflow is 5 feet;

- The depth from the bottom of the bioretention facility to the seasonally high water table must be a minimum of 2 feet;

- Runoff captured by facility must be sheet flow to prevent erosion of the organic or mulch layer. Velocities entering the mulch layer must be between 1-2 fps;

- Continuous flow from groundwater, sump pumps or other areas to the bioretention area is prohibited;

- An overflow structure and a non-erosive overflow channel must be provided to safely pass the flow from the bioretention area that exceeds the storage capacity to a stabilized downstream area. The high flow structure within the bioretention area can consist of a yard drain catch basin, with the throat of the catch basin inlet typically 6 inches above the elevation of the shallow ponding area; and

- If the bioretention area is used as a sediment control measure during active construction, the sediment must be cleaned out of the bioretention area and elevations and grades reestablished as noted in the approved stormwater management plan for post-construction runoff control.

7.2.4.2 Performance Standards

Bioretention areas designed, constructed and maintained as noted in this manual shall provide the following pollutant reductions:

Pollutant	Percent Reduction
TSS	80%
Total P	30%
Total N	50%
Metals	60%

7.2.4.3 Advantages

The advantages of bioretention areas are as follows:

- They are applicable to small drainage areas;

- They are often located in landscape islands;
- They have the capability for high pollutant removal; and
- There is greater community acceptance, if designed and maintained correctly.

7.2.4.4 Disadvantages

The disadvantages of bioretention area include:

- They require extensive landscaping; and
- They are not recommended for areas with steep slopes.

7.2.4.5 Maintenance

Landscaping is critical to the performance and function of the bioretention area. A dense and vigorous groundcover must be established over the contributing pervious drainage area before runoff can be diverted into the facility.

The BMP owner is responsible for maintenance and inspections. Each BMP on a site must have an operations and maintenance plan. The BMP owner must maintain and update the BMP operations and maintenance plan. At a minimum, the operations and maintenance plan must include, but is not limited to:

- Inspection, repair and replacement of all treatment components;
- The bioretention area shall be vegetated like a terrestrial forest ecosystem, with a mature tree canopy, subcanopy of understory trees, scrub layer and herbaceous ground cover. Three species of each tree and shrub type shall be planted;
- The tree-to-shrub ration shall be 2:1 to 3:1. On average, trees shall be spaced 8 feet apart. Plants shall be placed at regular intervals to replicate a natural forest. Woody vegetation shall not be planted at inflow locations.
- After the trees and shrubs are established, the ground cover and mulch shall be established; and

- Use native plants, selected based upon hardiness and hydric tolerance.

7.2.5 Sand Filters

Sand filters are structural stormwater controls that temporarily store stormwater and pass it through a filter bed of sand. Most sand filter systems contain two chambers. The first chamber is a sedimentation chamber that removes floatables and heavy sediments. The second chamber is the filtration chamber, which removes additional pollutants by filtering the runoff through a sand bed. The filtered runoff is typically collected and returned to the conveyance system, though it can be partially or fully exfiltrated into the surrounding soil in areas with porous soils.

Sand filters are primarily designed as off-line structures for stormwater quality and typically need to be used in conjunction with another structural BMP to provide water quantity control.

A schematic example of sand filters and variations can be found in **Appendix E**, Post-Construction Stormwater Quality Details.

7.2.5.1 Site and Design Considerations

The following design and site considerations must be followed when designing sand filters:

- The maximum-effective drainage area to an individual stormwater filtering system is less than 10 acres. Sand filters cannot be designed to treat the entire contributing drainage area;

- The design volume must be based on one-inch rainfall and must be designed to fully empty in 36 hours;

- Adequate pretreatment (e.g., filter strips, see Section 7.2.7) is required to prevent sediment from overloading the filters. The inlet structure to the filtration chamber must be designed to spread the flow uniformly across the surface of the filter media. Stone riprap or other dissipation devices must be installed to prevent gouging of the sand media and to promote uniform flow;

- The allowable minimum head is one foot. The maximum allowable head is 6 feet;

- Construct sand bed to a depth of at least 18 inches;

- Underdrain pipes must consist of main collector pipes and perforated lateral branch pipes. Reinforce the underdrain piping to withstand the weight of the overburden. Internal diameters of lateral branch pipes must be 4 inches or greater (6 inches preferred) and perforations shall be 1/8 inch. Space perforations a maximum of 6 inches between rows. All piping must be schedule 40 polyvinyl chloride or greater strength or similarly rated HDPE pipe. The minimum grade of piping shall be 1/8 inch per foot (1% slope). Provide access for cleaning all underdrain piping;

- Surface filters may have a grass cover to aid in pollution adsorption;

- Establish vegetation over the contributing drainage areas before runoff can be accepted into the facility; and

- Two allowable surface sand bed filter configurations are:

  Sand Bed with Gravel Layer
  - Top layer of sand must be a minimum of 18 inches of 0.02 - 0.04 inch diameter sand (smaller sand size is acceptable).
  - A layer of one-half to 2-inch diameter gravel under the sand must be provided for a minimum of 2 inches of cover over the top of the under-drain lateral pipes.
  - No gravel is required under the lateral pipes.
  - A layer of geotextile fabric (permeable filter fabric) must separate the sand and gravel.

  Sand Bed with Trench Design
  - Top layer of sand is to be 12-18 inches of 0.02 - 0.04 inch diameter sand (smaller size is acceptable).
  - Laterals to be placed in trenches with a covering of one-half to 2- inch gravel and geotextile fabric.
  - The lateral pipes are to be underlain by a layer of drainage matting.

- A presettling basin and/or biofiltration swale is recommended to pretreat runoff discharging to the sand filter.
- A maximum spacing of 10 feet between lateral underdrain pipes is recommended.

7.2.5.2 Performance Standards

Sand filters designed, constructed and maintained as noted in this manual shall provide the following pollutant reductions:

Pollutant	Percent Reduction
BOD	60%
TSS	85%
Total P	65%
Total N	50%
Bacteria	40-80%
Metals	60%

7.2.5.3 Variations

There are three primary sand filter system designs, the surface sand filter, the perimeter sand filter, and the underground sand filter.

Surface Sand Filter- The surface sand filter is a ground-level open-air structure that consists of a pretreatment sediment forebay and a filter bed chamber. This system can treat drainage areas up to 10 acres in size and is typically located off-line. Surface sand filters can be designed as an excavation with an earthen embankment or as a concrete structure.

Perimeter Sand Filter- The perimeter sand filter is an enclosed filter system typically constructed just below grade in a vault along the edge of an impervious area such as a parking lot. The system consists of a sedimentation chamber and a sand bed filter. Runoff flows into the structure through a series of inlet grates located along the top of the control.

Underground Sand Filter- The underground sand filter is intended primarily for extremely space-limited and high-density areas.

7.2.5.4 Advantages

The advantages of sand filters include:

- They are applicable to small drainage areas;
- They are good for highly impervious areas; and
- They have good retrofit capability.

7.2.5.5 Disadvantages

The disadvantages of sand filters include:

- They are high maintenance;
- They are not recommended for areas with high sediment content in stormwater;
- They can be relatively costly; and
- There are possible odor problems associated with the use of them.

7.2.5.6 Maintenance

The developer is responsible for the inspection and the maintenance of each sand filter. Each BMP must have an operations and maintenance plan. The BMP owner must maintain and update the BMP operations and maintenance plan, as necessary. The operations and maintenance plan must include, but is not limited to:

- The removal of sediment layer buildup during dry periods with steel rakes or other devices.
- The replacement of some or all of the sand when permeability of the filter media is reduced to unacceptable levels, which shall be specified in the design of the facility. A minimum infiltration rate of 0.5 inches per hour shall be used for all infiltration designs.

7.2.6 Dry Water Quality Swales

Dry water quality swales are channels designed and constructed to capture and treat stormwater runoff within dry cells formed by check dams or other means. Dry water quality swales are also described as biofiltration swales. These swales are designed with a limited slope for slow, shallow flow to allow particulates to settle out and to promote

infiltration. Water quality swales are limited to areas with low impervious acreage, such as residential and industrial developments.

Dry swales are channels designed with a filter bed and underdrain system. They are designed to filter and infiltrate the entire WQv through the bottom of the swale. Runoff is collected by a perforated pipe and discharged at the outlet. Water quality swales are dry most of the time and are therefore well suited for residential areas.

A schematic example of a water quality swale can be found in **Appendix E**, Post-Construction Stormwater Quality Details.

7.2.6.1 Site and Design Considerations

The following design and site considerations must be followed when designing water quality swales:

- Water quality swales treat only the WQv. An additional measure is needed to provide detention in conjunction with the water quality swale. The swales can be designed as on-line or off-line structures. Larger storms pass non-erosively through the channels;

- Water quality swales are limited to peak discharges generally less than 5 to 10 cfs and runoff velocities less than 2.5 ft/sec. The maximum drainage area is 5 acres. The maximum ponding time must be less than 48 hours, and a minimum ponding time of 30 minutes is recommended;

- The maximum design flow depth is 1 foot, with a ponding depth of 18 inches at the end of the channel;

- Swale cross-section must have side slopes of 3:1 (h:v) or flatter. Bottom widths must be between 2-8 feet wide;

- Underlying soils shall have a high permeability (fc > 0.5 inches per hour). Seasonally high water table must be greater than 3 feet below the bottom of the swale;

- Water quality swales must have a minimum length of 100 feet; and

- Provide a sediment forebay at the inlet to the swales.

7.2.6.2 Performance Standards

Water quality swales designed, constructed and maintained (on a 4% or flatter slope) as noted in this manual shall provide the following pollutant reductions:

Pollutant	Percent Reduction
BOD	10%
TSS	80%
Total P	83%
Total N	92%
Metals	75%

7.2.6.3 Advantages

The advantages of water quality swales include:

- They are typically well accepted in residential settings;
- They are inexpensive;
- They combine water quality treatment with runoff conveyance;
- They reduce runoff velocities; and
- They are low maintenance.

7.2.6.4 Disadvantages

The disadvantages of water quality swales include:

- They cannot be used on steep slopes; and
- They only provide a limited amount of stormwater quantity control.

7.2.6.5 Maintenance

The developer is responsible for the inspection and maintenance of each water quality swale. Each BMP must have an operations and maintenance plan. The BMP owner must maintain and update the BMP operations and maintenance plan, as necessary. The operations and maintenance plan must include, but is not limited to:

- Adequate access for inspection and maintenance.

- The maintenance of dry swales to keep grass cover dense and vigorous.

- At a minimum, maintenance shall include periodic mowing, occasional spot reseeding, and weed control. Swale grasses must never be mowed close to the ground. Grass heights in the 4 to 6 inch range are recommended.

- The fertilization of grass swale shall be done when needed to maintain the health of the grass, with care not to over-apply the fertilizer.

- The removal of sediment accumulated in forebay when it is 50% full.

7.2.7 Biofilters

Biofilters are densely vegetated sections of land, designed to treat run-off from and remove pollutants through vegetative filtering and infiltration. Biofilters must receive runoff from adjacent areas as sheet flow. The vegetation slows the runoff and filters out sediment and other pollutants. However, the TSS removal provided is less than 80 percent. Therefore, biofilters must be used in a treatment train in conjunction with other management practices to provide the 80 percent performance goal.

Biofilters are best suited to treating runoff from roadways, rooftops, small parking areas and pervious areas. They can be easily incorporated into residential development as land-use buffers and setbacks.

A schematic example of biofilters can be found in **Appendix E**, Post-Construction Stormwater Quality Details.

7.2.7.1 Site and Design Considerations

The following site and drainage considerations must be followed when designing biofilters:

- To ensure sheet flow into the filter strips and riparian buffers, flow spreaders or level spreaders must be designed and installed where concentrated runoff flows into filter strips or riparian buffers;

- Level Spreader: The grade of a level spreader shall be 0%. The channel grade for the last 20 feet of the dike or diversion entering the level spreader must be less than or equal to 1% and designed to provide a smooth transition into spreader. The depth of a level spreader as measured from the lip must be at least 6 inches. The level spreader lip must be constructed on undisturbed soil (not fill material) to uniform height and zero grade over length of the spreader. The maximum drainage area to the level spreader shall be 10 acres or less with the optimal size being less than 5 acres. The maximum flow into the level spreader must be 30 cfs or less;

- Appropriate length, width, and depth of level spreaders shall be selected from the following table;

Design Flow (cfs)	Entrance Width (ft)	Depth (ft)	End Width (ft)	Length (ft)
0-10	10	0.5	3	10
10-20	16	0.6	3	20
20-30	24	0.7	3	30

- Capacity of the spreader, filter strip and riparian buffer length (perpendicular to flow) must be determined by estimating the volume of flow that is diverted to the spreader for water quality control;

- The released runoff to the outlet must be on undisturbed stabilized areas in sheet flow and not allowed to re-concentrate below the structure;

- Slope of the filter strip from a level spreader must not exceed 10 percent;

- All disturbed areas must be vegetated immediately after construction;

- The minimum filter strip width is 20 feet;

- Filter strips must be designed for slopes between 2 percent and 6 percent;

- Ensure that flows in excess of design flow move across and around the filter strip without damaging it;

- Filter strips can be used effectively as pretreatment measures. The minimum sizing criteria are as follows:

Parameters	Impervious Area				Pervious Area			
Maximum inflow Approach length (ft)	35		75		75		100	
Filter strip slope (max = 6%)	<2%	>2%	<2%	>2%	<2%	>2%	<2%	>2%
Filter strip minimum length	10	15	20	25	10	12	15	18

- Riparian buffers: The use of buffers is limited to drainage areas of 10 acres or less with the optimal size being less than 5 acres;

- Slope of the buffer from a level spreader cannot exceed 10 percent; and

- The top edge of buffer must directly abut the contributing impervious area and follow the same elevation contour line.

7.2.7.2 Performance Standards

Biofilters designed, constructed and maintained as noted in this manual shall provide the following pollutant reductions:

Pollutant	Percent Reduction (riparian buffer/filter strip)
BOD	40/10%
TSS	60/30%
Total P	35/10%
Total N	25/10%
Metals	70/30%

7.2.7.3 Variations

Filter strip: A filter strip is a uniformly graded and densely vegetated strip of land. The vegetation can be grasses or a combination of grass and woody plants. Pollutant removal

efficiencies are based upon a 50-foot wide strip. Uniform sheet flow must be maintained through the filter strip to provide pollutant reduction and to avoid erosion.

Riparian buffer: A riparian buffer is a strip of land with natural, woody vegetation along a stream or other watercourse. Besides the undergrowth of grasses and herbaceous vegetation, the riparian buffer includes deep rooted trees. The 20-foot zone closest to the stream or watercourse contains the trees, while the outer 30 feet of the riparian buffer contains a dense stand of grasses. The overall width of the riparian buffer is 50 feet. Uniform sheet flow must be maintained through the filter strip to provide pollutant reduction and to avoid erosion.

7.2.7.4 Advantages

The advantages of biofilters include:

- Filter strips and riparian buffers can easily be incorporated into new development design;
- They are low maintenance once a dense ground cover is established in filter strips and level spreaders and once trees and other woody vegetation is established in riparian buffers; and
- Riparian buffers provide wildlife habitat.

7.2.7.5 Disadvantages

The disadvantages of biofilters include:

- Filter strips, riparian buffers and level spreaders have limited drainage areas; and
- Constructing a level lip on a level spreader can be difficult. Failure to construct a level lip makes the level spreader ineffective.

7.2.7.6 Maintenance

The developer is responsible for the inspection and maintenance of all biofilters. Each BMP must have an operations and maintenance plan. The BMP owner must maintain and update the BMP operations and maintenance

plan, as necessary. The operations and maintenance plan must include, but is not limited to:

- The mowing of the biofilter as necessary, or the utilization of an appropriate management technique for existing species.

- The removal of sediment accumulation and debris in order to sustain sediment removal efficiency.

7.2.8 Catch Basin Inserts

Many variations of catch basin insert designs exist. Catch basin inserts can be designed and installed in a storm drain system provided the following minimum criteria for the inserts are met:

- Provide an overflow weir to pass storm events larger than the design storm.

- Catch basin inserts must meet the 80% TSS removal rate.

- Each design for catch basins can have specific maintenance needs or issues. Maintenance requirements must be clearly defined, and a specific maintenance agreement submitted to the City for review and approval.

Supporting documentation from the manufacturer to verify maintenance requirements and TSS removal rates must be submitted to the City for verification and approval. A maintenance plan must be submitted to the City prior to stormwater management plan approval and maintained and updated by the BMP owner. The BMP owner is responsible for routine maintenance, operation and inspection.

7.2.9 Other Pre-Approved BMPs

Other pre-approved BMPs include, but are not limited to, porous pavement systems, gravity oil grit separators, equipment maintenance and washing areas, infiltration trenches, hydrodynamic separators, hazardous material storage, subsurface detention, and parking lot islands.

The applicant should consult *The Indiana Stormwater Quality Manual* (formerly *The Indiana Handbook for Erosion Control in Developing Areas*) for detailed design, construction and maintenance criteria for these post-construction stormwater management practices.

AGREEMENT FOR THE CONSTRUCTION, MAINTENANCE, AND REPAIR OF A STORMWATER MANAGEMENT FACILITY

WHEREAS, the undersigned is/are the owner(s) (hereinafter "Owners") of certain real estate located in Wayne County, Indiana, and legally described herein as Exhibit "A;" and

WHEREAS, the Owners are desirous of constructing a stormwater management facility over a portion of said real estate described at Exhibit "A;" and

WHEREAS, in order to construct such stormwater detention the Owners must obtain review and permits from the City of Richmond (hereinafter "City").

NOW THEREFORE, for good and valuable consideration, receipt of which is herein acknowledged, the Owner covenants with the City as follows:

1. Owner agrees to obtain prior approval from the City for design and construction of the stormwater management facility. Plans and specifications, which Owner shall strictly adhere to, will be on file with the Development Services Department of the City of Richmond, Indiana. Failure to obtain said approval will render this Agreement void and any stormwater management facility on this property illegal.

2. Owner agrees to construct and be responsible for the perpetual, maintenance, repair, and replacement, if necessary, of the stormwater management facility that will serve the real estate identified in Exhibit "A." Owner agrees to maintain said facility in a condition acceptable to the City.

    a. Maintenance shall include, but not be limited to cosmetic maintenance (including structural) to the stormwater management facility during and after construction, mowing, weed control, trash pick-up, algae, mosquito control, and general maintenance.

    b. All maintenance will be done so as to assure that all stormwater runoff designed to be detained within the stormwater management facility will be so detained, and the designed rate of runoff will not be increased after the improvements have been constructed as contemplated upon the said real estate.

    c. Owner expressly grants the right of entry over, across, and through the real estate described herein at Exhibit "A" to the City for the purpose of inspecting, evaluating, or repairing the stormwater management facility.

    d. City will notify the Owner in writing of maintenance or repairs required. Said notice may be delivered by U.S. mail to the last provided address of the Owner. If the Owner fails to address the problems outlined satisfactorily within thirty (30) days of said notice, City shall have the right to enter over and upon all necessary portions of the real estate as described in Exhibit "A" for the purpose of repairing and maintaining said stormwater management facility.

    e. In the event that an emergency situation exists, as defined by the Board of Public Works of the City of Richmond, and the City is unable to locate the Owner or its agent after reasonable attempts have been made to do so, the City shall have the right to enter upon the real estate and make such emergency repairs as it deems necessary.

    f. At any time the City is required to enter upon the real estate of the Owner and make such repairs, the costs of same shall be the obligation of the Owner. If the

Owner does not pay said costs within thirty (30) days after receiving written notice of the same from the City, the City shall have the right to place a lien against and upon the real estate (described in Exhibit "A") for costs incurred by it for the repair and maintenance of the stormwater management facility, including interest at the rate of eight (8%) percent per annum, and reasonable attorney's fees.

3. The Owner agrees to indemnify and hold harmless the City from all claims arising out of the installation, maintenance, or use of the stormwater management facility.

4. The most recent deed of record for the real estate has been recorded in the Office of the Recorder of Wayne County, Indiana, as document number_____.

5. This Agreement may only be amended by prior written consent signed by the Owner and the City.

6. The rights and obligations created by this Agreement shall be binding upon and shall run with the real estate for the benefit of the heirs, personal representative, successors and assigns of the Owner.

7. The laws of the State of Indiana shall govern this Agreement.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement the day and year first above written.

Date:_____ Owner:_____

Printed Name:_____

Owner:_____

Printed Name:_____

STATE OF INDIANA)
SS:)
COUNTY OF WAYNE)

BEFORE ME, a Notary Public, in and for said County and State, this ____ day of _____, 200 personally appeared the within named _____ and _____ who being first duly sworn upon their oath state that they are Owners of the subject real estate at Exhibit A and as such duly authorized to execute the foregoing instrument and acknowledged the same as their voluntary act and deed for the uses and purposes therein set forth.

IN WITNESS WHEREOF, hereunto subscribed my name, affixed my official seal.

_____
Notary Public

_____
Printed Name of Notary

My Commission Expires:

Resident of _____County

For the CITY OF RICHMOND – Stormwater Engineering

BY:_____ Printed Name _____

STATE OF INDIANA)
SS:)
COUNTY OF WAYNE)

BEFORE ME, a Notary Public, in and for said County and State, this _____day of _____, personally appeared the within named**,** _____**,** by me personally known, who being by me duly sworn has authority so to do and acknowledges said instrument to be the voluntary act and deed of said **City** for the uses and purposes therein set forth.

IN WITNESS WHEREOF, hereunto subscribed my name, affixed my official seal.

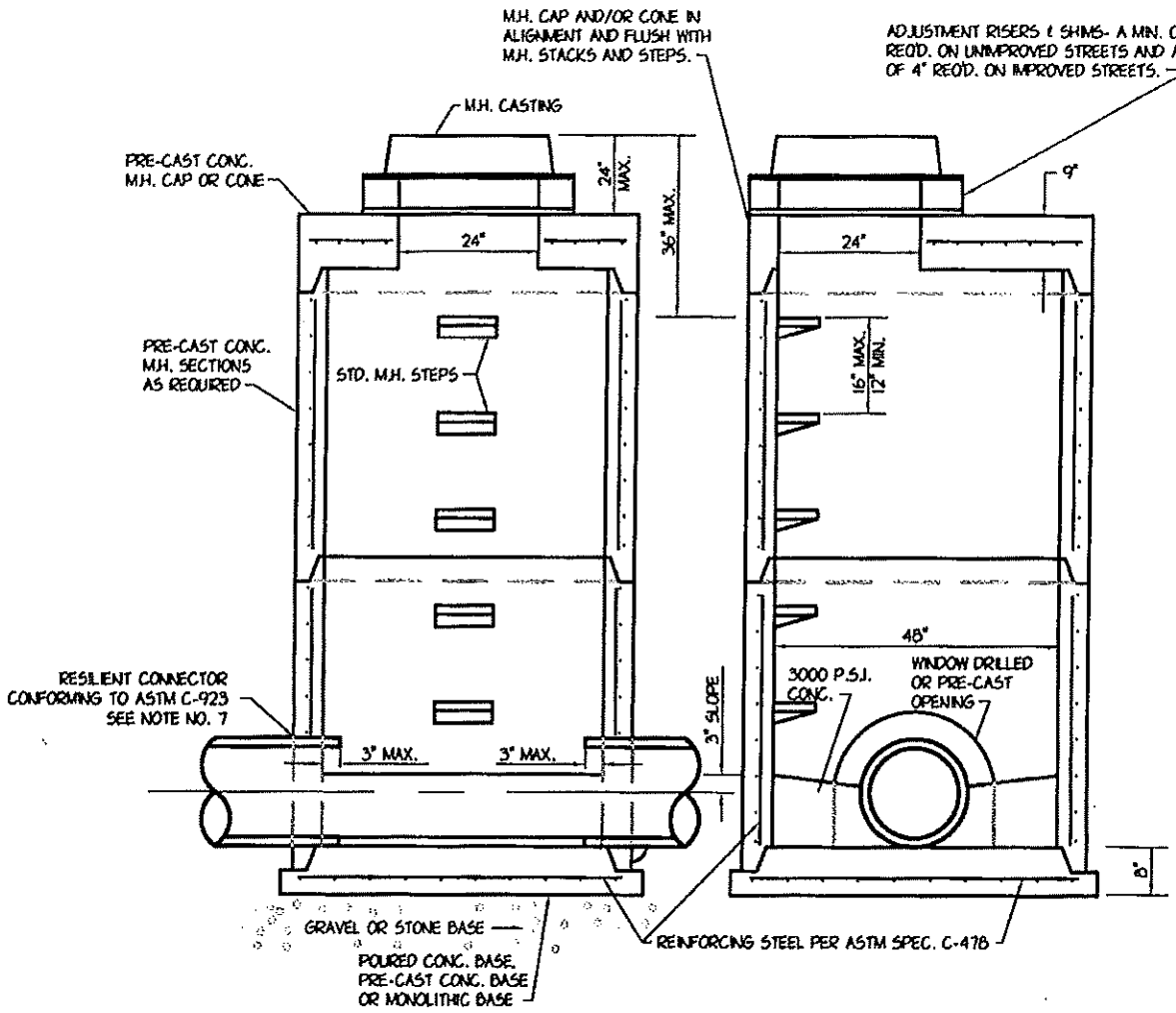
_____
Notary Public

_____
Printed Name of Notary

My Commission Expires:
Resident of _____County

APPENDIX C

STORMWATER CONVEYANCE DETAILS



GENERAL CONSTRUCTION REQUIREMENTS

1) MANHOLE MADE IN ACCORDANCE WITH ASTM C-478.

2) ALL PIPES SHALL HAVE A SMOOTH FINISH.

3) MANHOLE JOINTS SHIP-LAP WITH GASKET IN ACCORDANCE WITH ASTM C-443.

4) THE BASE SHALL BE PLACED ON 4" MINIMUM COMPACTED GRAVEL OR STONE.

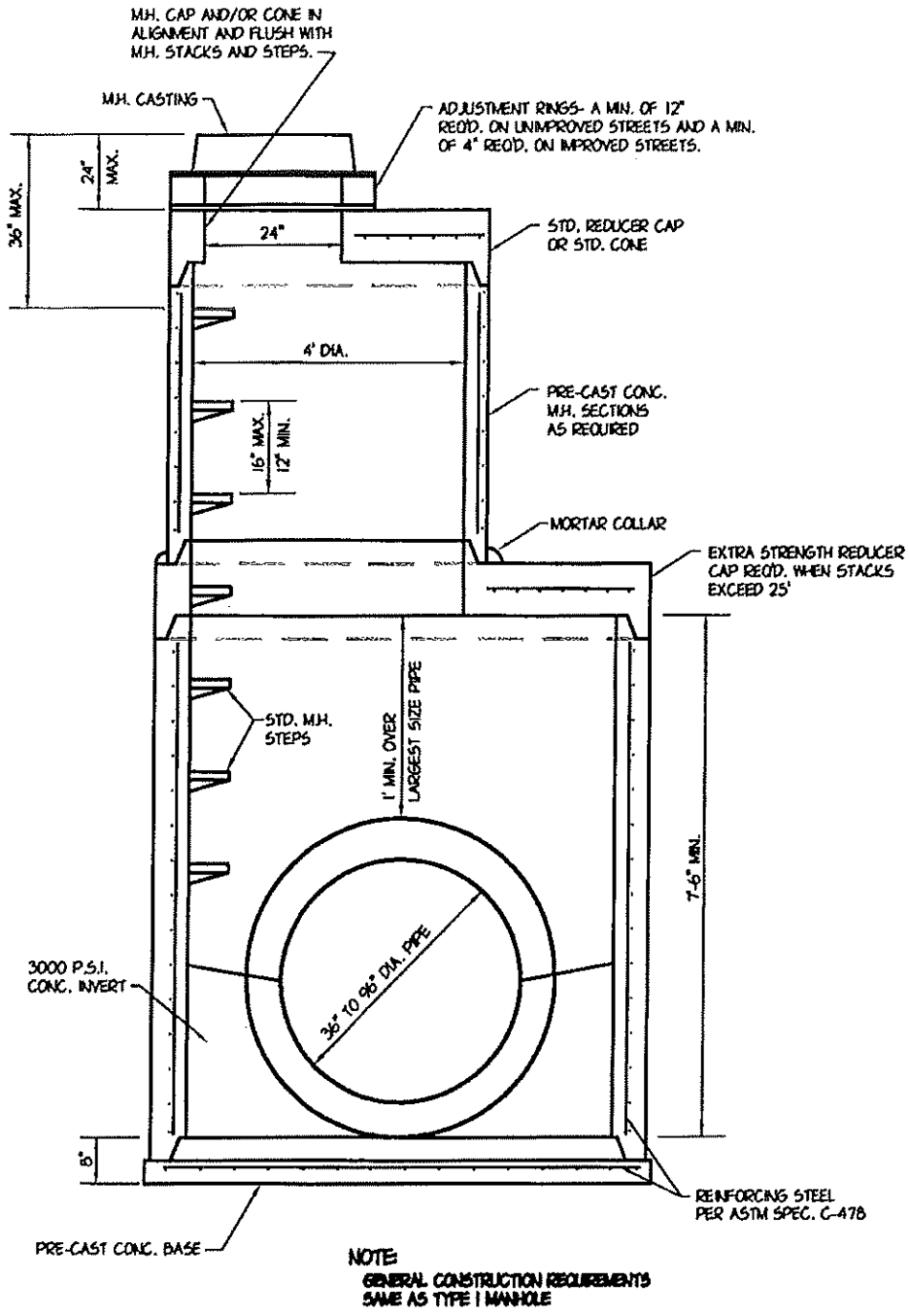
5) BASE DIAMETER 48"

6) PIPE DIAMETER 6" TO 33" STRAIGHT THRU TO 45; 6" TO 24" 135° TO 90°

7) CONTRACTOR MAY SELECT A BOOT TYPE (AS MANUFACTURED BY PRESS SEAL GASKET OR APPROVED EQUAL) OR A COMPRESSION TYPE CONNECTOR (AS MANUFACTURED BY A-LOK PRODUCTS INC. OR EQUAL)

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

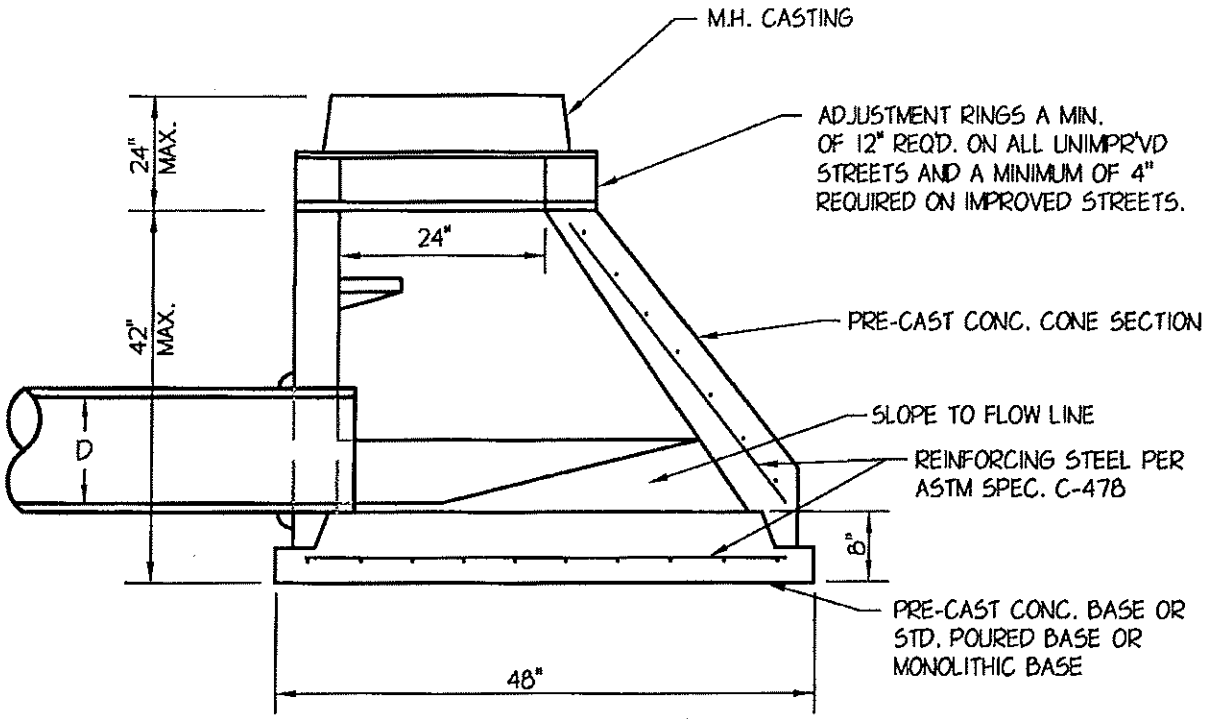
STRUCTURE DETAILS		
TYPE I MANHOLE		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. S - 1



NOTE:
GENERAL CONSTRUCTION REQUIREMENTS SAME AS TYPE I MANHOLE

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

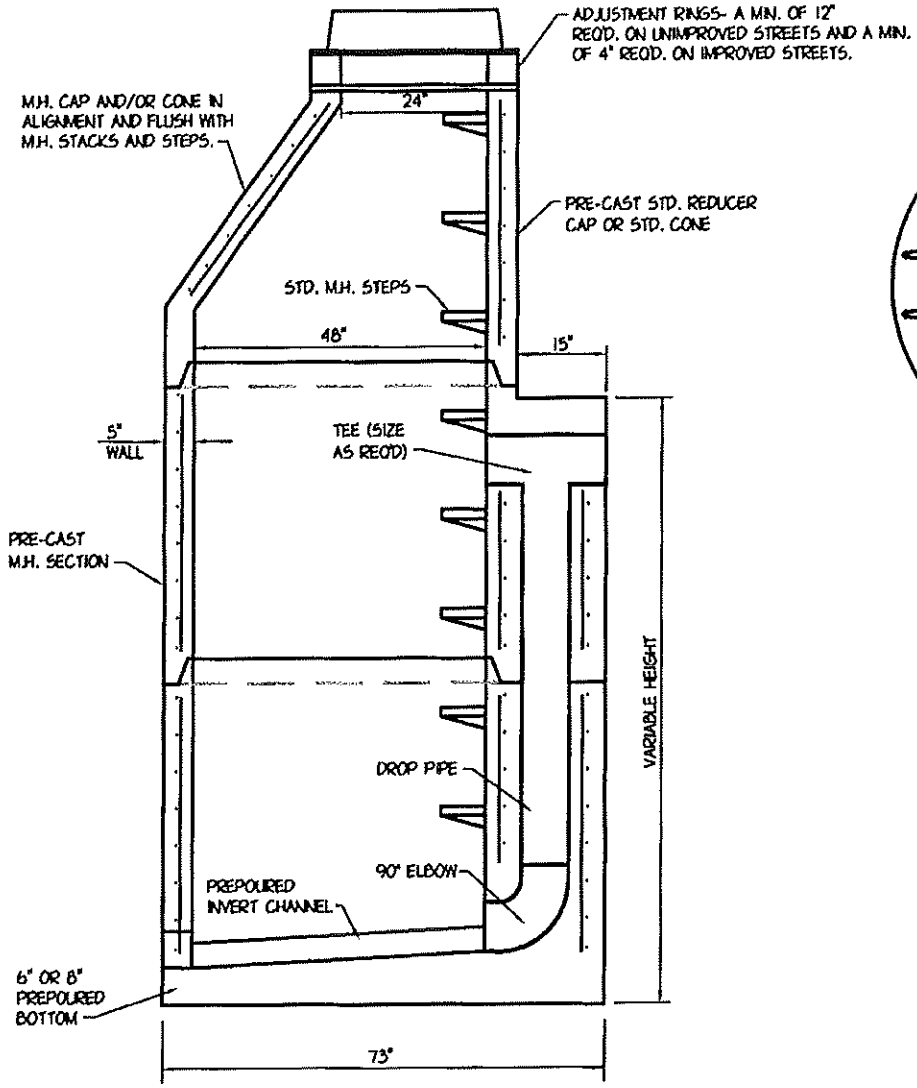
STRUCTURE DETAILS		
TYPE II MANHOLE		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. S - 2

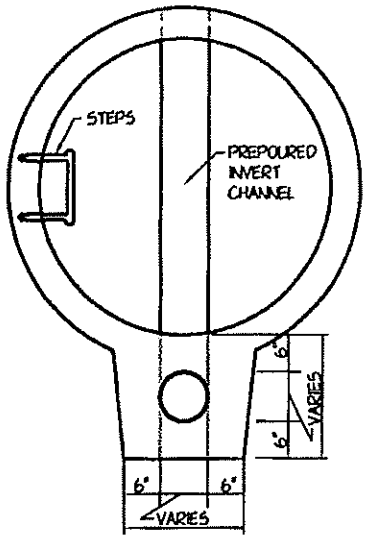


NOTE:
GENERAL CONSTRUCTION REQUIREMENTS SAME AS TYPE I MANHOLE

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

STRUCTURE DETAILS		
TYPE IV MANHOLE		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. S - 3

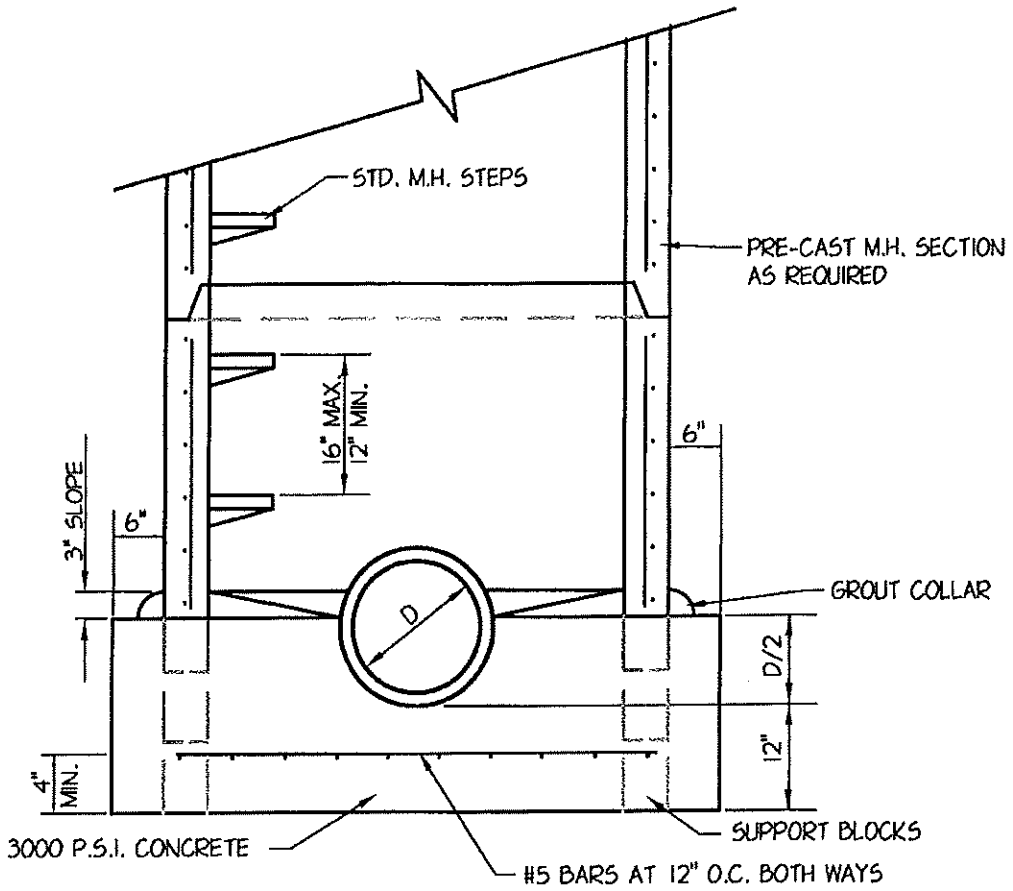




NOTE:
GENERAL CONSTRUCTION REQUIREMENTS SAME AS TYPE I MANHOLE

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

STRUCTURE DETAILS	
TYPE VI MANHOLE (DROP MANHOLE)	
SCALE: NONE	DATE: JAN. 2005
	DWG. NO. S - 4

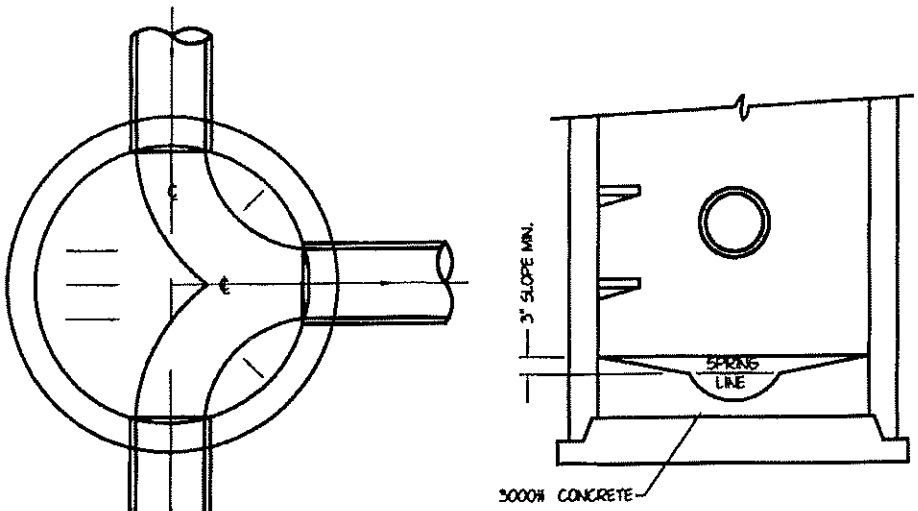


NOTE:

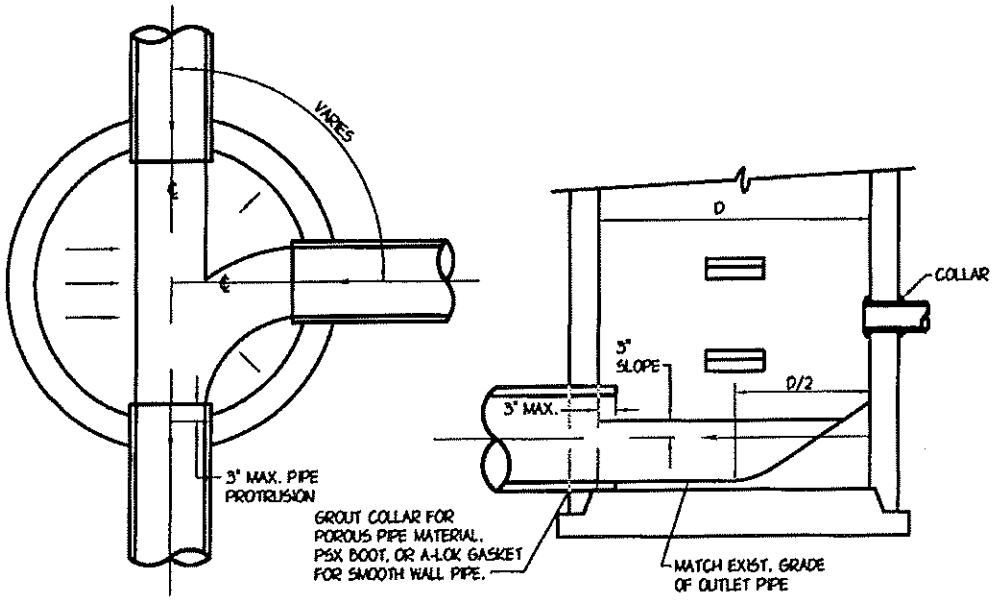
GENERAL CONSTRUCTION REQUIREMENTS SAME AS TYPE I MANHOLE.

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

STRUCTURE DETAILS		
INVERT FOR CAST IN PLACE PIPE & BASE		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. 5 - 5



DROP, END, OR STEP-UP MANHOLE



NOTE:

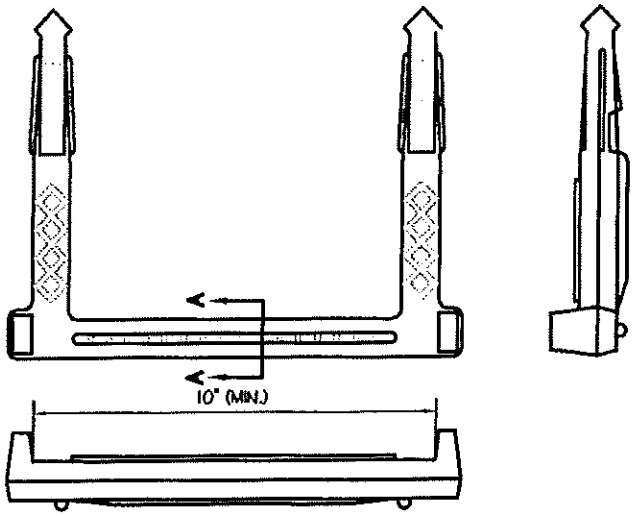
1.) ℄ OF ALL PIPE TO INTERSECT ℄ OF M.H.

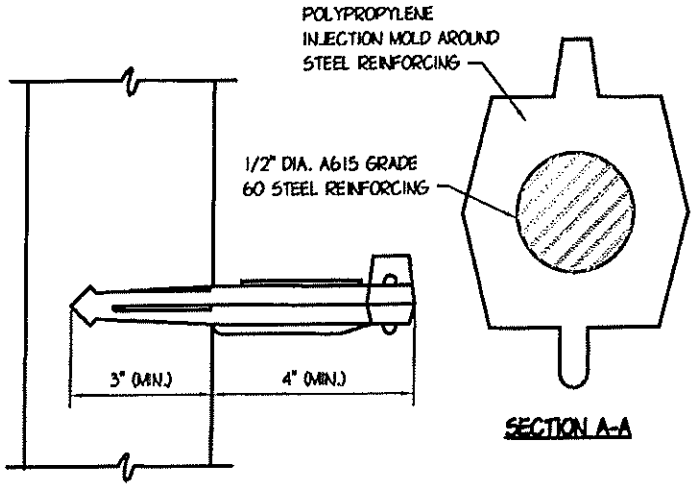
2.) ALL INCOMING PIPE SHALL HAVE A SMOOTH FINISH.

3.) INVERTS TO BE CAST UNDER DRY PIPE CONDITIONS.

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

STRUCTURE DETAILS		
INVERT SHAPES		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. S - 6





SECTION A-A

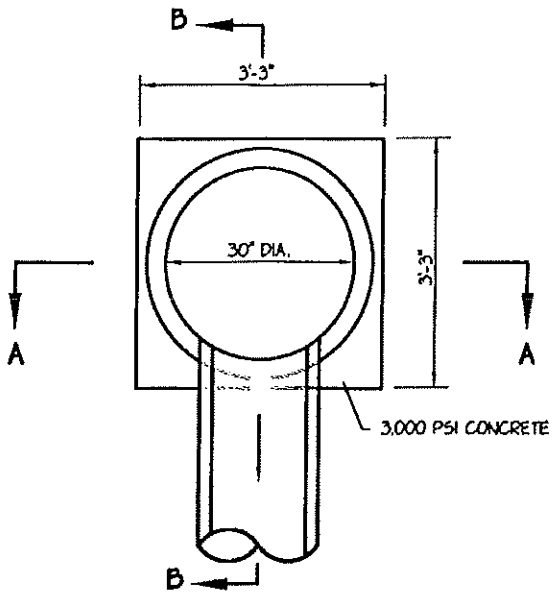
NOTES:

1) STEPS SHALL BE PLACED INTO WET CONCRETE WALL DURING MANUFACTURE OR MORTARED INTO HOLES AFTER CONCRETE HAS SET.

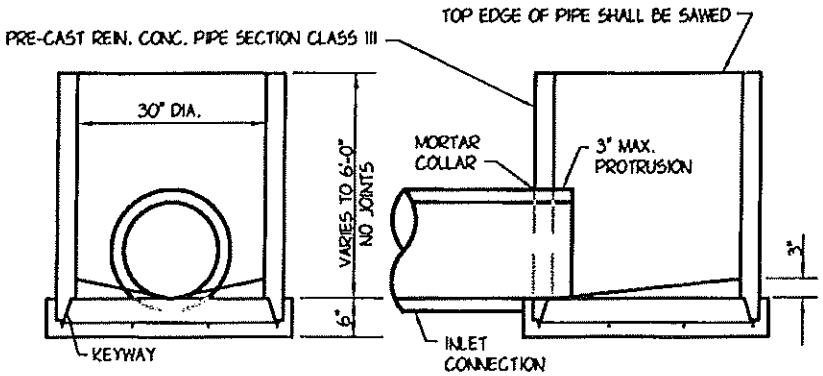
2) DESIGN OF STEP SHALL MEET REQUIREMENTS OF ASTM C-478, LATEST EDITION.

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

STRUCTURE DETAILS		
REINFORCED PLASTIC MANHOLE STEP		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. S - 7



PLAN VIEW



SECTION A-A SECTION B-B

NOTES:

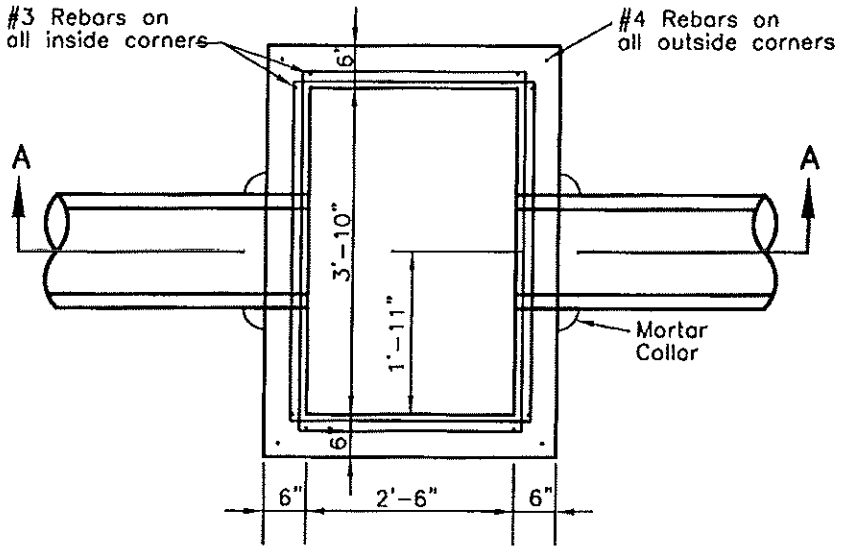
1) 30" DIA. UP TO 15" PIPE

2) 33" FOR 18" PIPE

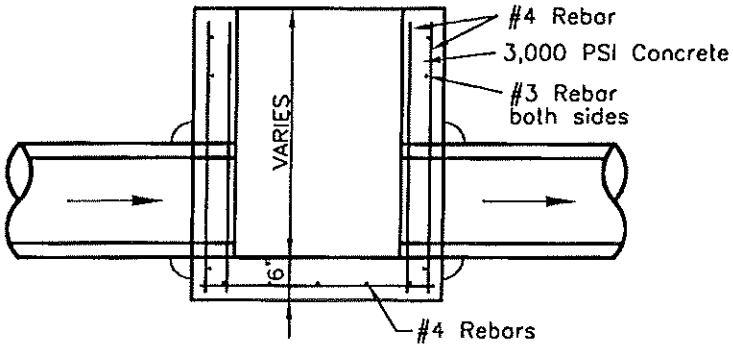
3) POURED CONC. BASE WITH #5 BARS BOTH WAYS 12" C TO C.

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

STRUCTURE DETAILS		
TYPE I INLET		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. S - 8



PLAN VIEW



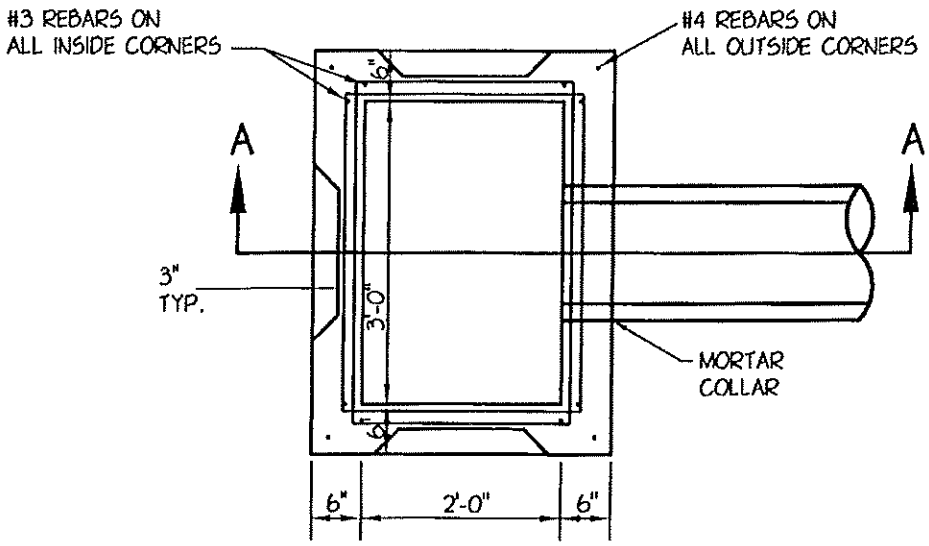
SECTION A-A

NOTES:

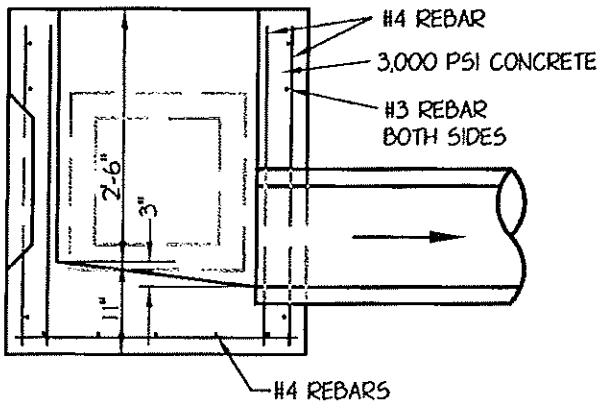
1) All pipe shall have smooth finish.
2) Reinforcing Steel Per ASTM C478.

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

STRUCTURE DETAILS		
TYPE II INLET		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. 5 - 9



PLAN VIEW



SECTION A-A

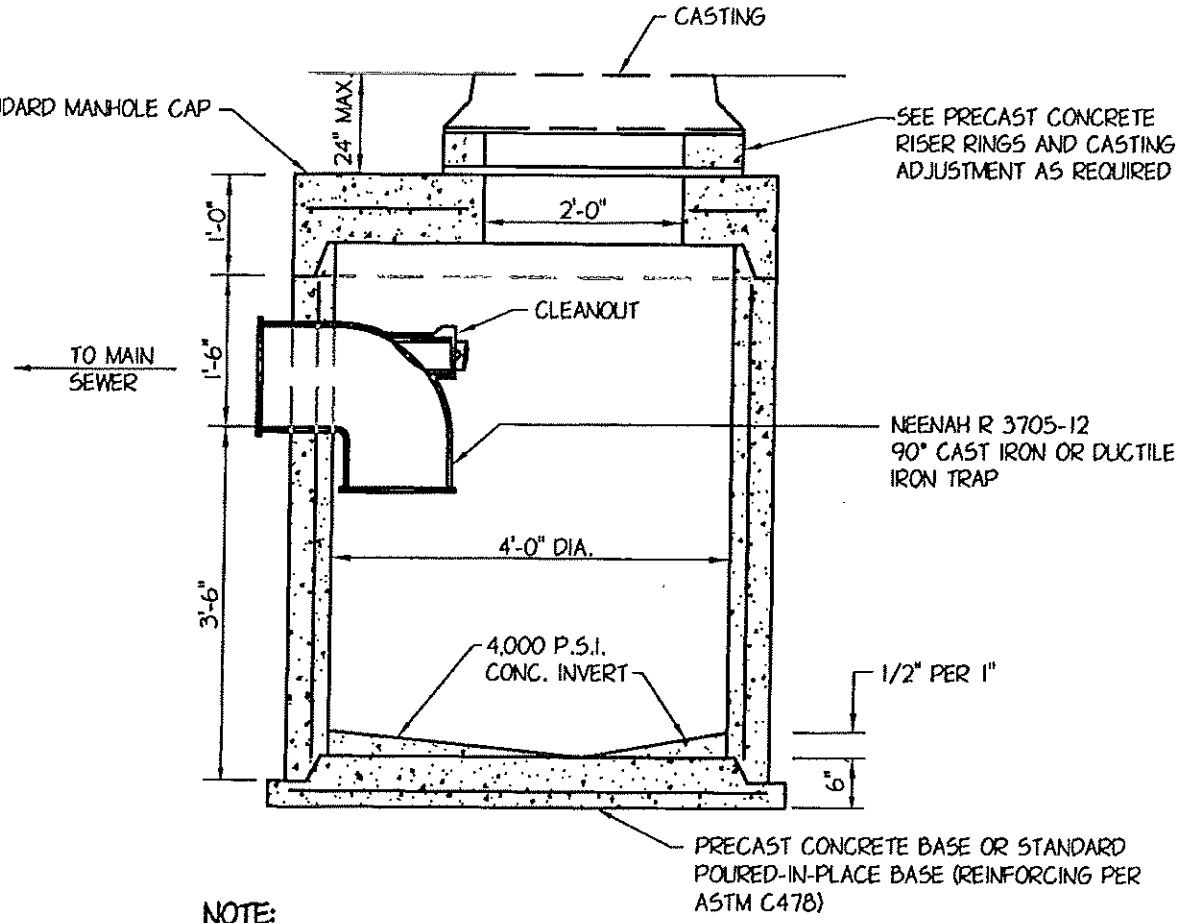
NOTES:

1) ALL PIPE SHALL HAVE SMOOTH FINISH.

2) REINFORCING STEEL PER ASTM C478.

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

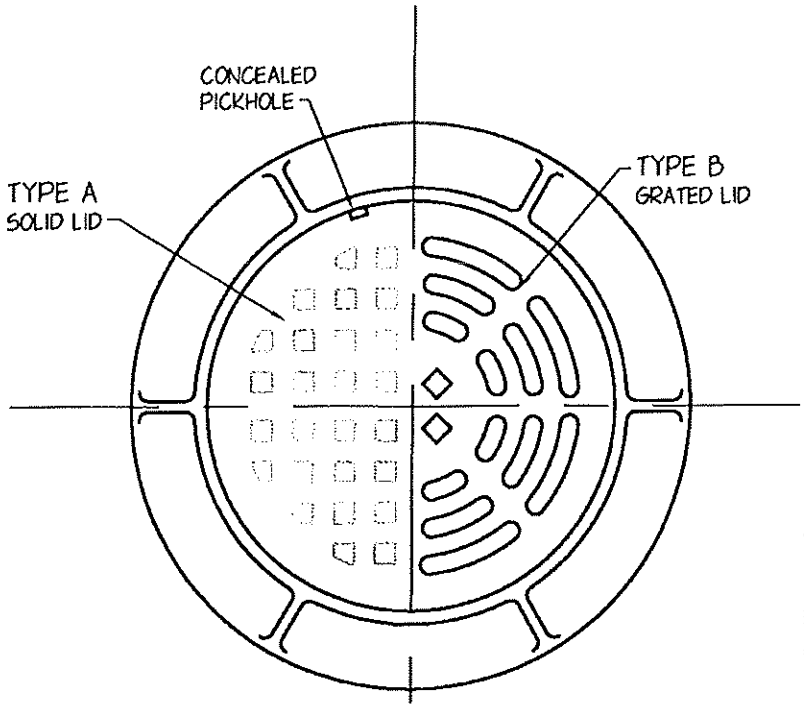
STRUCTURE DETAILS		
TYPE III INLET		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. S - 10



NOTE:
GENERAL CONSTRUCTION REQUIREMENTS SAME AS TYPE I MANHOLE
STRUCTURE BASE ALTERNATIVES SAME AS TYPE I MANHOLE

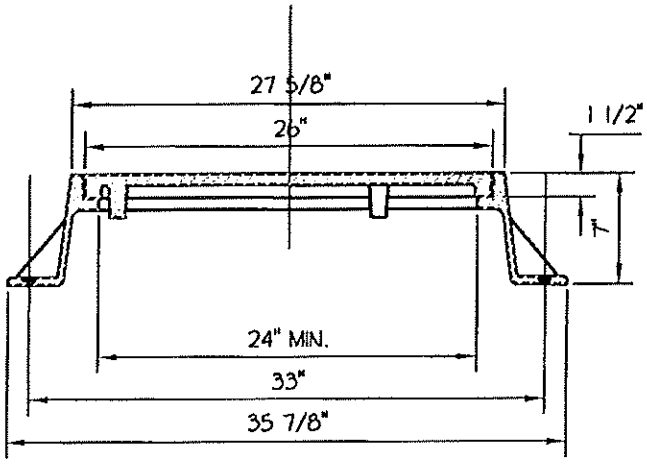
RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

STRUCTURE DETAILS		
STANDARD CATCH BASIN		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. S - 11



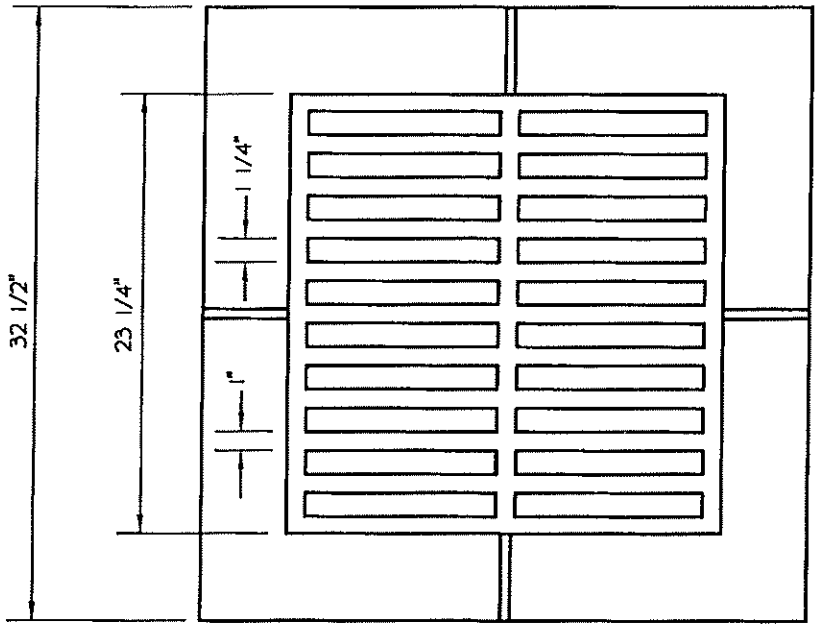
TYPE A CASTING
NEENAH R-1642 OR
EAST JORDAN 1045
LID SHALL BE HEAVY
DUTY WITH SELF SEALING GASKETS

TYPE B CASTING
NEENAH R-2371 OR
EAST JORDAN 1045
WITH MI GRATE

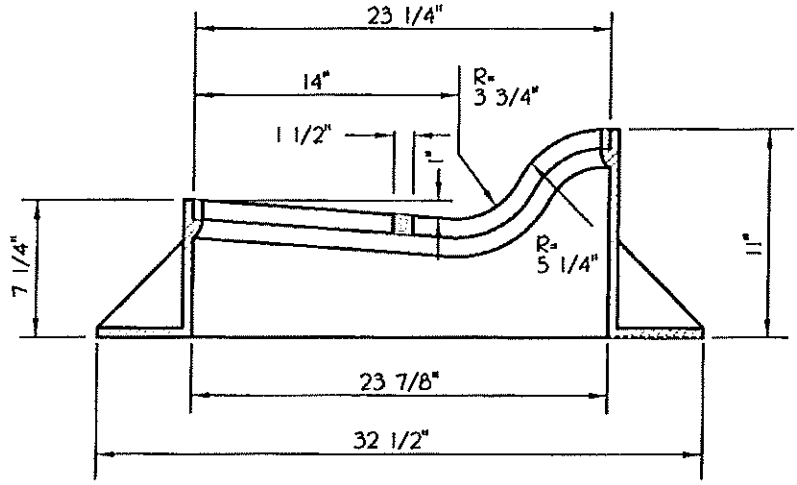


RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

CASTING DETAILS		
TYPE A OR B CASTING DETAIL		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. C - 1



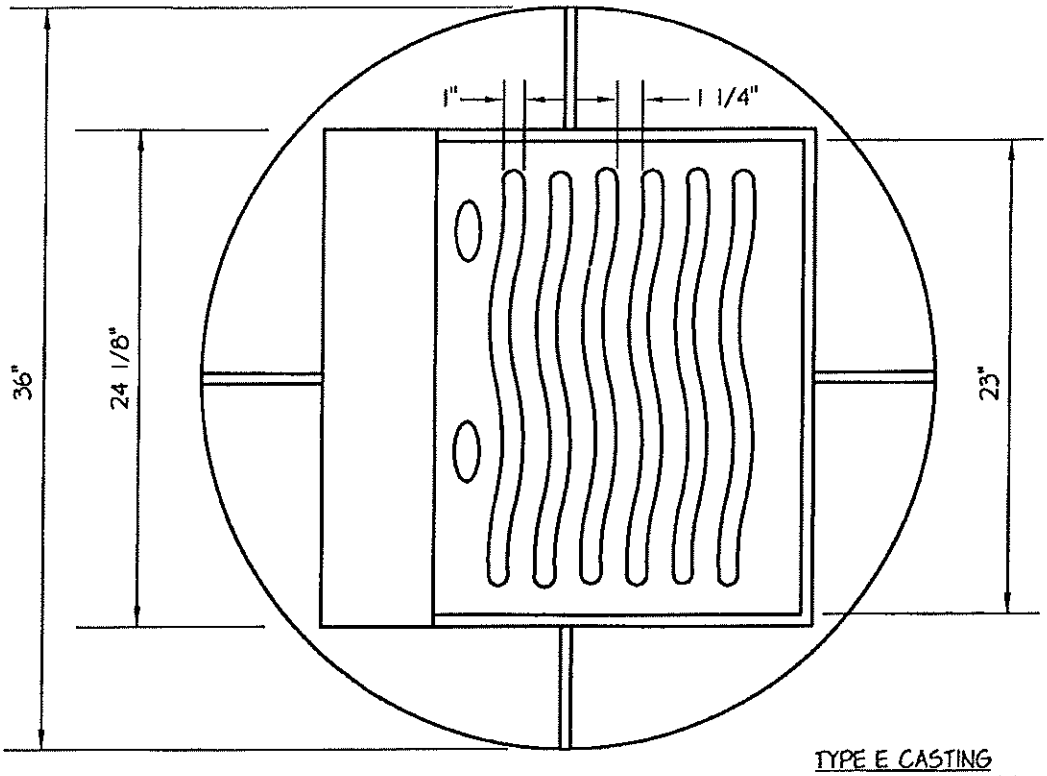
TYPE D CASTING
SHALL BE NEENAH
R-3501-N OR EAST
JORDAN 7490



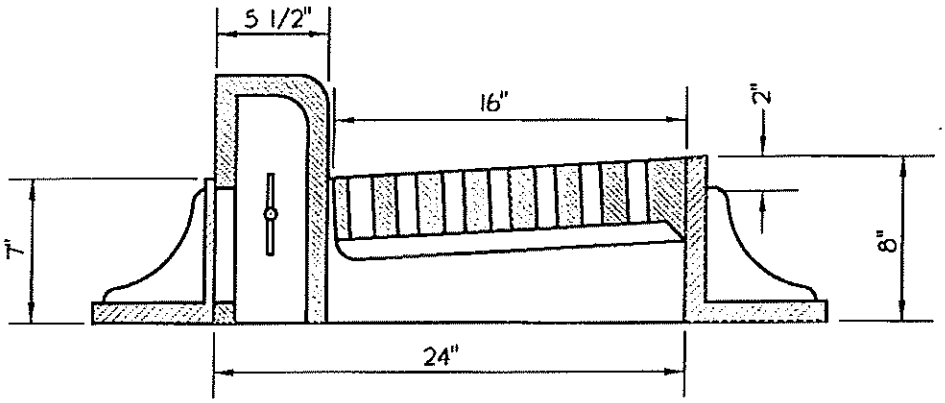
RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

CASTING DETAILS		
STANDARD CASTING DETAIL - ROLLED CURB TYPE D		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. C - 2

Delta

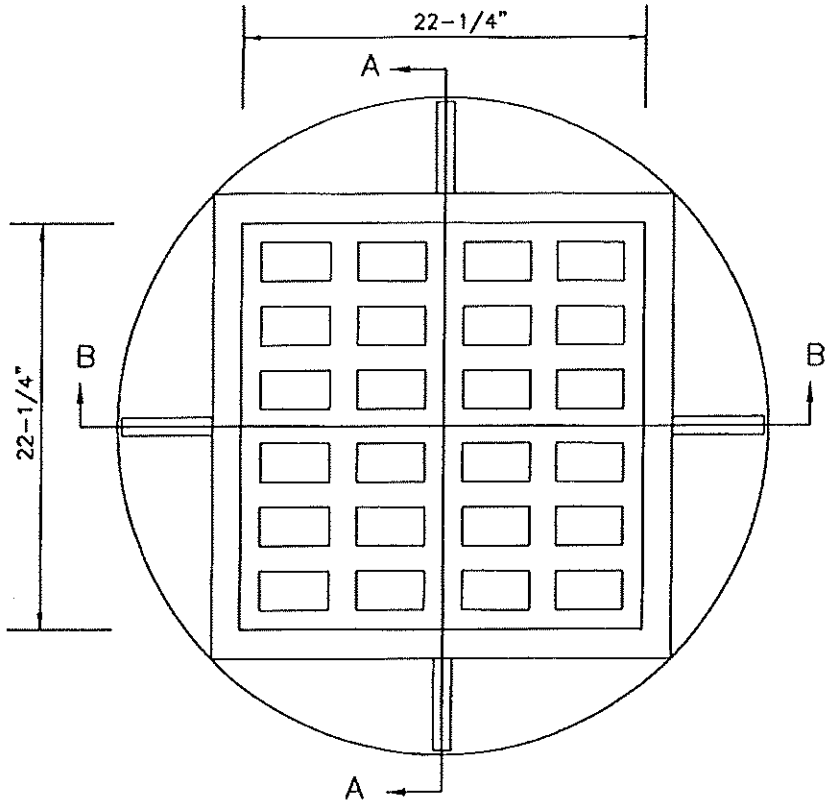


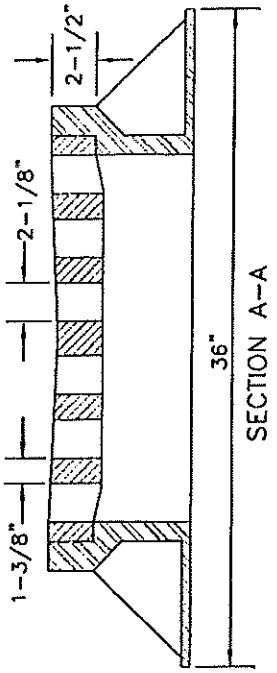
TYPE E CASTING
NEENAH R-3010 OR
EAST JORDAN 7010

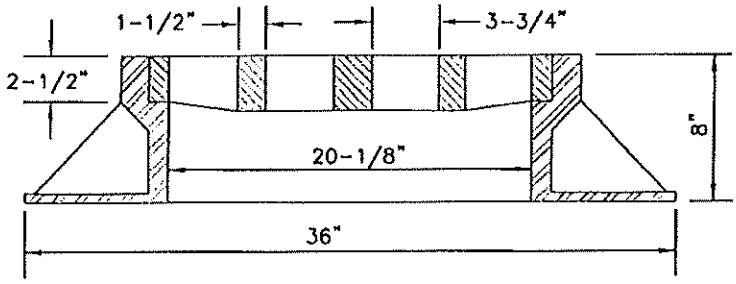


RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

CASTING DETAILS		
CURB CASTING DETAIL TYPE E		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. C - 3





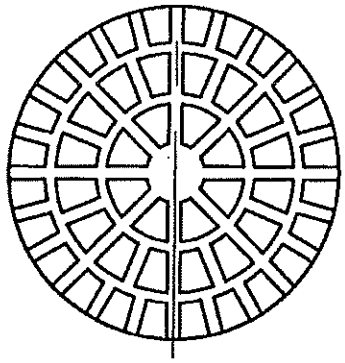


SECTION B-B

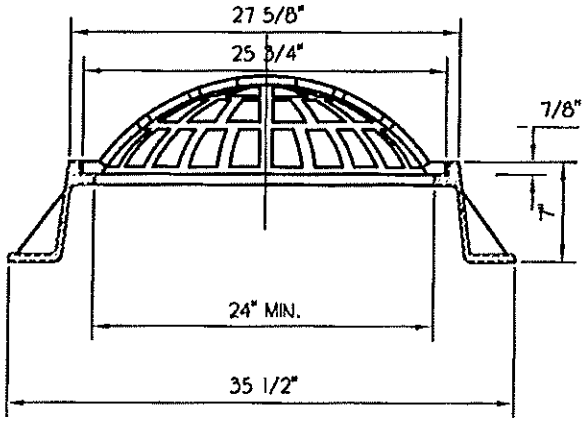
TYPE F CASTING
NEENAH R-3347 OR
EAST JORDAN 5100

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

CASTING DETAILS		
INVERTED CROWN CASTING DETAIL TYPE F		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. C - 4

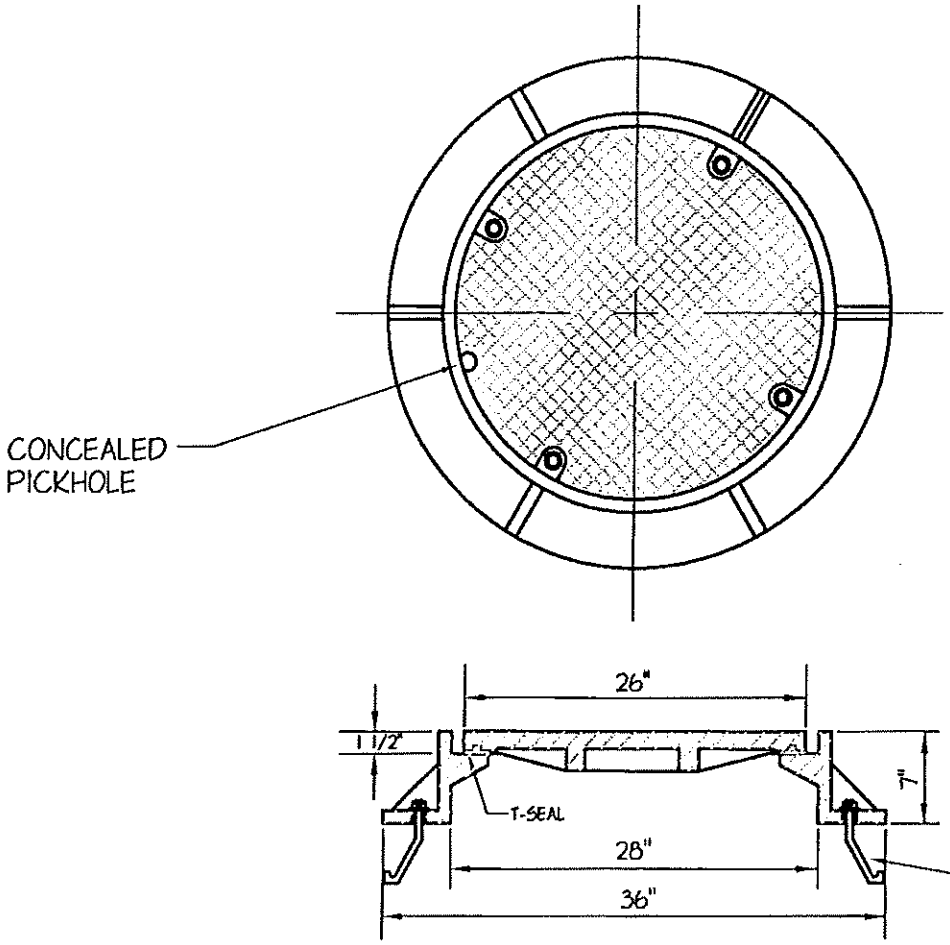


TYPE G CASTING
NEENAH R-2560-E1 OR
EAST JORDAN 1045
WITH 02 GATE



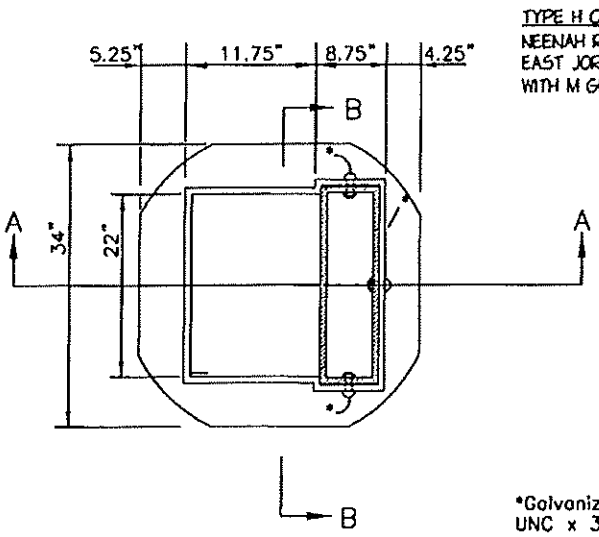
RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

CASTING DETAILS		
TYPE G CASTING DETAIL		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. C - 5

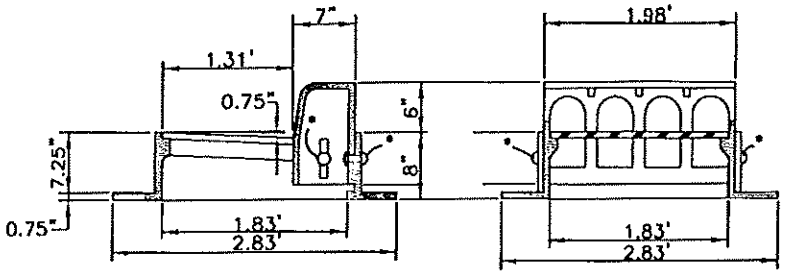


RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

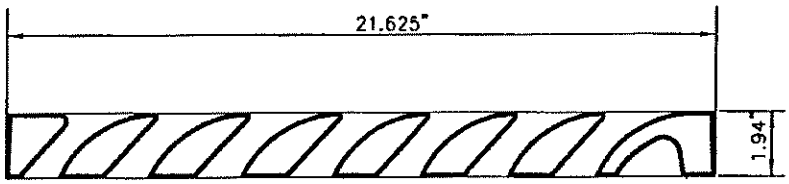
CASTING DETAILS		
TYPE J WATERPROOF MANHOLE FRAME W/BOLTED LID		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. C - 6



PLAN



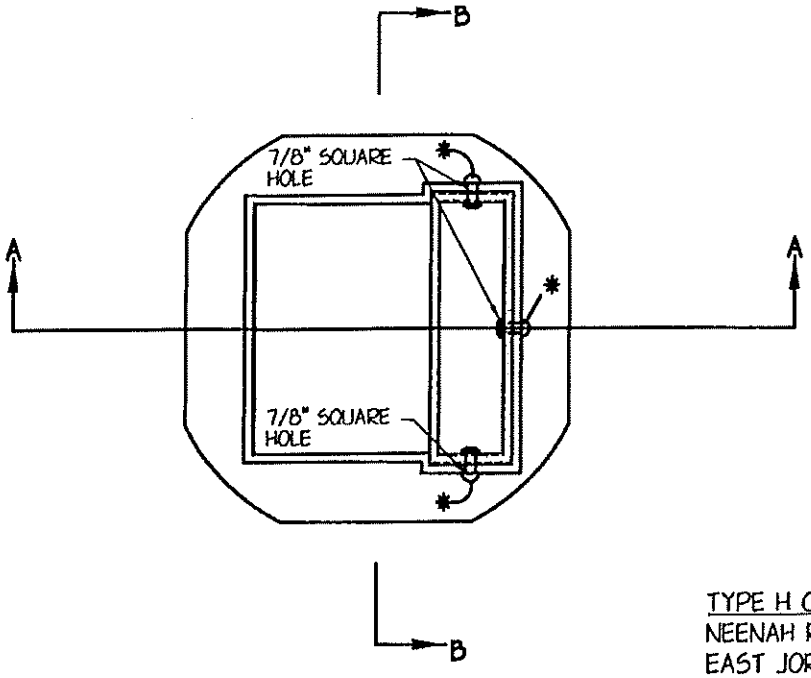
SECTION "A-A" SECTION "B"-B"



FIN DETAIL

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

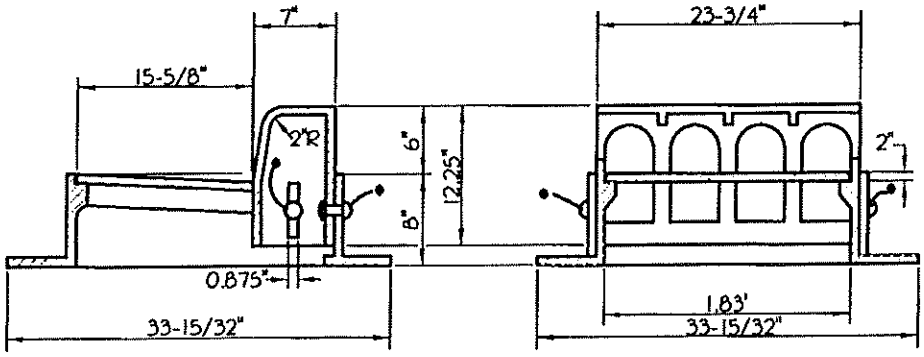
CASTING DETAILS	
TYPE H CASTING	
SCALE: NONE	DATE: JAN. 2005
DWG. NO. C - 7	



PLAN

- GALVANIZED OR STAINLESS STEEL 3/4"-10 UNC X 3 1/2" ROUND HEAD, SQUARE SHOULDERED BOLTS WITH 1 FLAT WASHER, 1 LOCK WASHER AND 1 NUT EACH.

TYPE H CASTING
NEENAH R-3286-8V OR
EAST JORDAN 7520-T1

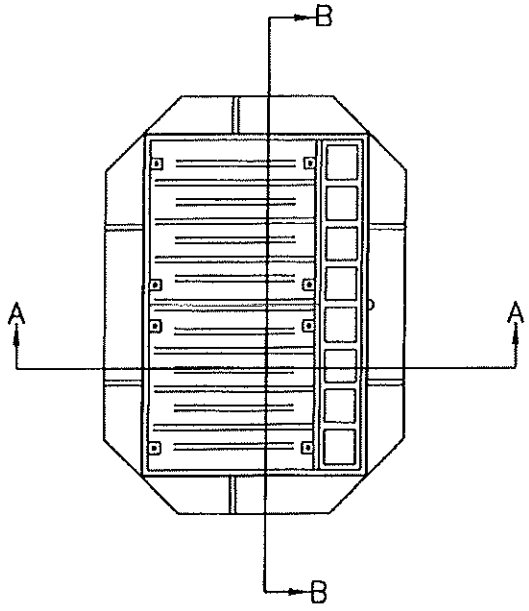


SECTION A-A

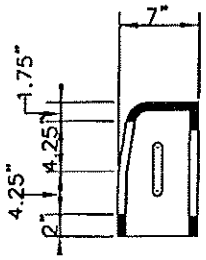
SECTION B-B

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

CASTING DETAILS		
TYPE H CASTING		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. C - 7A

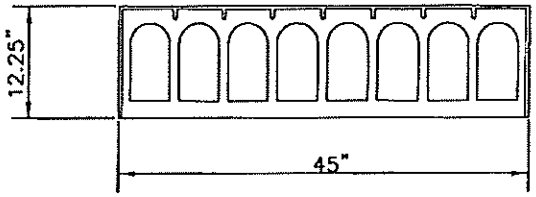


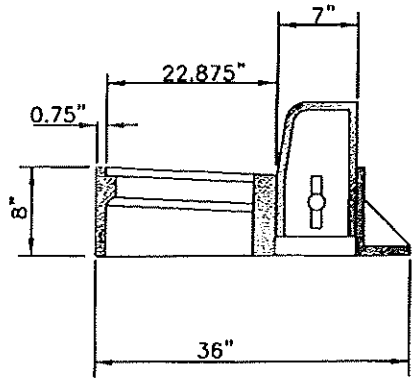
PLAN



CURB BOX SECTION

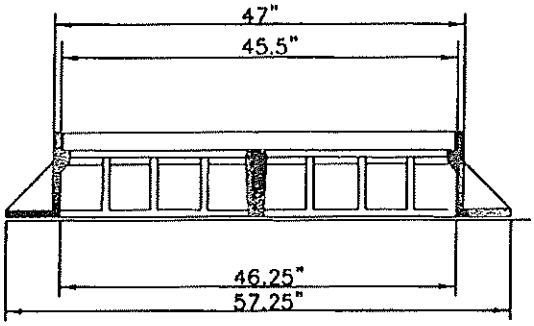
TYPE L CASTING
NEENAH R-3287-15 OR
EAST JORDAN 7565 TI





SECTION "A–A"

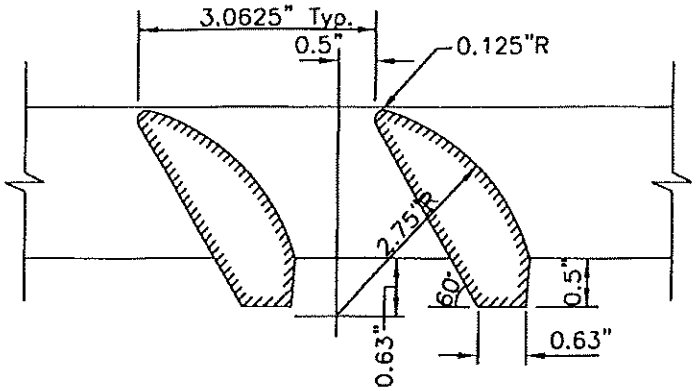
TO BE USED WITH TYPE II INLET



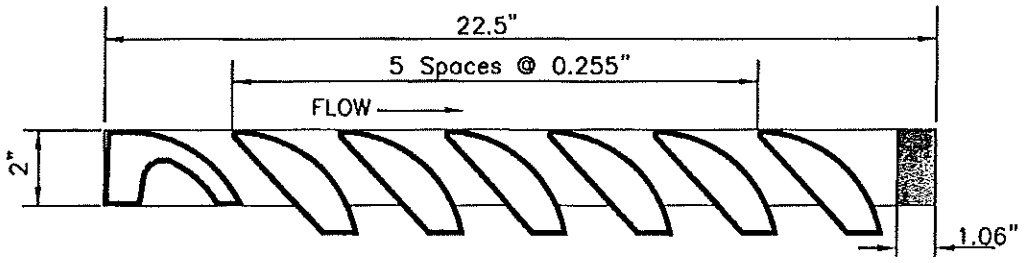
SECTION "B"–B"

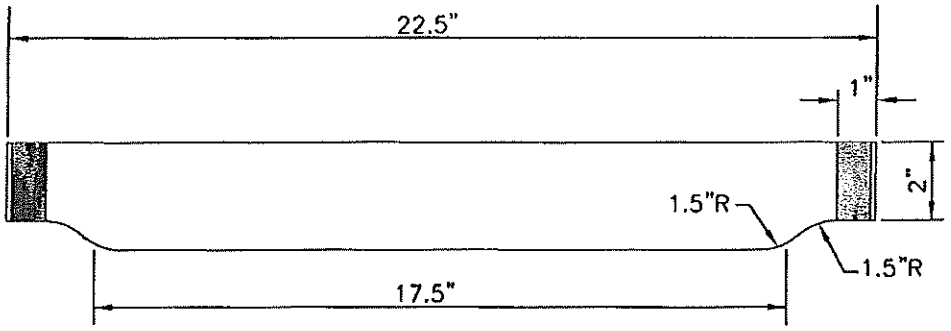
RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

CASTING DETAILS		
TYPE L CASTING		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. C - 8



TYPE L CASTING
NEENAH R-3287-15 OR
EAST JORDAN 7565 TI

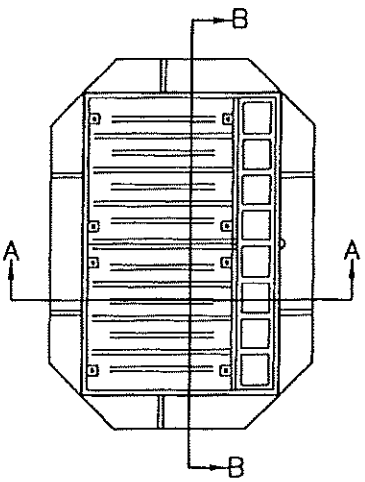




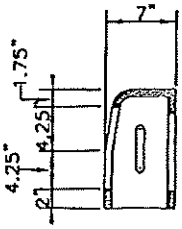
RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

CASTING DETAILS	
FIN DETAIL FOR TYPE L CASTING	
SCALE: NONE	DATE: JAN. 2005
DWG. NO. C - 8A	

TYPE M CASTING
NEENAH R-3287-10V
EAST JORDAN 7505 M1 & T2

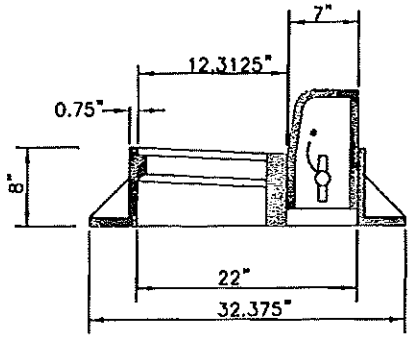


PLAN

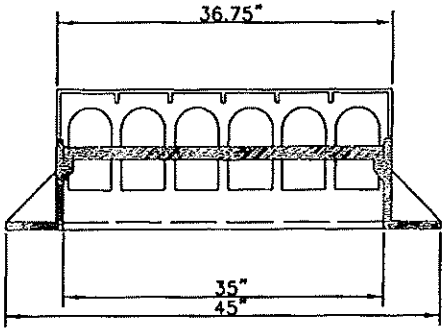


CURB BOX SECTION

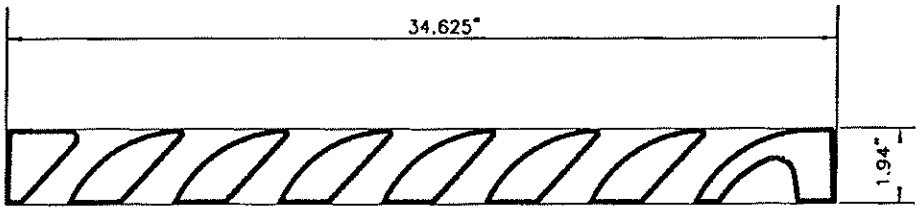
* Galvanized or stainless steel 3/4"–10 UNC x 3 1/2" round head, Square shouldered bolts with 1 flat washer, 1 lock washer and 1 nut each.



SECTION "A–A"



SECTION "B"–B"

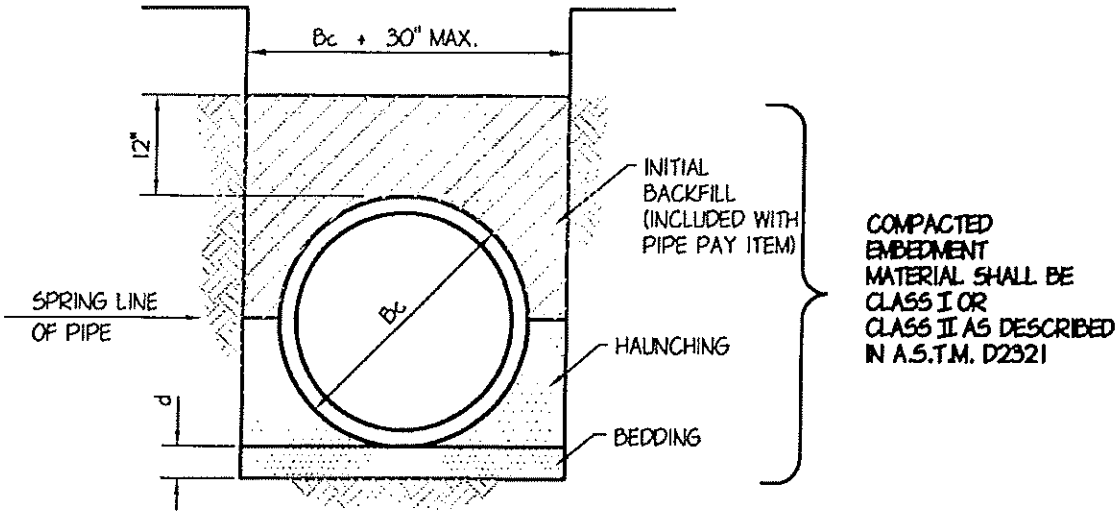


FIN DETAIL

TO BE USED WITH TYPE III INLET

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

CASTING DETAILS		
TYPE M CASTING		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. C - 9



GRANULAR FOUNDATION

DEPTH OF BEDDING MATERIAL BELOW PIPE	
D	d(MIN.)
27" & SMALLER	4"
30" TO 60"	4"
66" & LARGER	6"

LEGEND

Bc = OUTSIDE DIAMETER

D = INSIDE DIAMETER

d = DEPTH OF BEDDING MATERIAL BELOW PIPE BELL

NOTE:

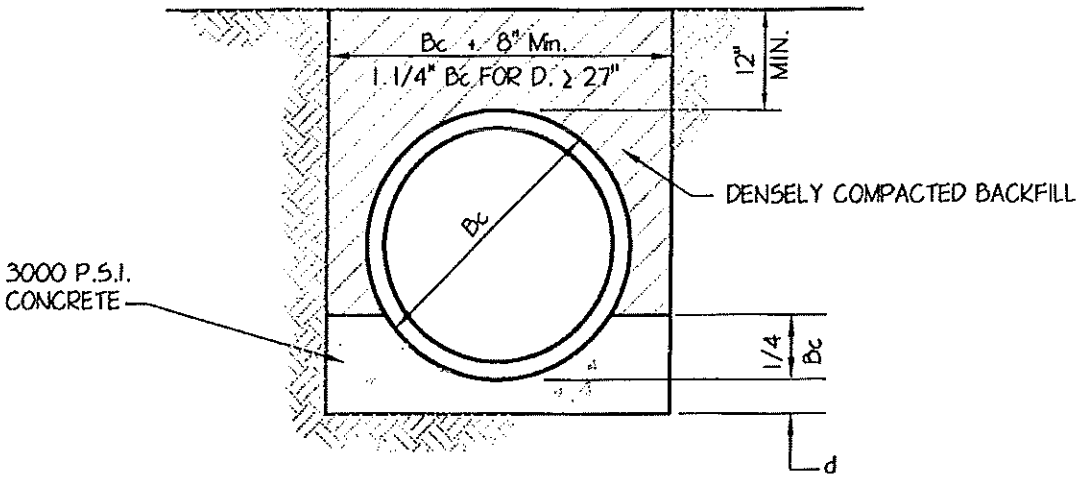
FOR ROCK OR OTHER NON-COMPRESSABLE MATERIAL: THE TRENCH SHOULD BE OVER-EXCAVATED A MIN. OF 6" & REFILLED WITH GRANULAR MATERIAL.

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

BEDDING & BACKFILL DETAILS

FLEXIBLE SEWER PIPE BEDDING DETAIL (CLASS I & II)

SCALE: NONE	DATE: JAN. 2005	DWG. NO. BB-1



CONCRETE CRADLE

DEPTH OF BEDDING MATERIAL BELOW PIPE	
D	d(MIN.)
27" & SMALLER	3"
30" TO 60"	4"
66" & LARGER	6"

LEGEND

Bc = OUTSIDE DIAMETER

D = INSIDE DIAMETER

d = DEPTH OF CONCRETE CRADLE BELOW PIPE BELL

NOTE:

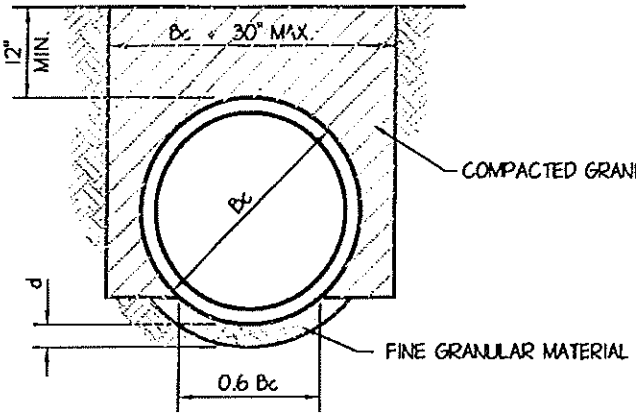
FOR ROCK OR OTHER NON-COMPRESSABLE MATERIAL: THE TRENCH SHOULD BE OVER-EXCAVATED A MIN. OF 6" & REFILLED WITH GRANULAR MATERIAL.

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

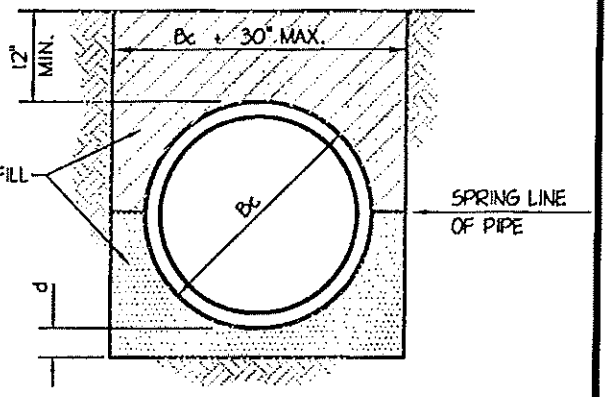
BEDDING & BACKFILL DETAILS

RIGID PIPE BEDDING DETAIL (CLASS "A")

SCALE: NONE	DATE: JAN. 2005	DWG. NO. BB-2



SHAPED SUBGRADE WITH GRANULAR FOUNDATION



GRANULAR FOUNDATION

DEPTH OF BEDDING MATERIAL BELOW PIPE	
D	d(MIN.)
27" & SMALLER	3"
30" TO 60"	4"
66" & LARGER	6"

LEGEND

Bc = OUTSIDE DIAMETER

D = INSIDE DIAMETER

d = DEPTH OF BEDDING MATERIAL BELOW PIPE BELL

NOTE:

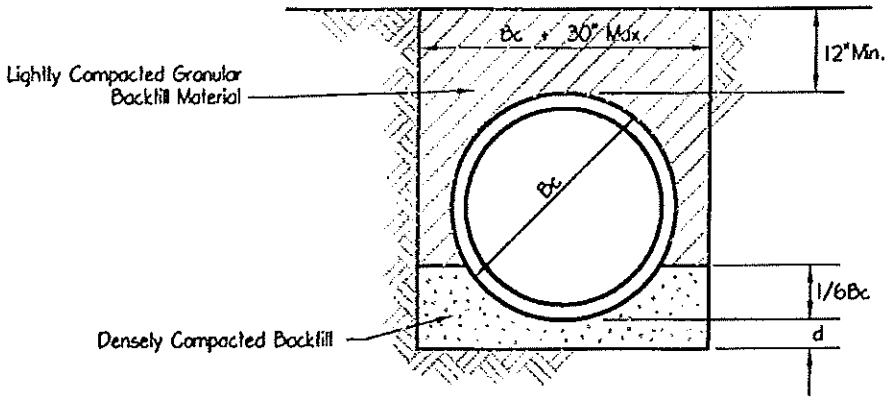
FOR ROCK OR OTHER NON-COMPRESSABLE MATERIAL: THE TRENCH SHOULD BE OVER-EXCAVATED A MIN. OF 6" & REFILLED WITH GRANULAR MATERIAL.

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

BEDDING & BACKFILL DETAILS

RIGID PIPE BEDDING DETAIL (CLASS "B")

SCALE: NONE	DATE: JAN. 2005	DWG. NO. BB-3



GRANULAR FOUNDATION

DEPTH OF BEDDING MATERIAL BELOW PIPE	
D	d(MIN.)
27" & SMALLER	3"
30" TO 60"	4"
66" & LARGER	6"

LEGEND

Bc = OUTSIDE DIAMETER

D = INSIDE DIAMETER

d = DEPTH OF BEDDING MATERIAL BELOW PIPE BELL

NOTE:

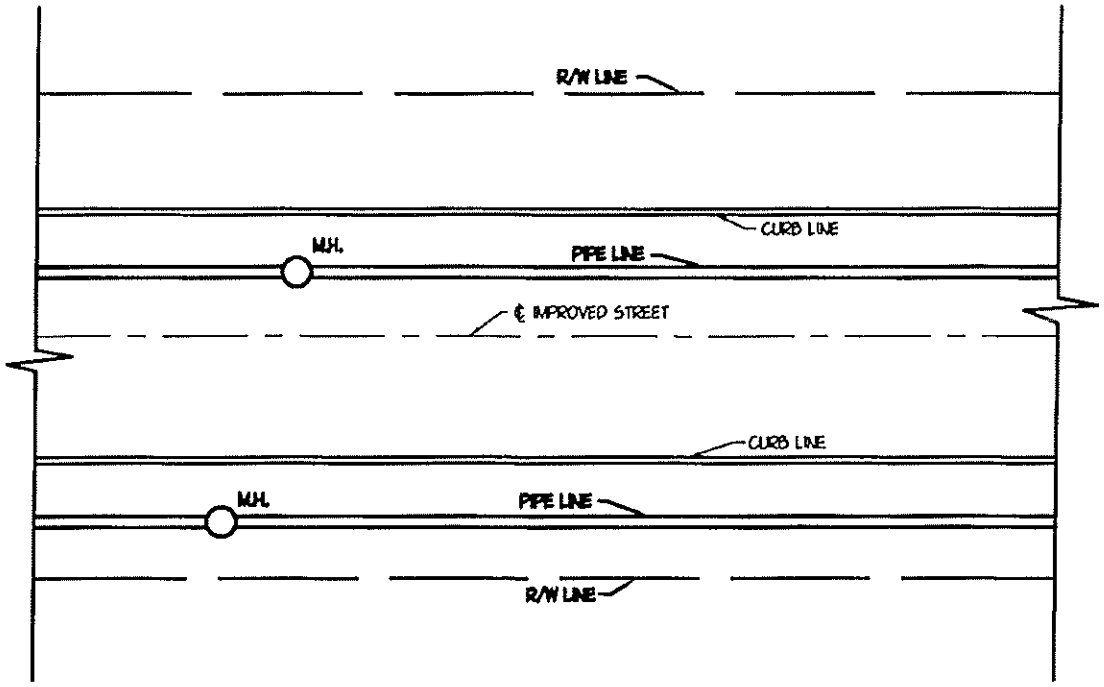
For Rock or Other Non-Compressable Materials The Trench should be over-excavated a min. of 6" & refilled with Granular Material.

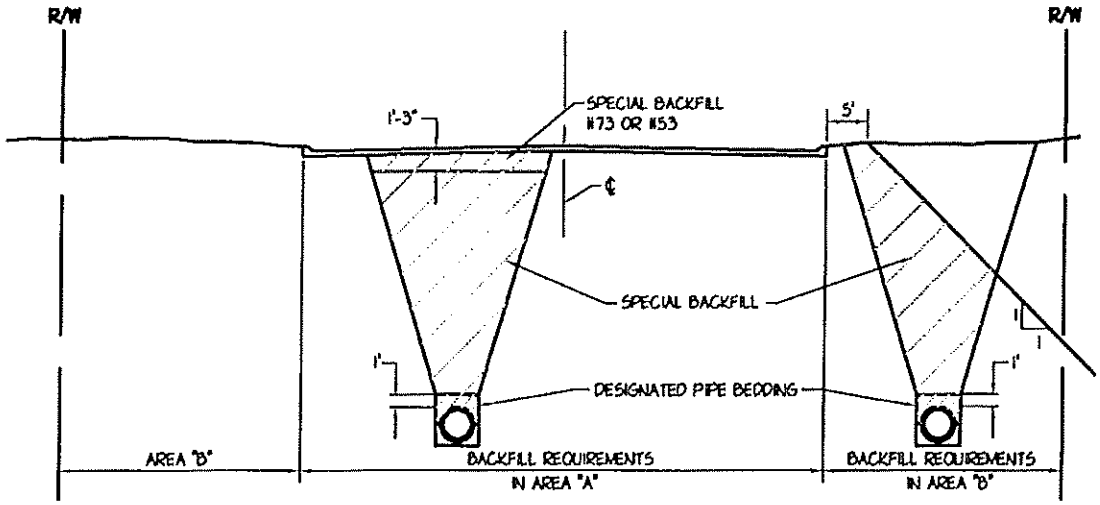
RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

BEDDING & BACKFILL DETAILS

RIGID PIPE BEDDING DETAIL (CLASS "C")

SCALE: NONE	DATE: JAN. 2005	DWG. NO. BB-4



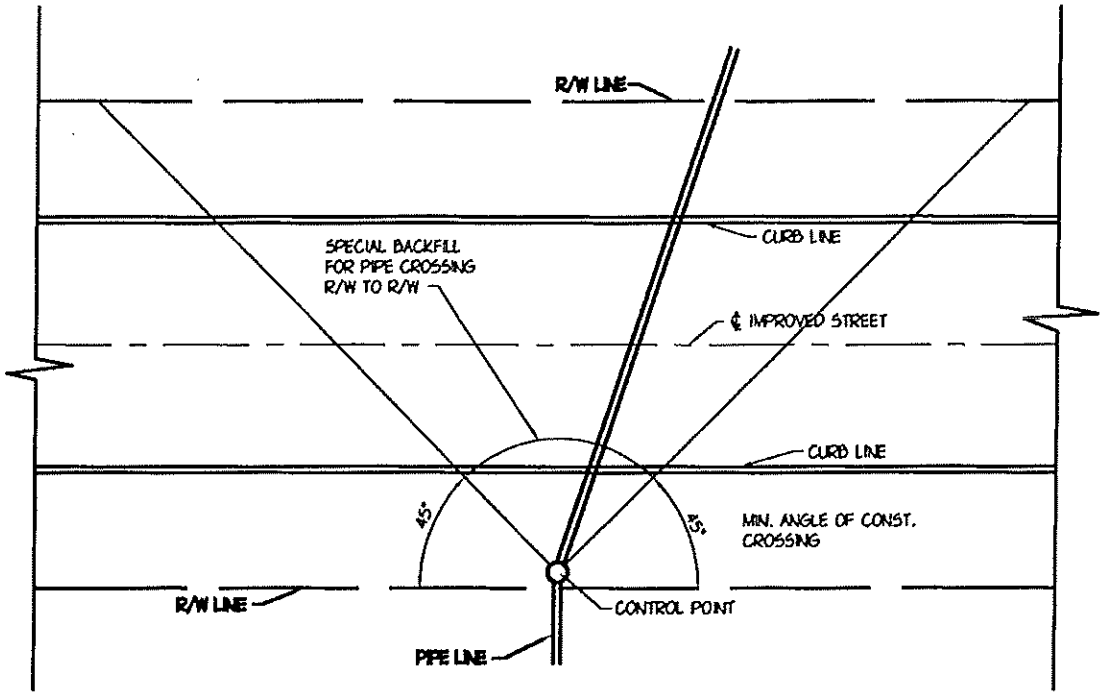


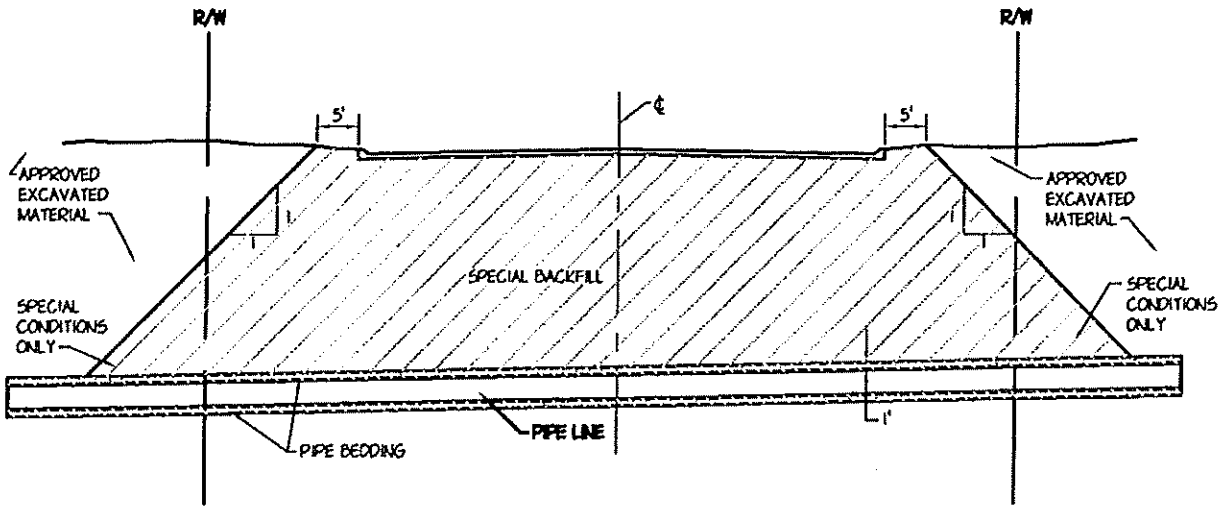
RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

BEDDING & BACKFILL DETAILS

BACKFILL REQUIREMENTS (WITHIN R/W)

SCALE: NONE	DATE: JAN. 2005	DWG. NO. BB-5



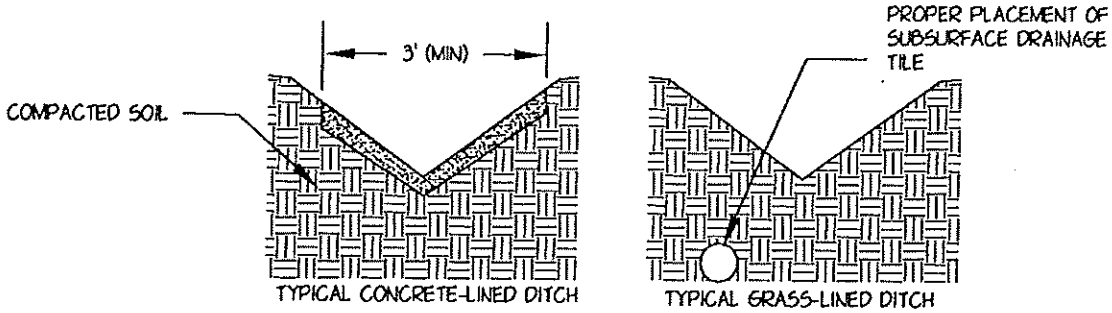


RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

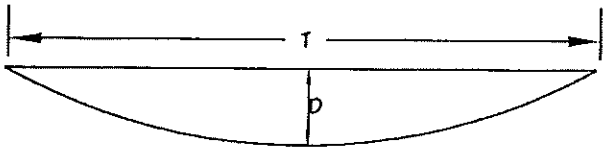
BEDDING & BACKFILL DETAILS

BACKFILL REQUIREMENTS (CROSSING R/W)

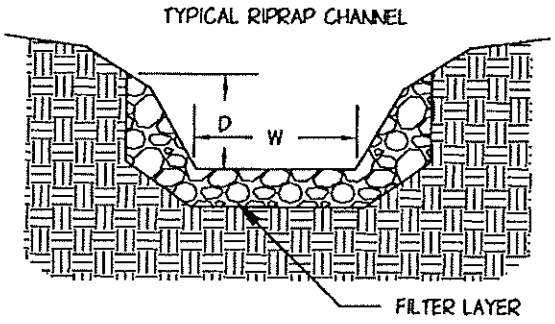
SCALE: NONE	DATE: JAN. 2005	DWG. NO. BB-6

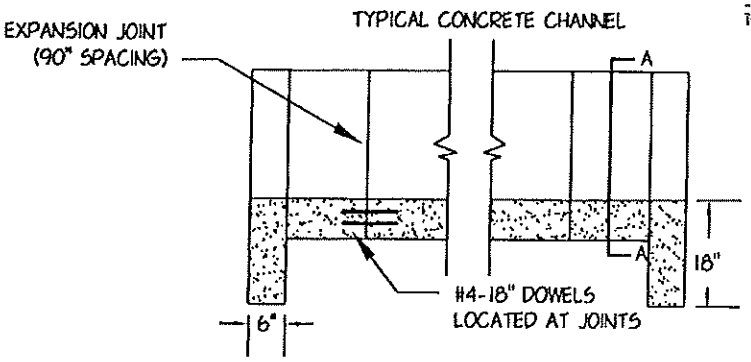


TYPICAL VEE CROSS-SECTIONS

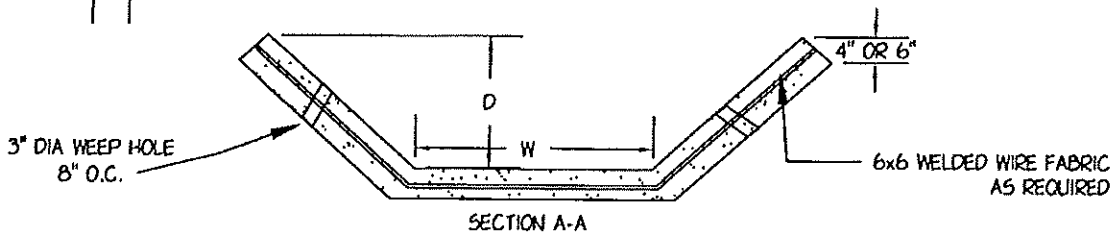


PARABOLIC WATERWAY CROSS-SECTION





TRAPEZOIDAL WATERWAY CROSS-SECTIONS

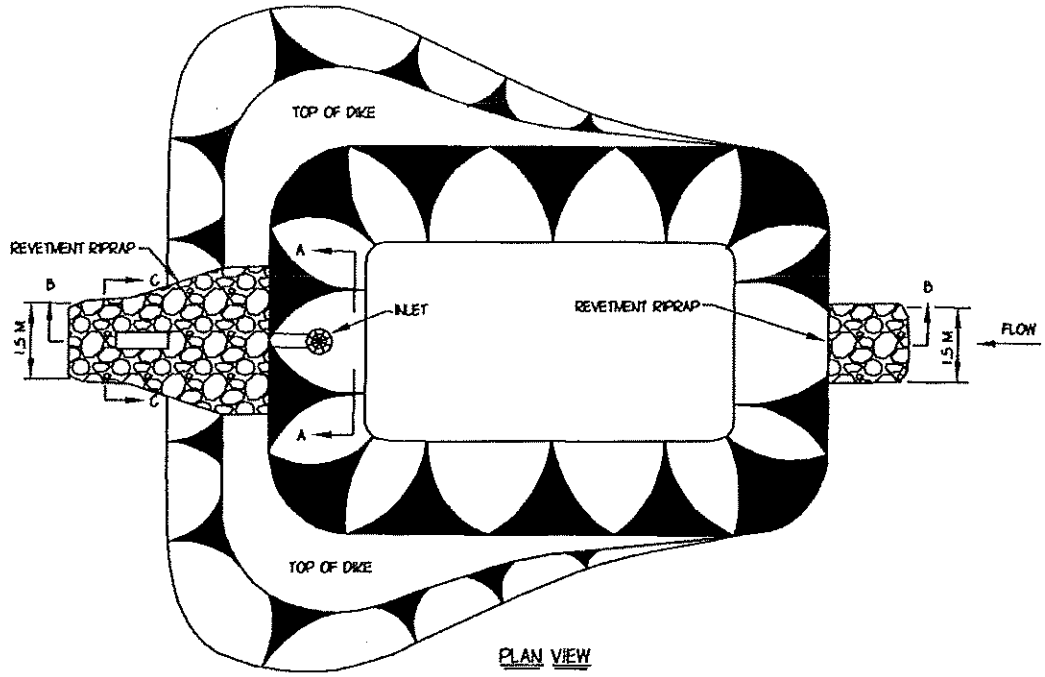


RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

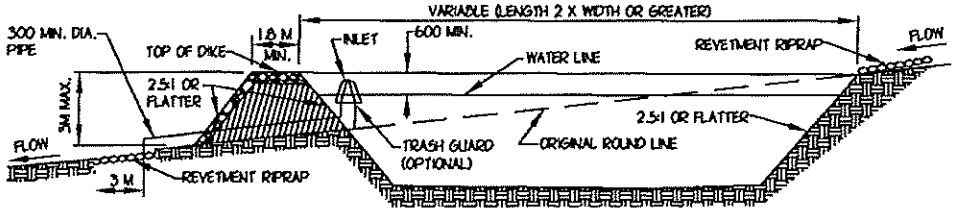
OPEN CHANNEL DETAIL		
TYPICAL OPEN CHANNEL CROSS-SECTION		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. O-1

APPENDIX D

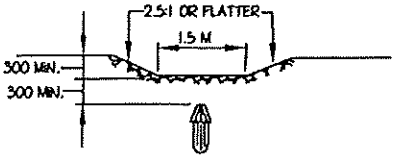
EROSION AND SEDIMENT CONTROL DETAILS



PLAN VIEW



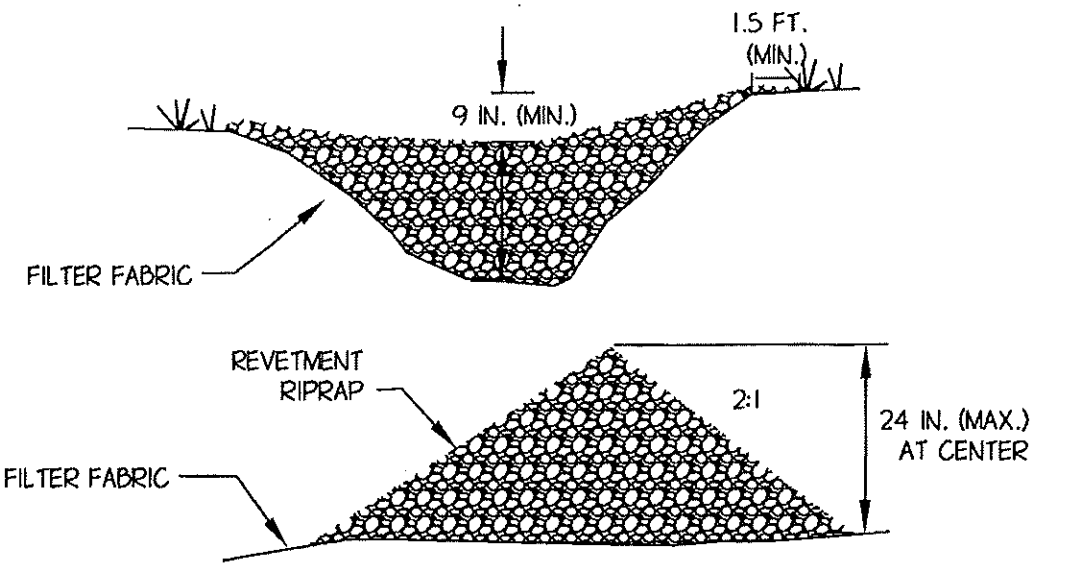
SEDIMENT BASIN DETAILS



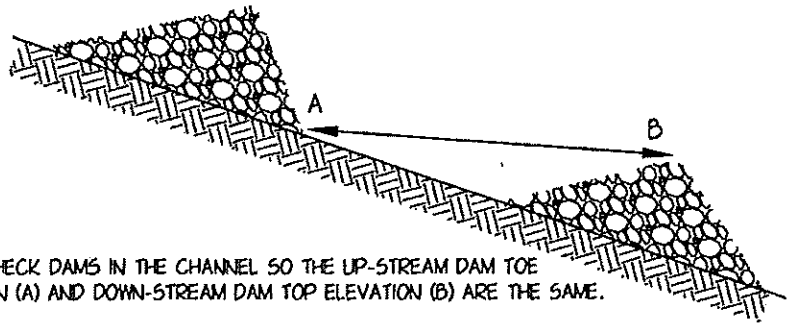
SPILLWAY DETAIL

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

EROSION AND SEDIMENT CONTROL DETAILS		
TEMPORARY SEDIMENT BASIN		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. EC-1



FORWARD AND CROSS-SECTION VIEWS OF A ROCK DAM CHECK.



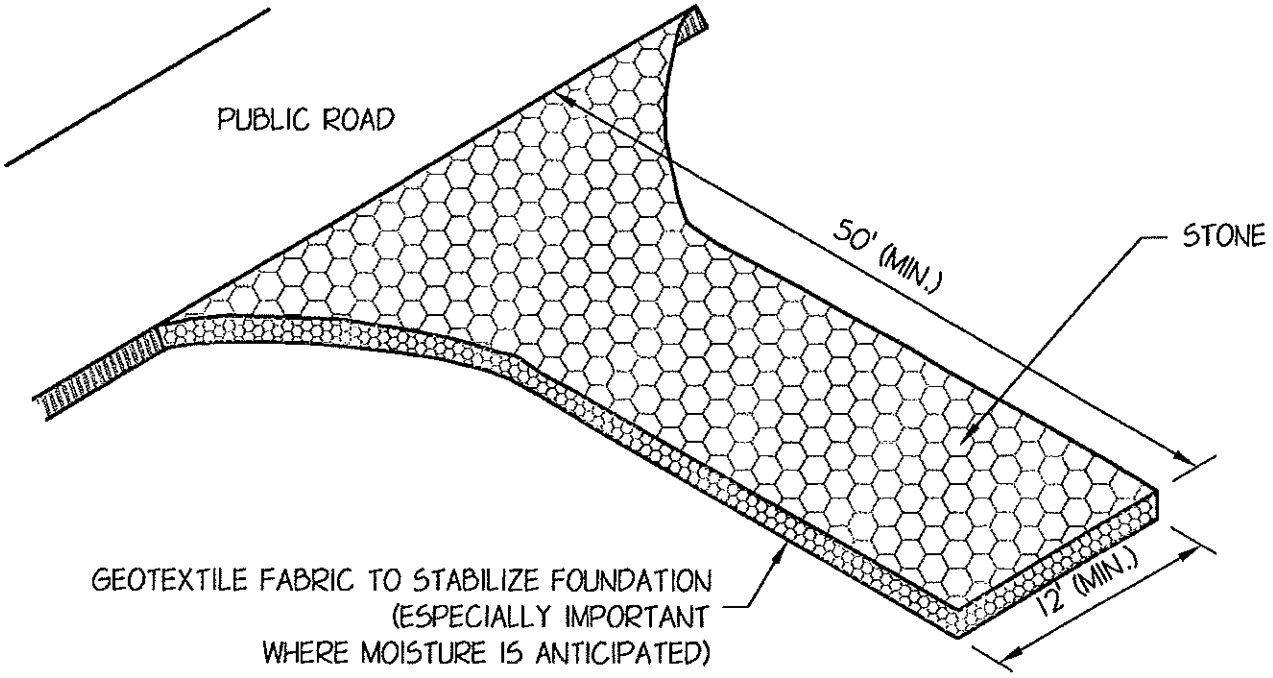
SPACE CHECK DAMS IN THE CHANNEL SO THE UP-STREAM DAM TOE ELEVATION (A) AND DOWN-STREAM DAM TOP ELEVATION (B) ARE THE SAME.

REQUIREMENTS

CONTRIBUTING DRAINAGE AREA: 2 ACRES MAXIMUM
DAM CENTER: 2' MAXIMUM HEIGHT BUT ATLEAST 9" LOWER THAN THE OUTER EDGES AT NATURAL GROUND ELEVATION.
DAM SIDE SLOPE: 2:1 OR FLATTER.
DISTANCE BETWEEN DAMS: SPACED SO THE TOE OF THE UPSTREM DAM IS THE SAME AS THE TOP OF THE DOWNSTREM DAM.
OVERFLOW AREAS ALONG CHANNEL: STABLILIZED TO RESIST EROSION.
ROCK SIZE: INDOT REVETMENT RIPRAP.

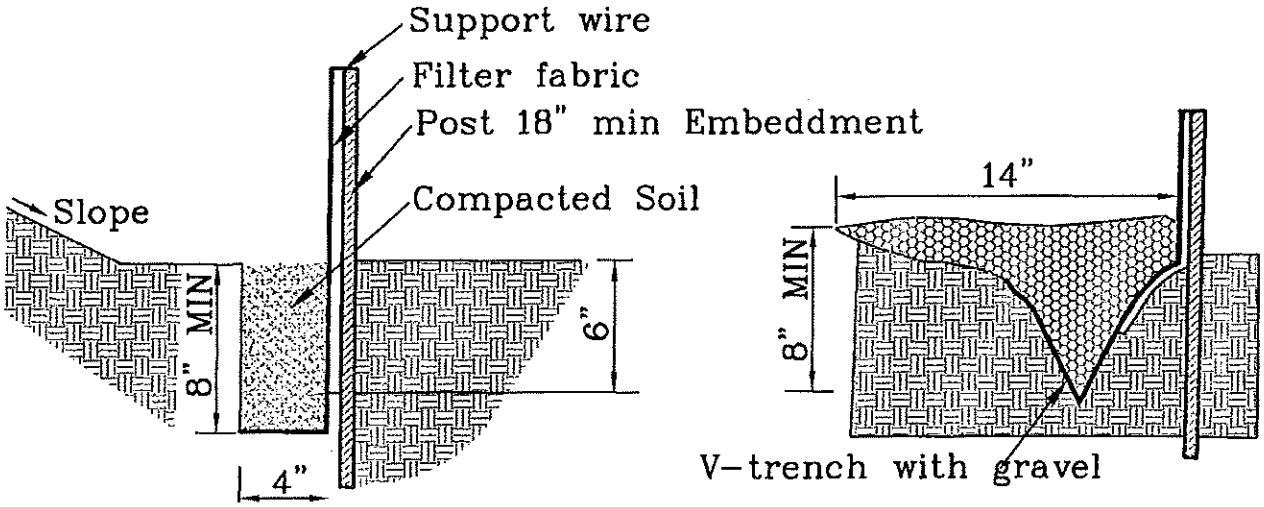
RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

EROSION AND SEDIMENT CONTROL DETAILS	
ROCK DAM CHECK	
SCALE: NONE	DATE: JAN. 2005
	DWG. NO. EC-2



RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

EROSION AND SEDIMENT CONTROL DETAILS		
TEMPORARY STONE CONSTRUCTION ENTRANCE		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. EC-3

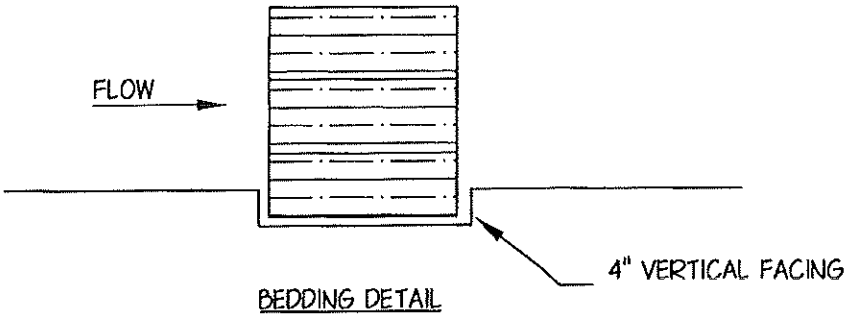


RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

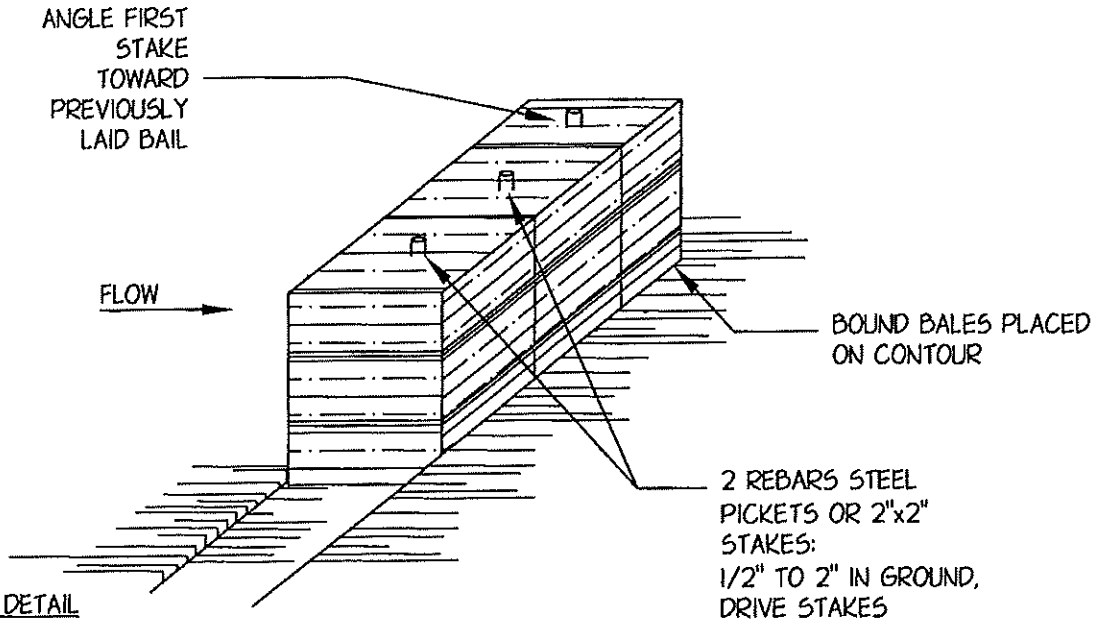
EROSION AND SEDIMENT CONTROL DETAILS

SILT FENCE DETAIL

SCALE: NONE	DATE: JAN. 2005	DWG. NO. EC-4



BEDDING DETAIL



ANCHORING DETAIL

CONSTRUCTION SPECIFICATIONS

1. BALES SHALL BE PLACED AT THE TOE OF A SLOPE OR ON THE CONTOUR AND IN A ROW THAT ENDS TIGHTLY ABUTTING THE ADJACENT BALES.

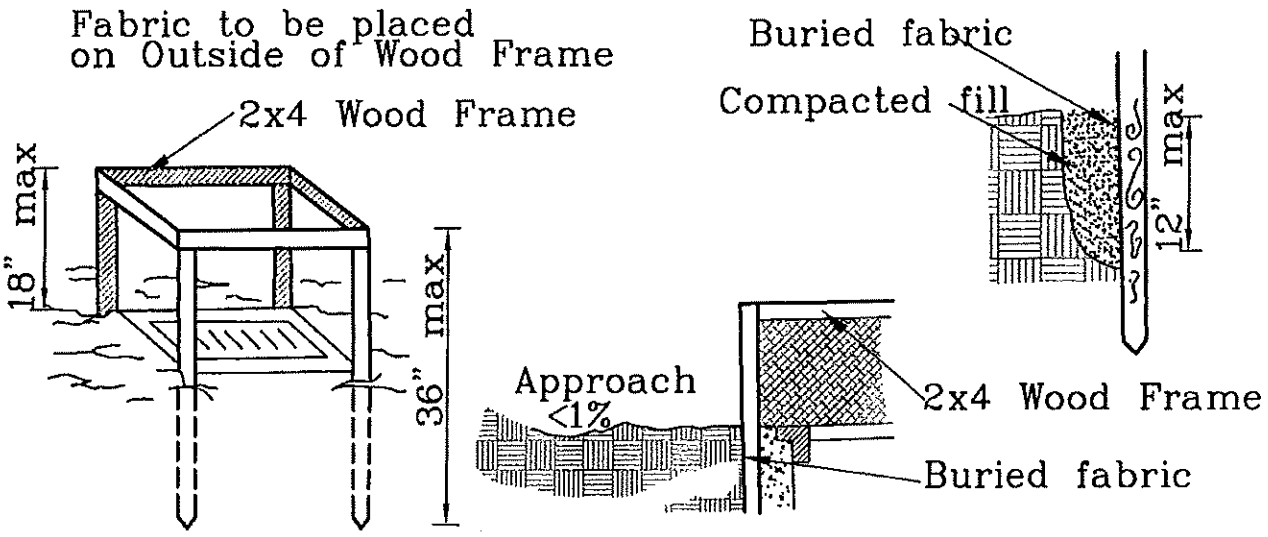
2. EACH BALE SHALL BE EMBEDDED IN THE SOIL A MINIMUM OF 4 INCHES AND PLACED SO BINDINGS ARE HORIZONTAL.

3. BALES SHALL BE SECURELY ANCHORED IN PLACE BY EITHER TWO STAKES OR RE-BARS DRIVEN THROUGH THE BALE. THE FIRST STAKE SHALL BE DRIVEN TOWARD THE PREVIOUSLY LAID BALE AT AN ANGLE TO FORCR THE BALES TOGETHER. STAKES SHALL BE DRIVEN FLUSH WITH THE BALES.

4. BALES SHALL BE REMOVED WHEN THEY HAVE SERVED THEIR USEFULNESS.

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

EROSION AND SEDIMENT CONTROL DETAILS		
STRAW DAM		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. EC-5

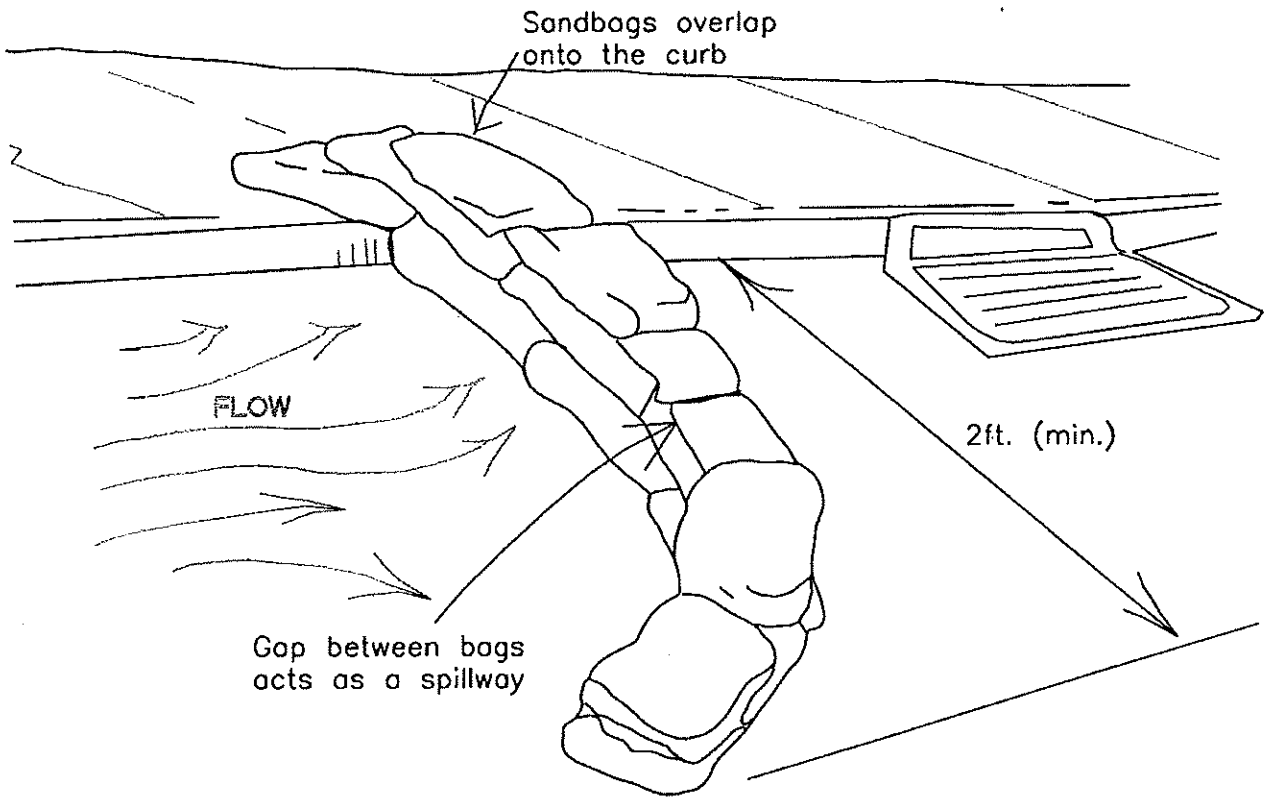


RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

EROSION AND SEDIMENT CONTROL DETAILS

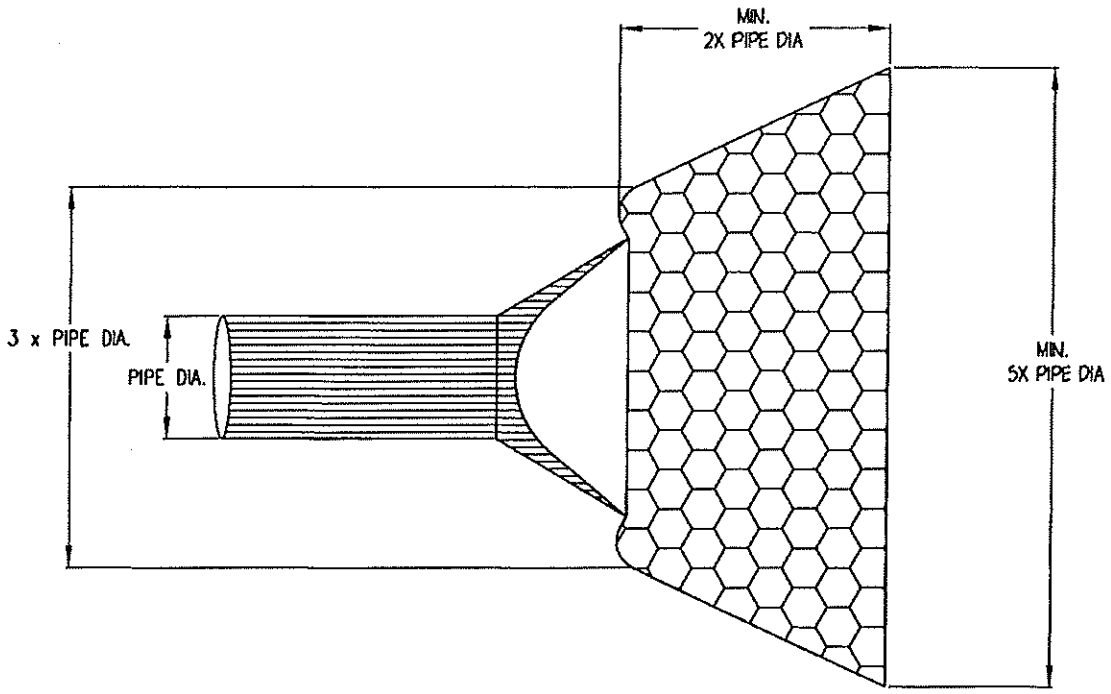
FABRIC DROP INLET PROTECTION DETAIL

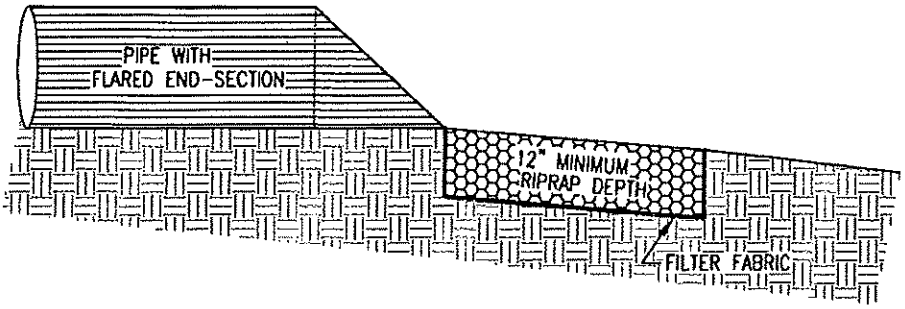
SCALE: NONE	DATE: JAN. 2005	DWG. NO. EC-6



RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

EROSION AND SEDIMENT CONTROL DETAILS		
SANDBAG CURB INLET PROTECTION DETAIL		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. EC-7





NOTE: DIMENSIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY.
ALTER DIMENSIONS AS SITE CONDITIONS DICTATE.

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

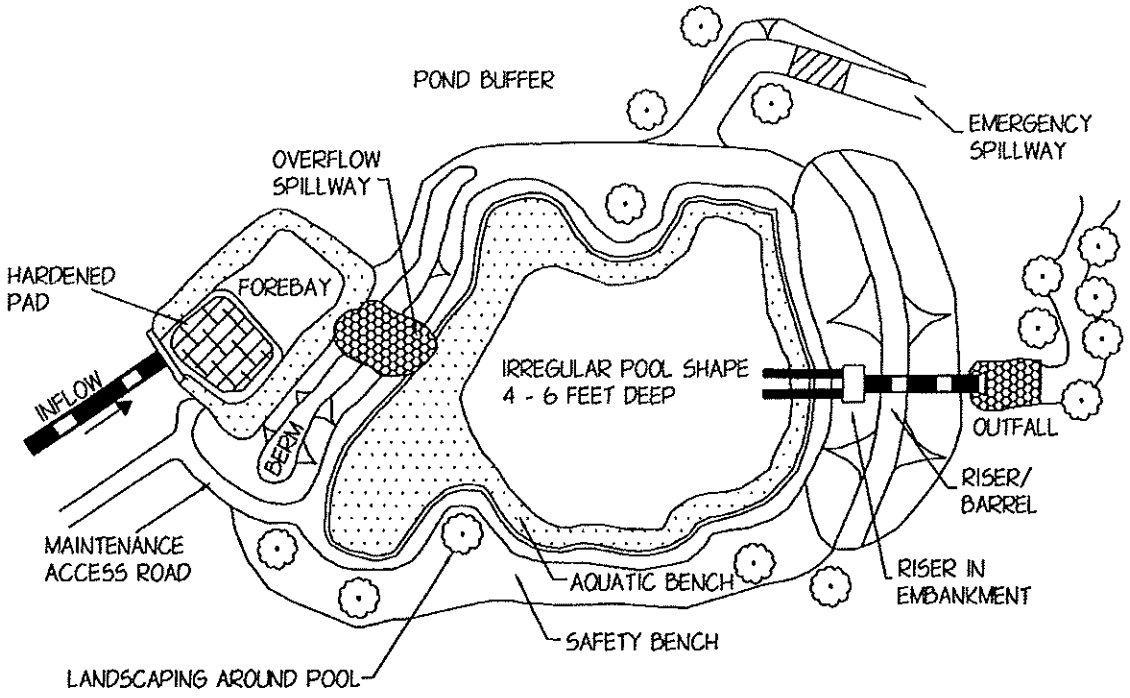
EROSION AND SEDIMENT CONTROL DETAILS

RIPRAP CHUTE DETAIL

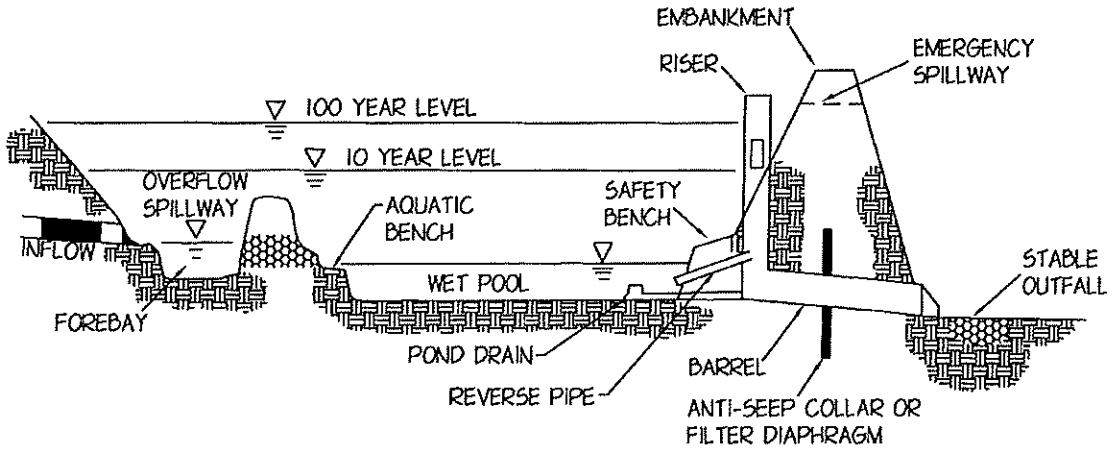
SCALE: NONE	DATE: JAN. 2005	DWG. NO. EC-8

APPENDIX E

POST-CONSTRUCTION STORMWATER RUNOFF CONTROL DETAILS



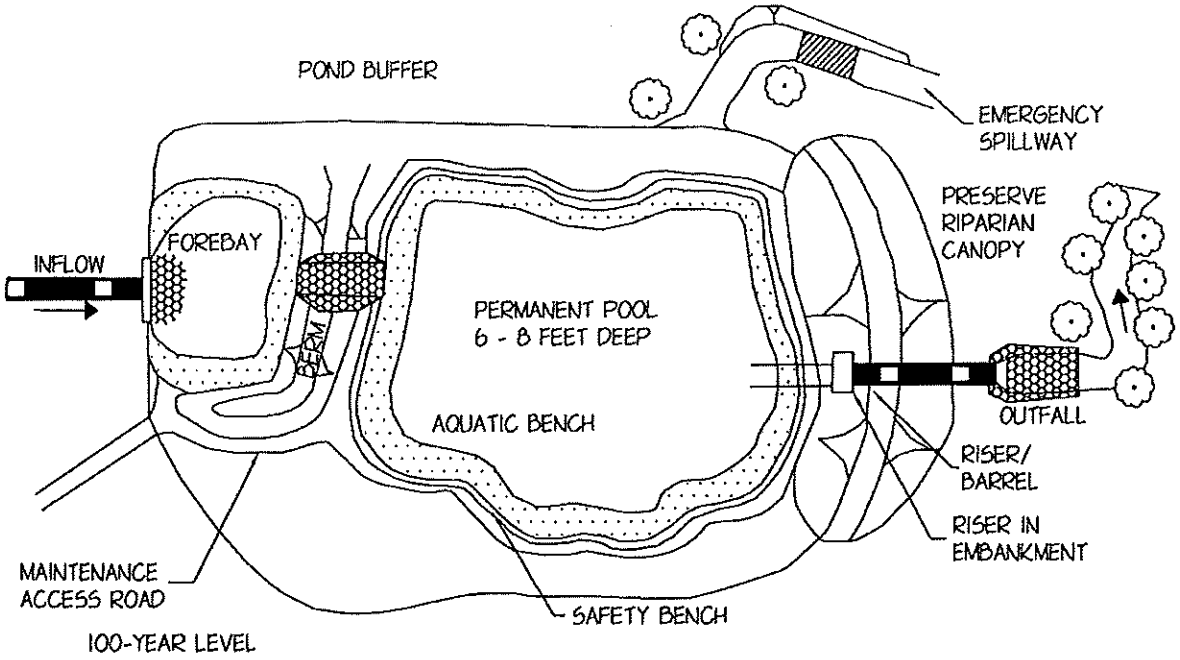
PLAN VIEW



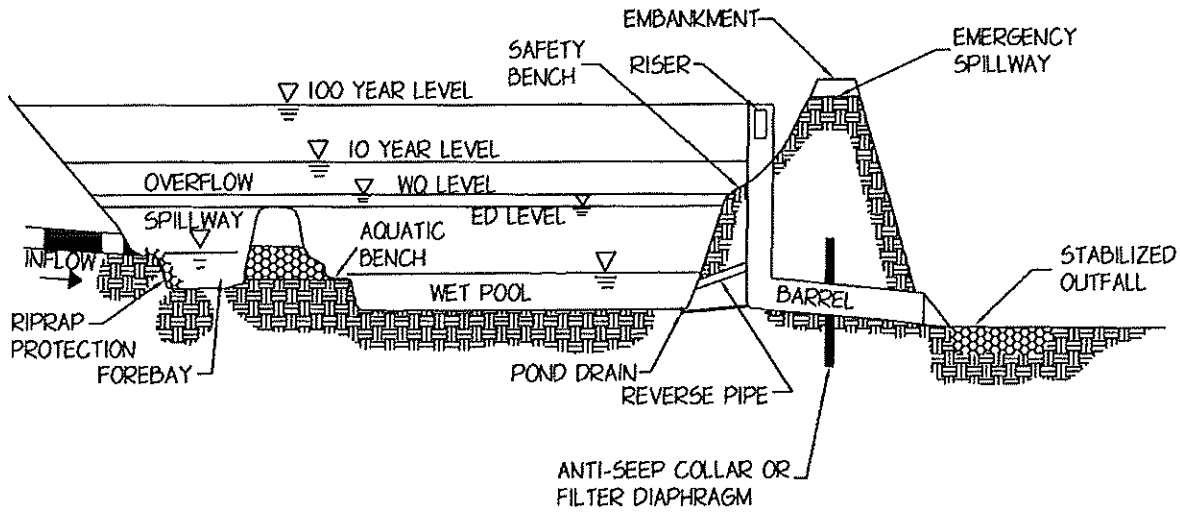
PROFILE

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS		
WET POND		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-1



PLAN VIEW



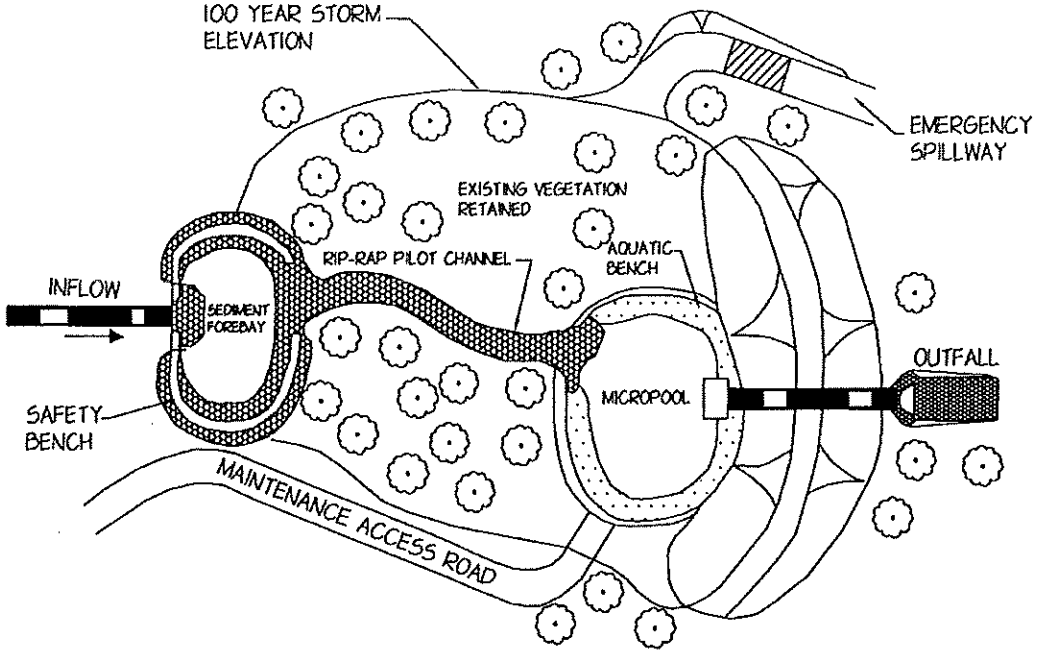
PROFILE

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

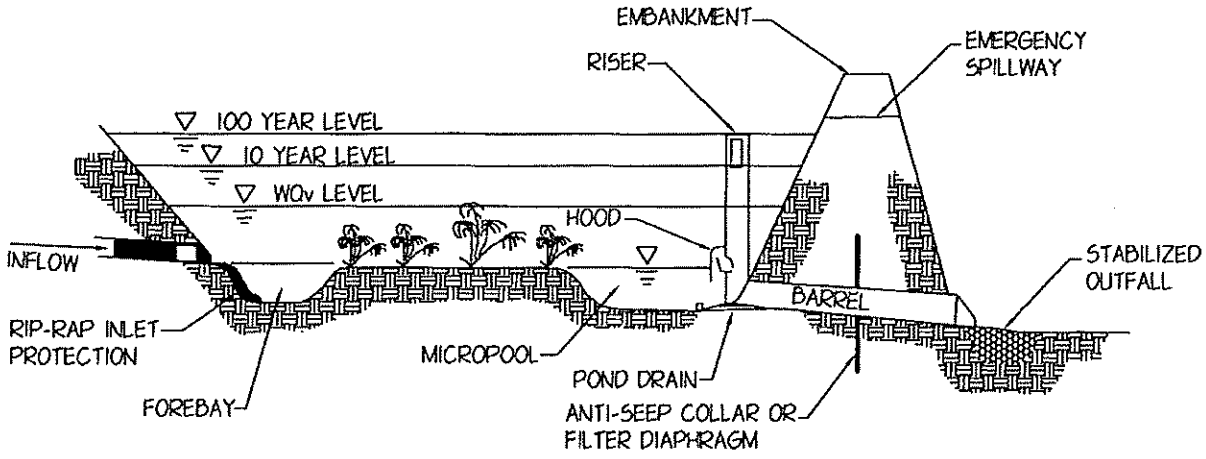
POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS

WET EXTENDED DETENTION POND

SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-2



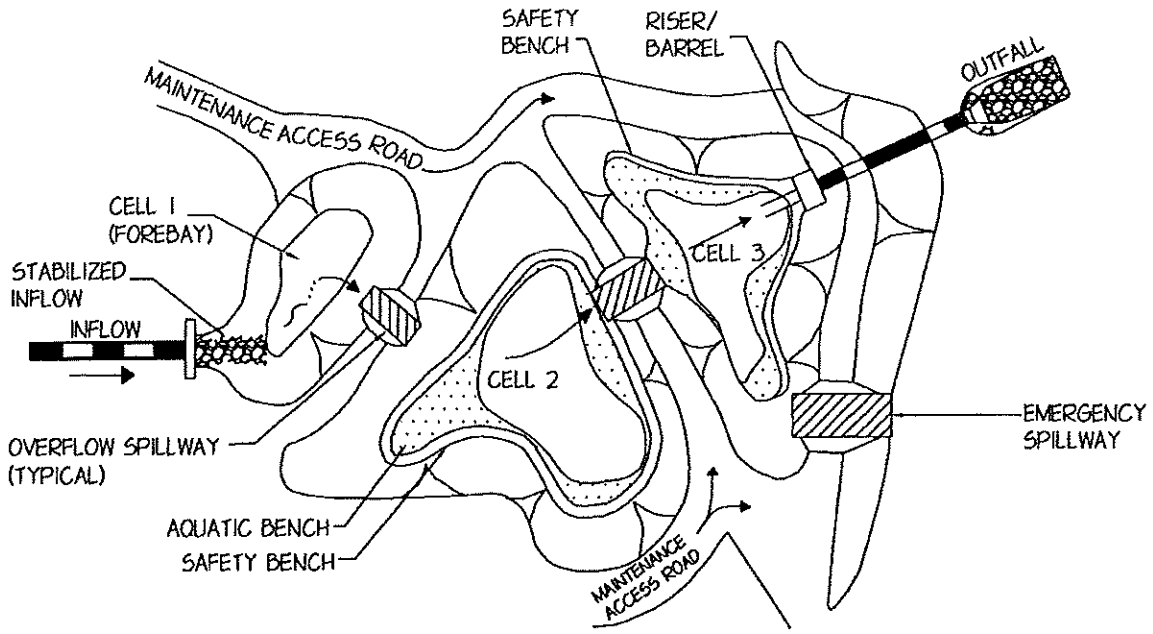
PLAN VIEW



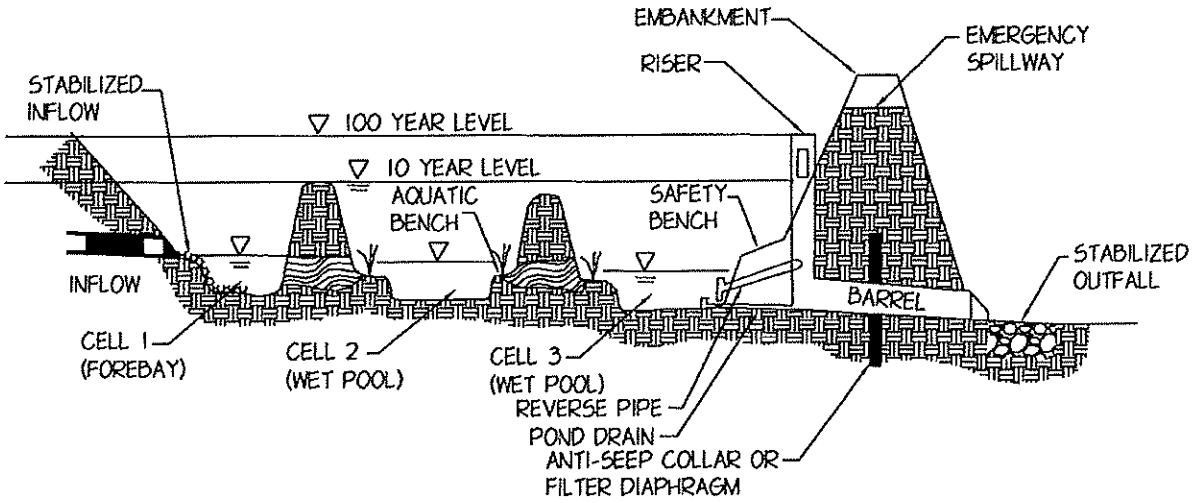
PROFILE

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS		
MICROPOOL EXTENDED DETENTION POND		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-3



PLAN VIEW



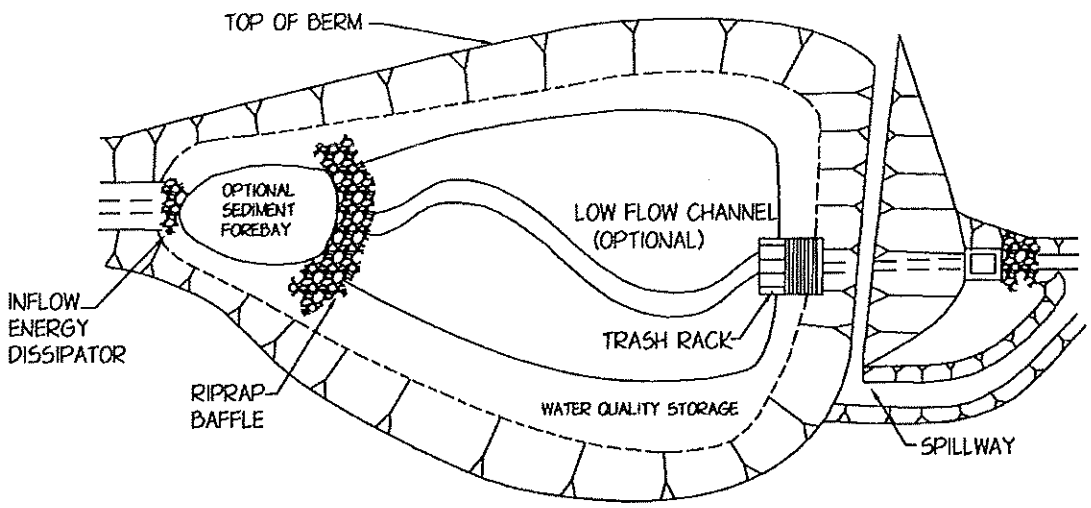
PROFILE

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

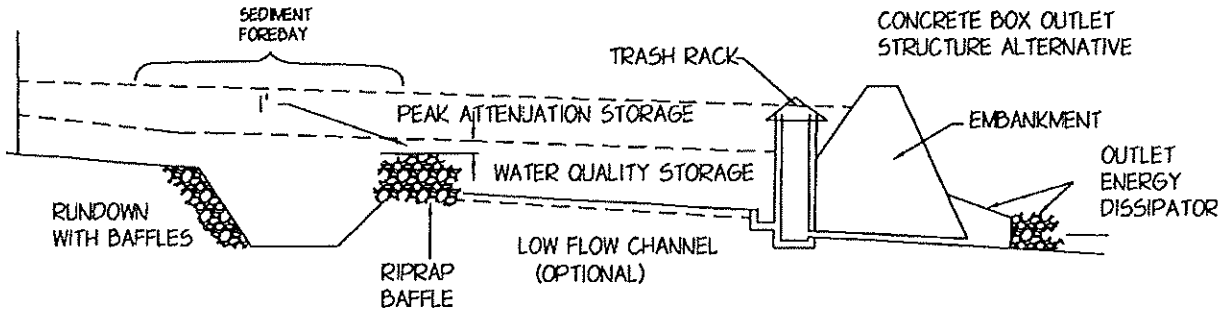
POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS

MULTIPLE POND SYSTEM

SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-4



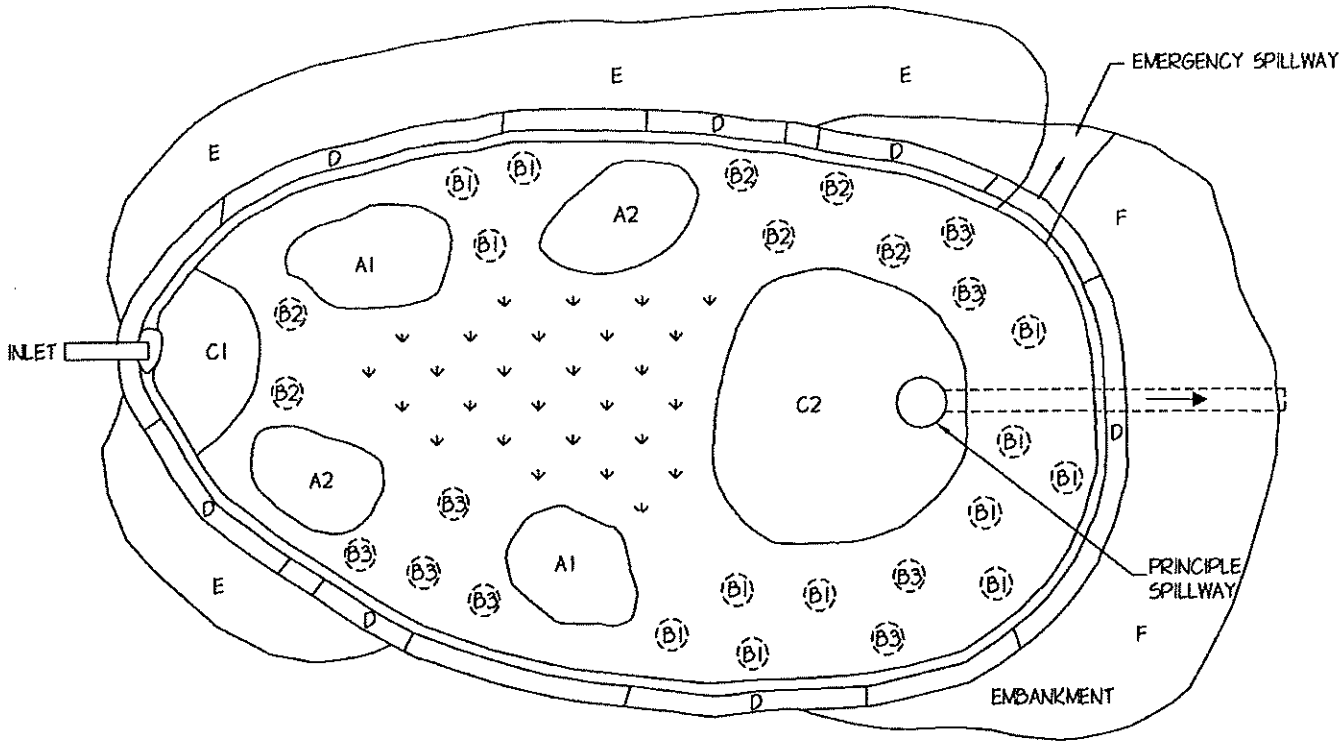
PLAN VIEW



PROFILE

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS		
EXTENDED DETENTION BASIN COMPONENTS		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-5



PLAN VIEW

LEGEND

A1: RAPID COLONIZER WETLAND SPECIES
A2: RAPID COLONIZER WETLAND SPECIES
B1: SLOW COLONIZER WETLAND SPECIES
B2: SLOW COLONIZER WETLAND SPECIES
B3: SLOW COLONIZER WETLAND SPECIES
} CONSISTS OF 65% OF THE POOL AREA. 0 TO 1 FT. DEEP. WETLAND SPECIES TO BE SELECTED BY WETLAND SPECIALIST.

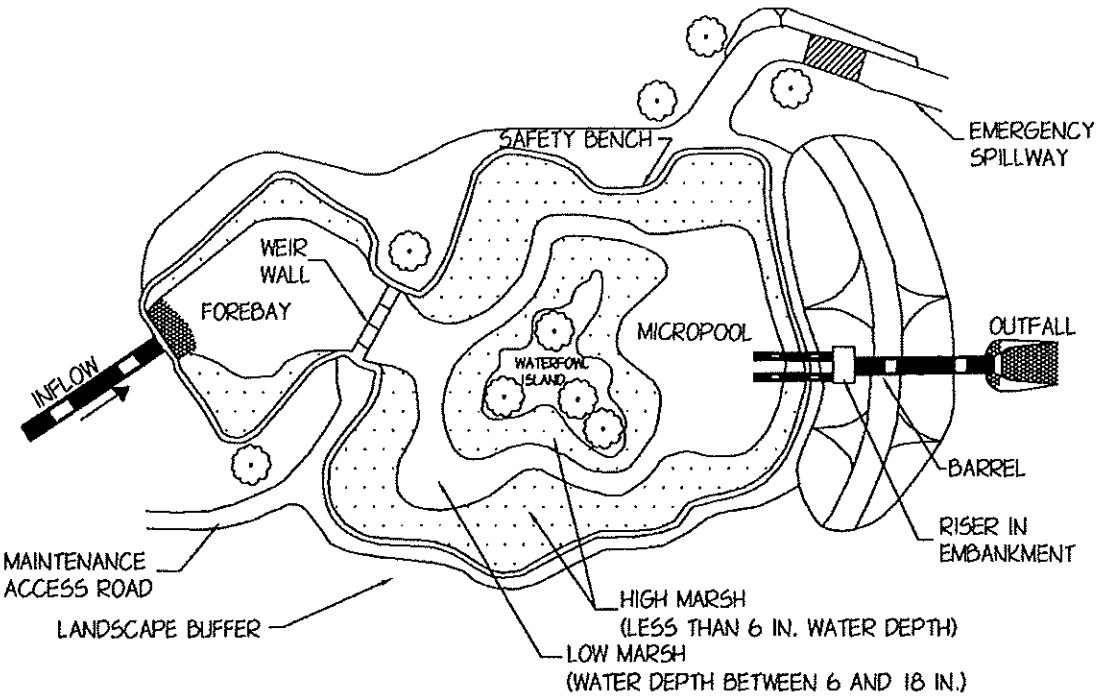
C1: FOREBAY-NO VEGETATION 3 TO 6 FT. DEEP-20% OF THE POOL AREA.
C2: OPEN WATER AREAS-NO VEGETATION 2 TO 3 FT. DEEP-15% OF THE POOL AREA
D: SHORELINE FRINGE OF SWITCHGRASS: 50% OF SAFETY BENCH.
E: WILDLIFE TREES AND SHRUBS IN BUFFER.
F: MAINTAIN GRASS COVER ON EMBANKMENT (NO TREES).

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

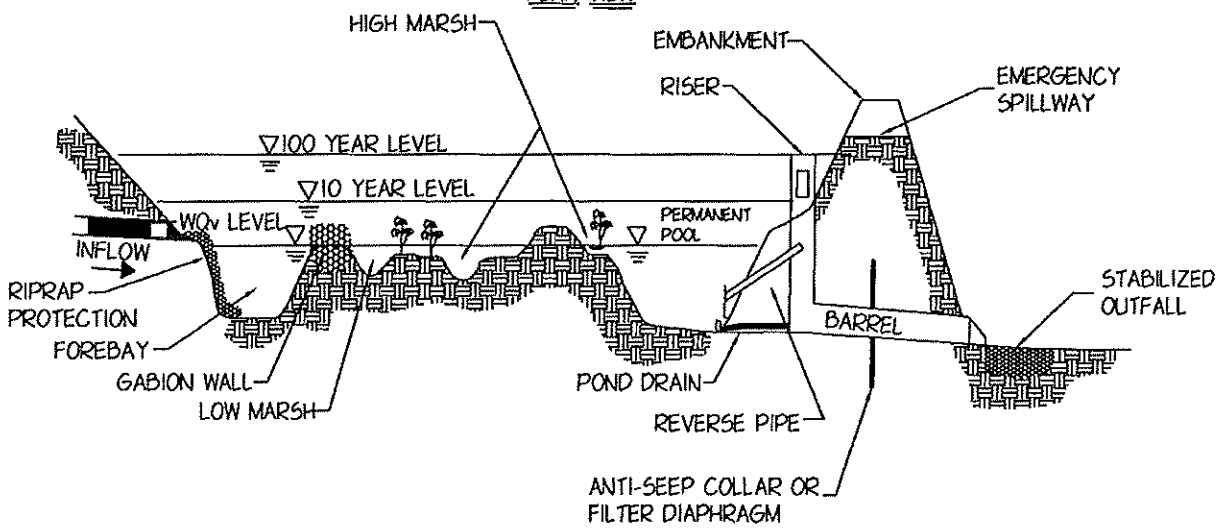
POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS

STORMWATER WETLANDS

SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-6



PLAN VIEW



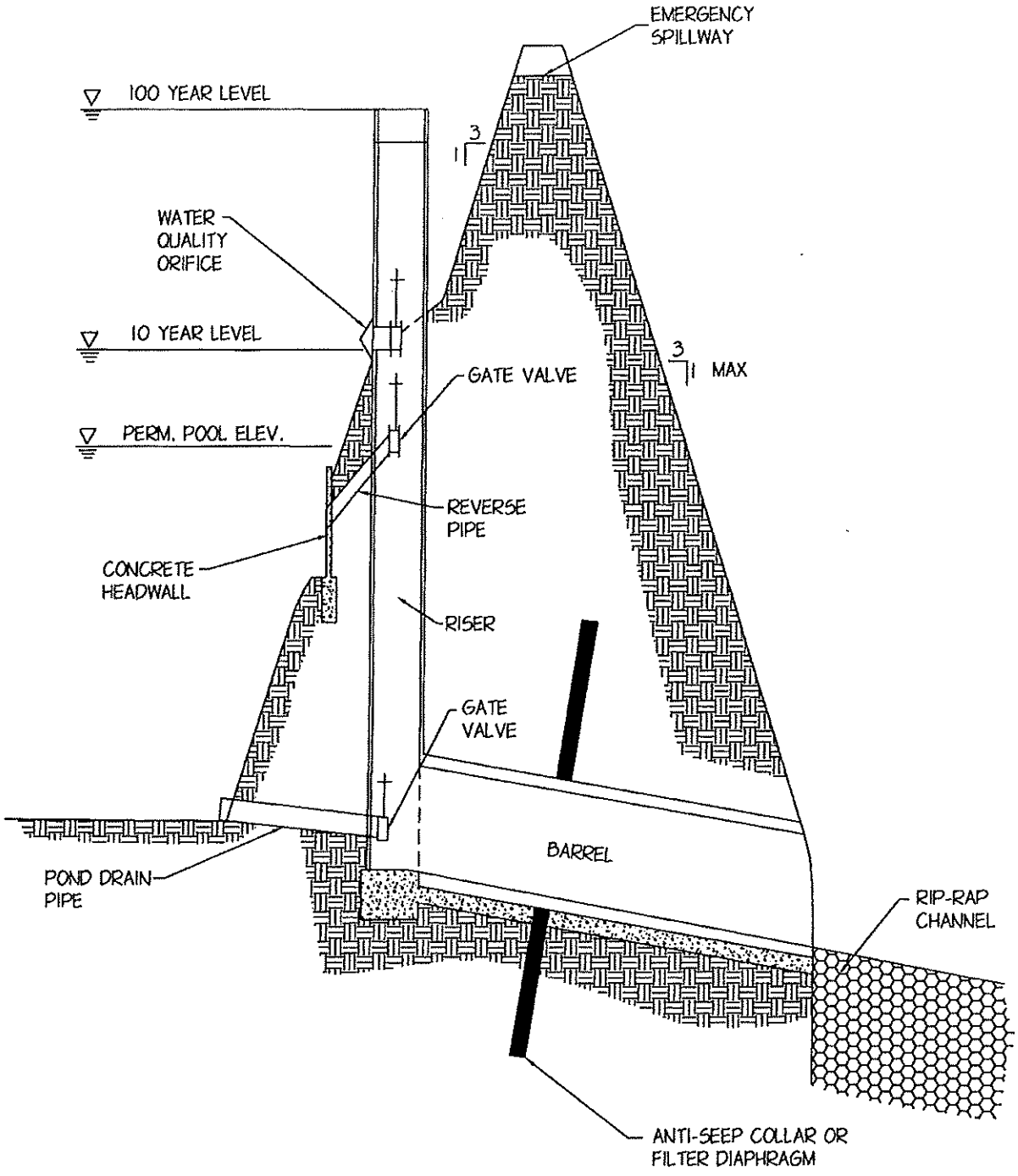
PROFILE

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS

SHALLOW WETLAND

SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-7

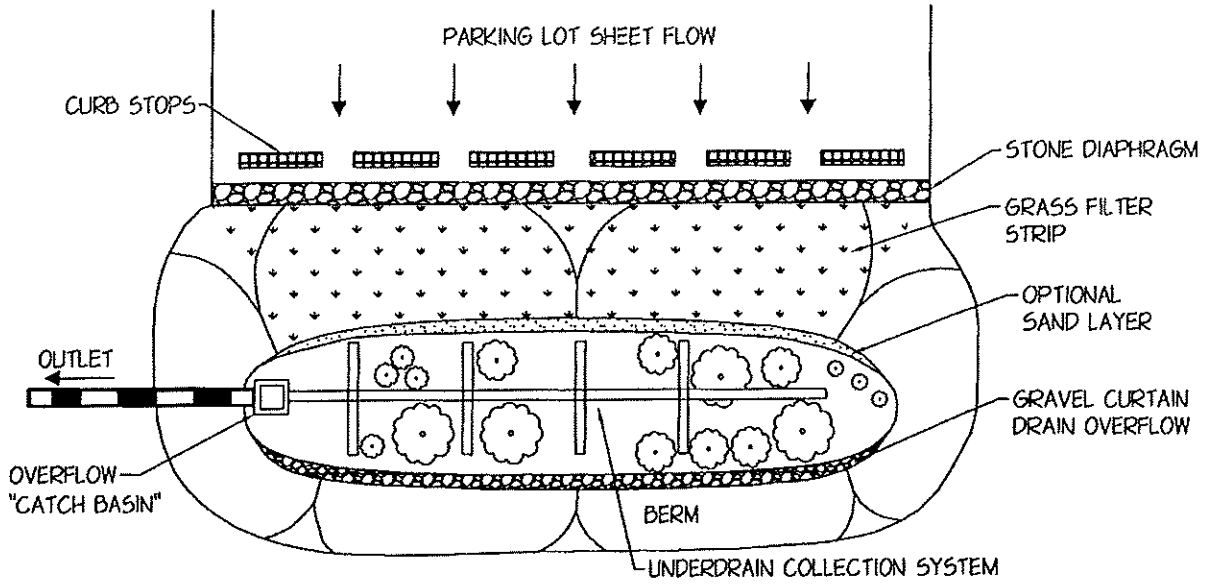


RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

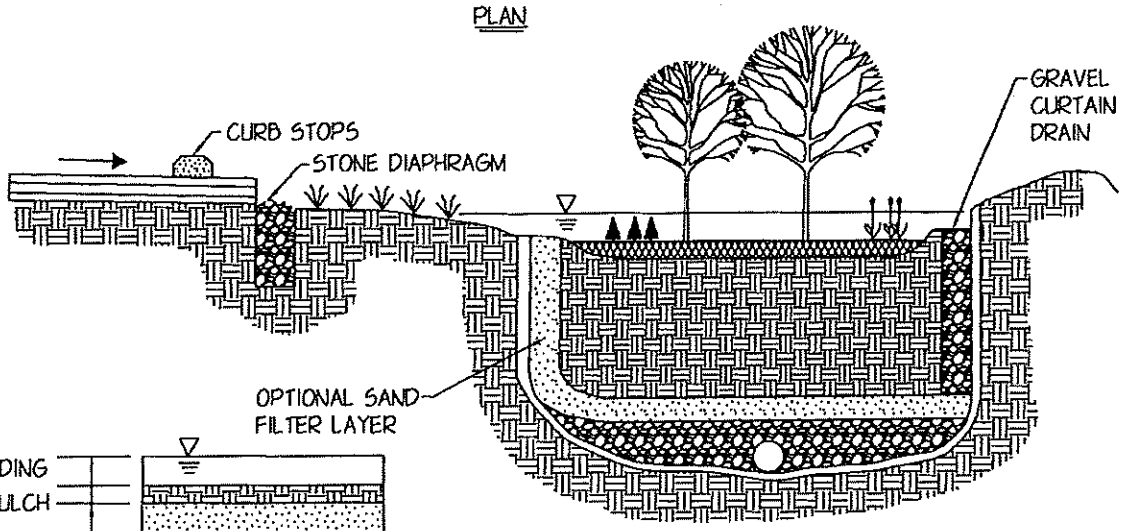
POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS

SCHEMATIC OF AN OUTLET SYSTEM

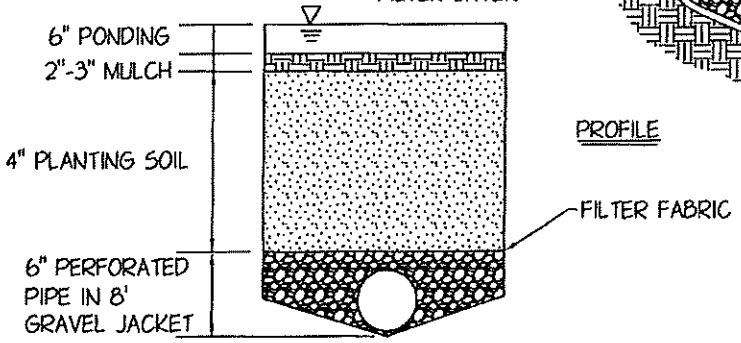
SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-8



PLAN



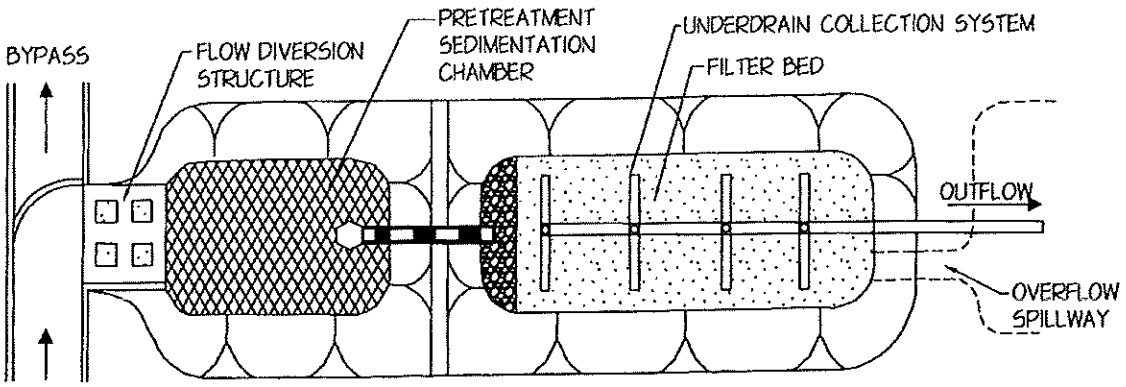
PROFILE



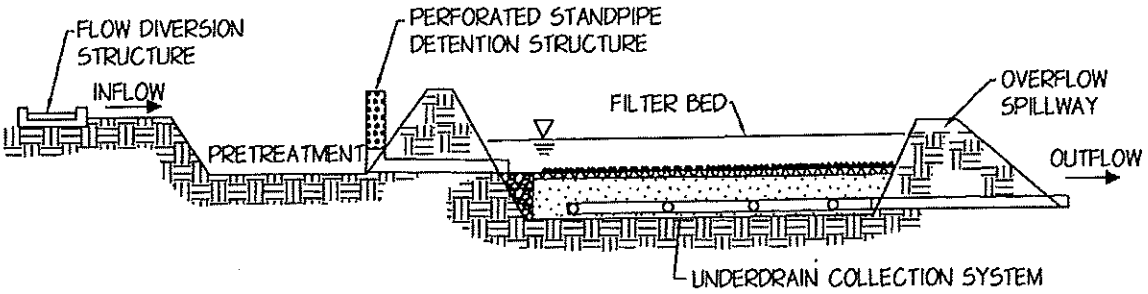
CROSS SECTION

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

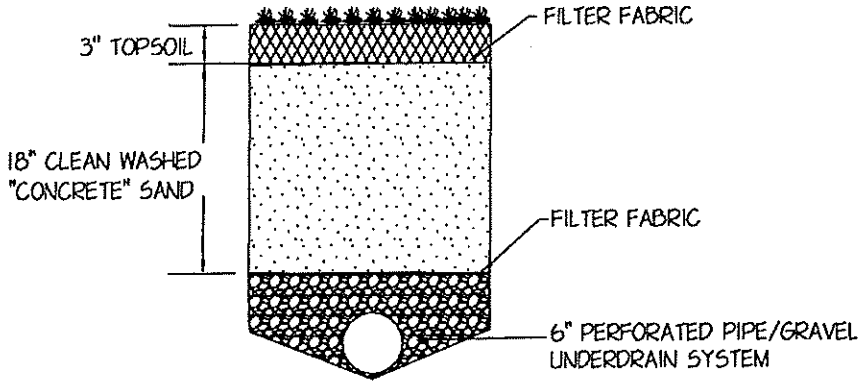
POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS		
BIORETENTION AREA		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-9



PLAN



PROFILE



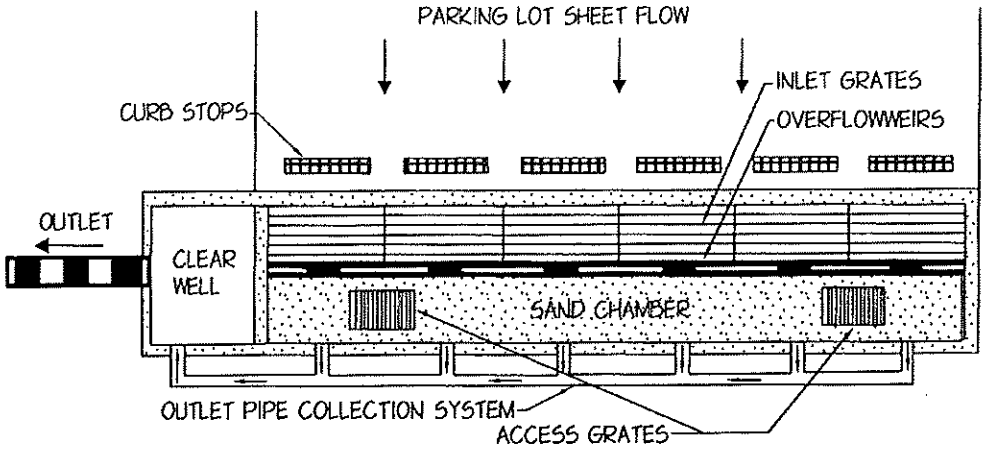
CROSS SECTION

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

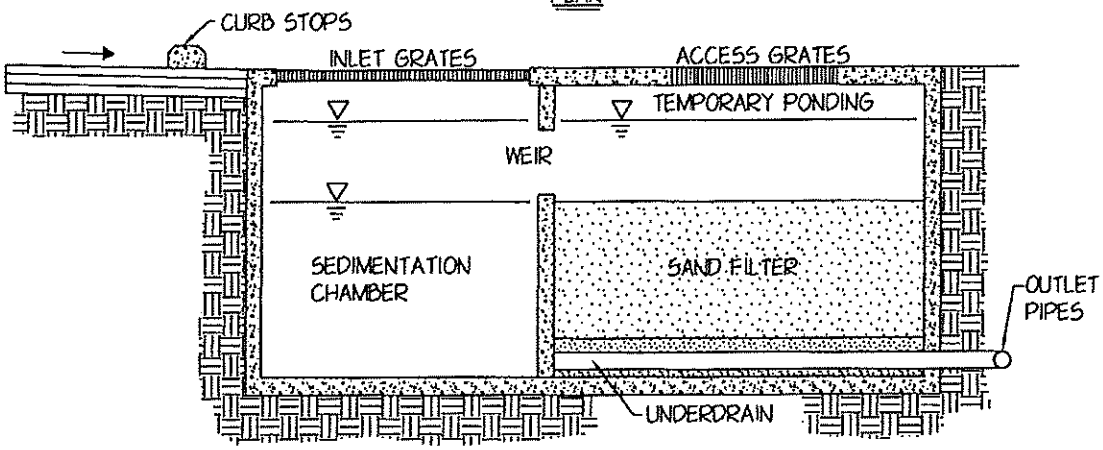
POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS

SURFACE SAND FILTER

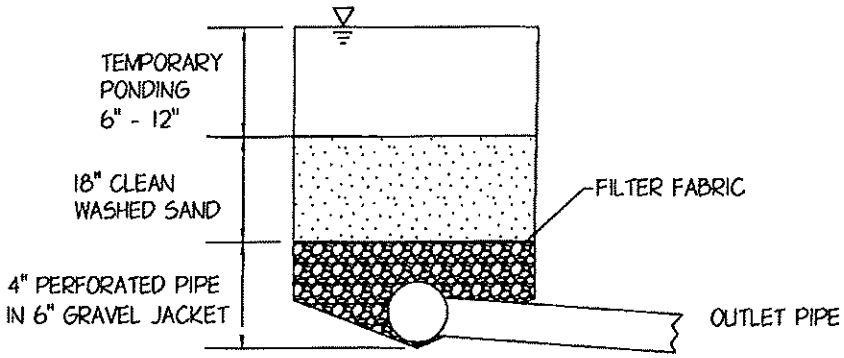
SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-10



PLAN



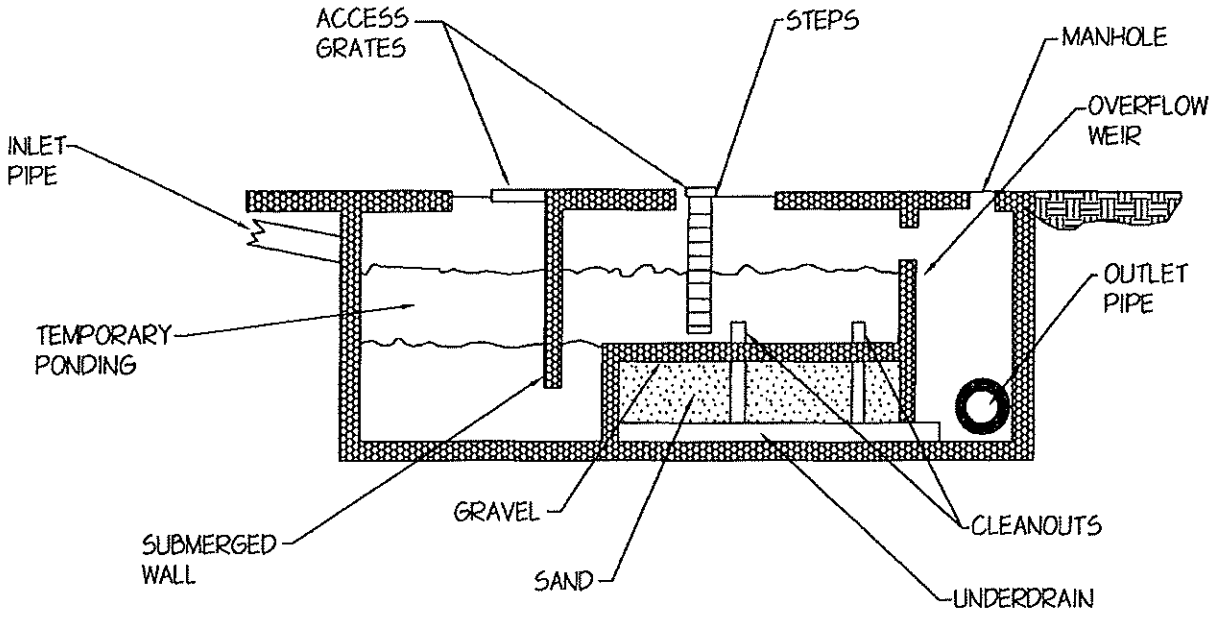
PROFILE



CROSS SECTION

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS		
PERIMETER SAND FILTER		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-11

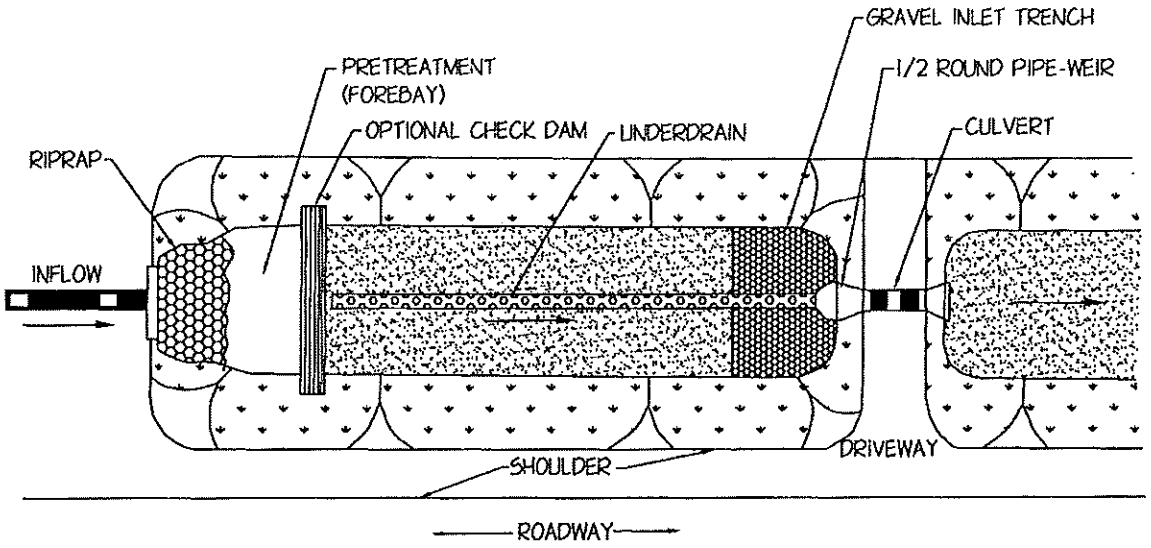


RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

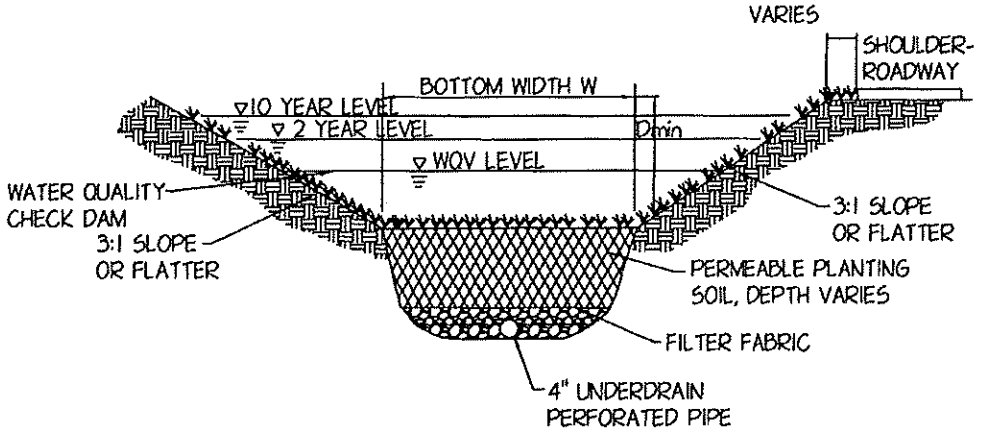
POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS

UNDERGROUND SAND FILTER

SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-12



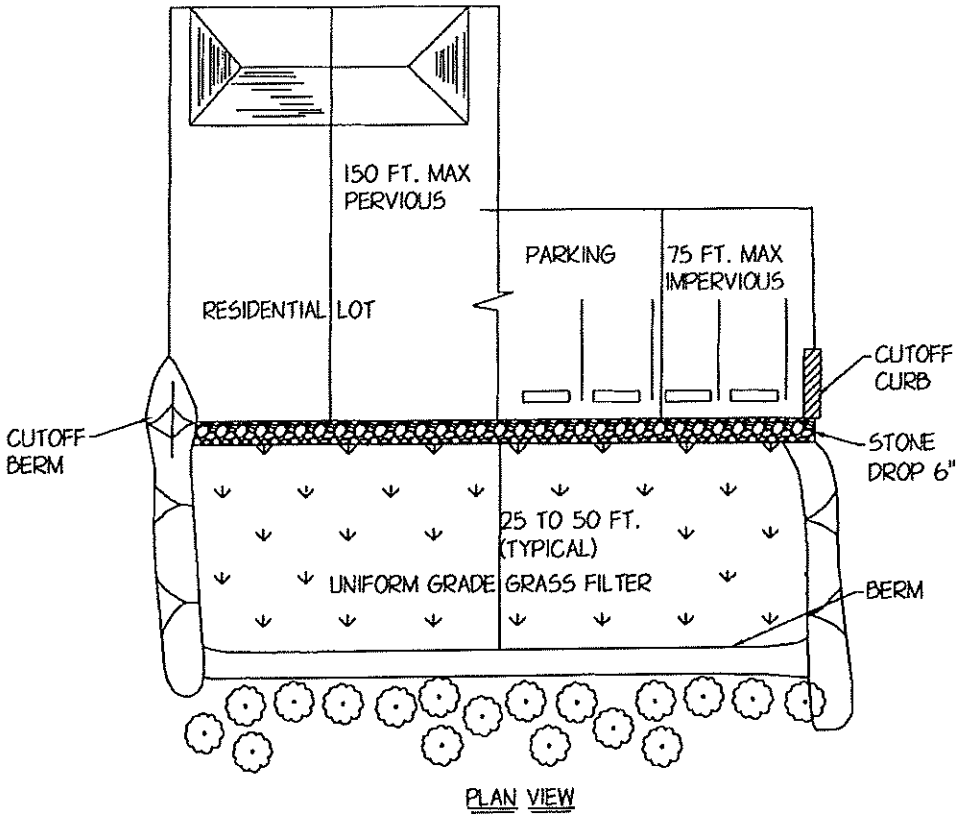
PLAN



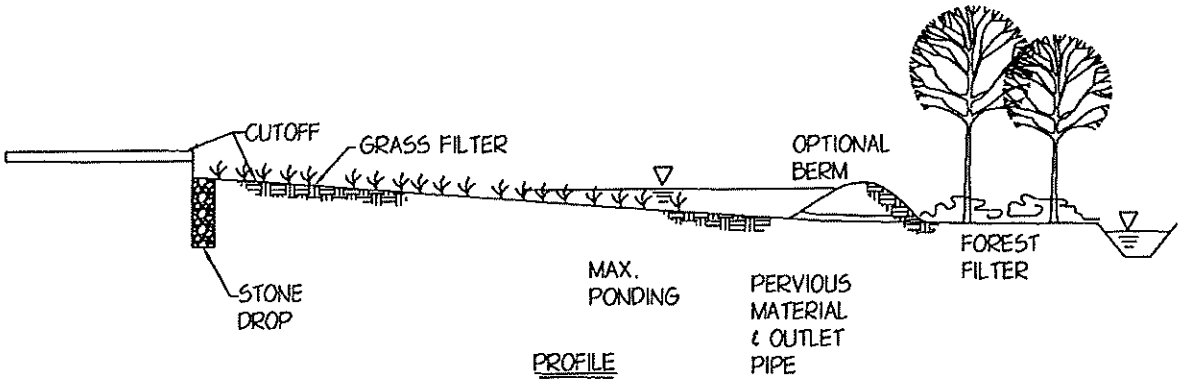
CROSS SECTION

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS		
DRY WATER QUALITY SWALE		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-13



PLAN VIEW



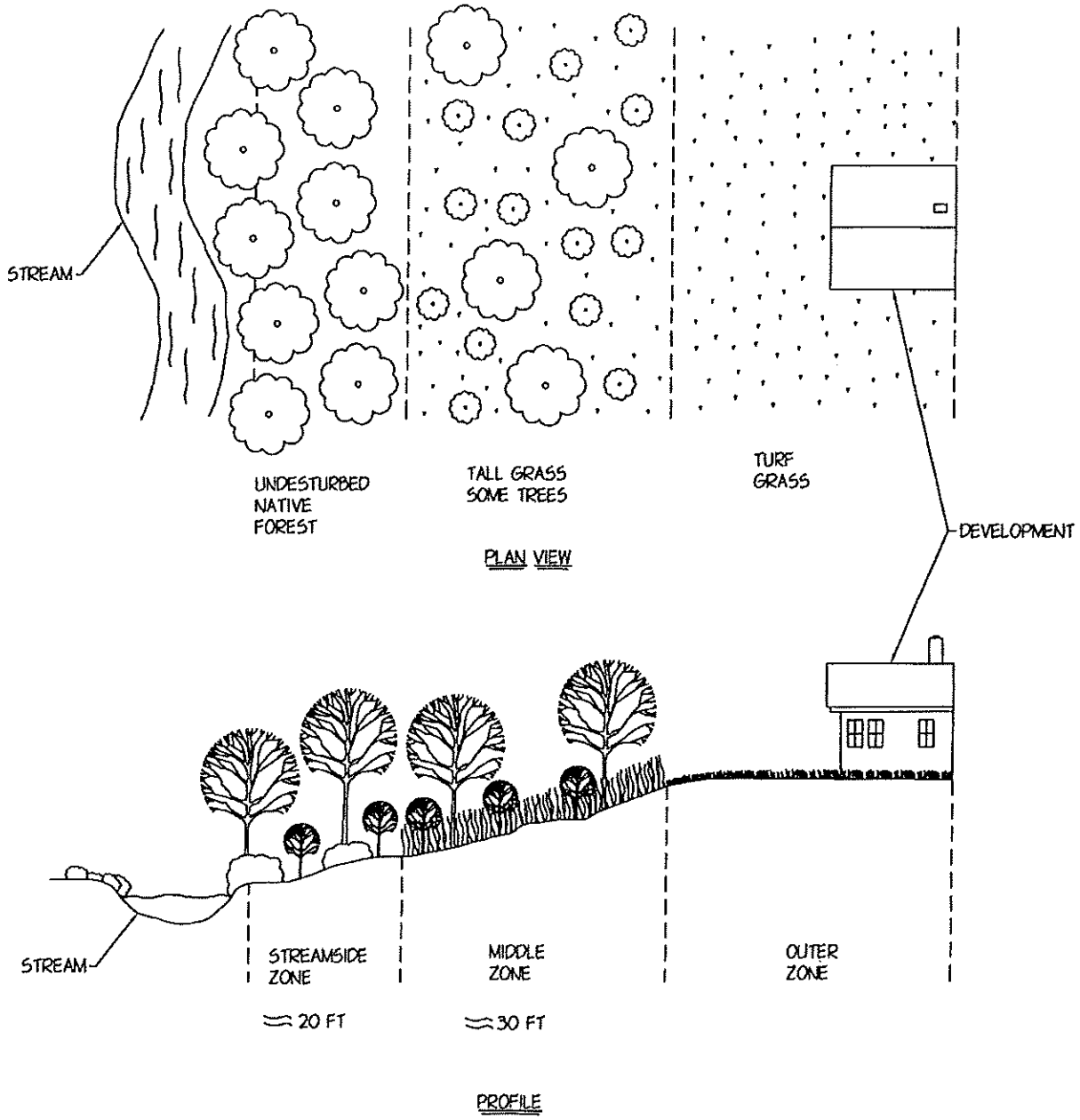
PROFILE

RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS

FILTER STRIP

SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-14



RICHMOND STORMWATER UTILITY DEVELOPMENT MANUAL

POST CONSTRUCTION STORMWATER RUN OFF CONTROL DETAILS		
RIPARIAN BUFFER ZONE		
SCALE: NONE	DATE: JAN. 2005	DWG. NO. PC-15