STORM WATER QUALITY MANAGEMENT GUIDANCE MANUAL

Prepared by

City of Houston

Harris County

Harris County Flood Control District

2001 Edition

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This manual provides general guidance for permanent non-structural and structural controls to reduce pollutants in storm water runoff from residential areas, commercial areas, light industrial areas, public facilities, and any industries not otherwise covered by Environmental Protection Agency (EPA) storm water permits in Harris County and the City of Houston. The Storm Water Management Joint Task Force (JTF), which includes Harris County, Harris County Flood Control District, and the City of Houston, has prepared this manual to satisfy National Pollution Discharge Elimination System (NPDES) storm water permit requirements established by EPA for storm water discharges from municipal separate storm sewer systems (MS4s). Emphasis is given to Best Management Practices (BMPs) that will work well in conditions specific to Harris County and the City of Houston. The manual provides information to owners, engineers, architects, and other citizens to facilitate the selection of BMPs for storm water quality control and for compliance with local regulations when adopted. The scope of this manual does not, however, include flood control design requirements, or water quality controls for construction activities. Water quality controls for the Texas Department of Transportation (TxDOT) rights-of-way are covered in a separate manual prepared by TxDOT, also a member of the JTF.

NPDES STORM WATER WEBSITE

The Storm Water Management Joint Task Force (JTF) maintains an NPDES Storm Water website at the following address:

http://www.cleanwaterclearchoice.org/

Information on updates to the *Storm Water Quality Management Guidance Manual* will be posted at the above site.

UPDATE MAILING LIST FORM

It is anticipated that this handbook will be updated periodically. If you are interested in receiving information on future updates, please complete this form and mail to:

Storm Water Management Joint Task Force
P.O. Box 131066
Houston, TX 77219

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RECORD OF AMENDMENTS

This record sheet is provided to document and summarize amendments to the *Storm Water Quality Management Guidance Manual.*

Section	Pages	Old Pages Removed (✓)	New Pages Inserted (✓)	Revision Date	Date

1.0

INTRODUCTION

1.0 INTRODUCTION

1.1 Background

The 1972 amendments to the Federal Water Pollution Control Act (also referred to as the Clean Water Act) prohibit the discharge of any pollutant to waters of the United States from a point source unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. Efforts to improve water quality under the NPDES program traditionally have focused on reducing pollutants in discharges of industrial process wastewater and from municipal sewage treatment plants. Efforts to address storm water discharges under the NPDES program have generally been limited to certain industrial categories with effluent limitations for storm water.

Based in part on its national assessments, U.S. Environmental Protection Agency (EPA) has found that non-point sources (e.g., runoff from agriculture, silviculture, and mining activities) and diffused point sources (e.g., storm water discharges from urbanized areas) are responsible for between one-third to two-thirds of existing and threatened impairments of the Nation's waters.

Congress amended the Clean Water Act (CWA) in 1987 to require the EPA to establish phased NPDES requirements for storm water discharges. To implement these requirements, on November 16, 1990, EPA published (55 *Federal Register* 47990) the initial permit application requirements for (a) 11 categories of storm water discharges associated with industrial activity, and (b) discharges from municipal separate storm sewer systems (MS4s or public drainage systems) serving a population of 100,000 or more.

The November 16, 1990 regulation established requirements of a two-part permit application designed to facilitate development of site-specific permit conditions for MS4s serving a population of 100,000 or more (e.g., the City of Houston, Harris County, the Harris County Flood Control District, and the Texas Department of Transportation). The CWA requires that NPDES permits for storm water discharges from MS4s include a requirement to effectively prohibit non-storm water discharges into the MS4 and to include controls to reduce the discharge of pollutants to the maximum extent practicable by implementation of management practices, control techniques, engineering methods, and other provisions appropriate for the control of such pollutants.

In response to the EPA municipal storm water permit requirements, the City of Houston, Harris County, the Harris County Flood Control District, and the Texas Department of Transportation (collectively, the "Permittees") formed a Storm Water Management Joint Task Force (Joint Task Force) to coordinate the preparation of the required permit applications and compliance during permit terms. EPA issued a permit, Permit No. TXS001201 (the "permit"), to the Permittees effective October 1, 1998.

The permit requirements provide Permittees an opportunity to propose appropriate management programs to control pollutants in discharges from their MS4s. Management programs required by EPA include implementing and maintaining structural and non-structural best management practices to reduce pollutants in storm water runoff from illicit sources and from residential, commercial and industrial areas to the MS4. In addition to these management programs, the Permittees are also required to reduce storm water runoff pollutants from construction sites.

Additional regulatory developments in storm water quality include Phase II regulations, which address MS4s serving less than 100,000 in population, and construction sites that disturb one or more acres but less than five acres. EPA has separate requirements and guidance for the storm water management programs of Phase II entities. Pursuant to a timetable published by EPA, Phase II entities will be generally required to seek permit coverage by March 2003. Accordingly, small construction sites that disturb one or more acres but less than five acres are not addressed in this manual at this time. Further information on the upcoming regulations can be found at the EPA Phase II and Construction Permit webpages at the following addresses:

http:\\www.epa.gov\owm\sw\phase2\

http:\\www.epa.gov\owm\sw\construction\index.htm

NPDES permitting authority was given to the Texas Natural Resource Conservation Commission (TNRCC) in 1999. New state regulations for MS4s will be promulgated in the future by TNRCC under a TPDES program. Pursuant to a timetable published by EPA, TNRCC must issue permits for small MS4s (less than 100,000 population) by March 2003. It is anticipated that TNRCC will assume permitting responsibility for large MS4s (100,000 population and over), including the Permittees, upon expiration of the current MS4 permits. The Permittees' NPDES permit expires on September 30, 2003.

1.2 Purposes of the Guidance Manual

This guidance manual has been prepared to provide guidance and criteria related to non-structural and structural controls to reduce pollutants in storm water runoff from residential areas, commercial areas, light industrial areas, and public facilities. This includes industries not otherwise covered by EPA storm water permits. Guidance for controlling pollutants at construction sites is provided in a separate document entitled, *Storm Water Management Handbook for Construction Activities,* also prepared by the Joint Task Force. The purposes of this document are as follows:

(1) To satisfy NPDES storm water permit requirements established by EPA for storm water discharges from the MS4.

(2) To be used in the jurisdictional areas of the City of Houston, Harris County and the Harris County Flood Control District as a guidance manual to facilitate compliance with local requirements for new development and significant redevelopment. Note that State highway rights-of-way under the jurisdiction of the Texas Department of Transportation will be subject to a separate guidance document prepared by the Texas Department of Transportation.

The technical guidance and best management practices (BMP) described in this manual will provide information to owners, engineers, architects, and other citizens to facilitate compliance with local requirements for new development and significant redevelopment. It should be noted that the manual is not intended to be exhaustive, but to provide an overview of the generally available options for storm water quality management in this region. Other options which may be applicable, depending on the site, are given in the sources cited. As a general guide, the manual discusses the considerations for selecting non-structural and structural controls, design and maintenance criteria, and plan requirements.

1.3 Organization of the Manual

This manual is organized to function as a user's guide to meet the purposes previously described. The remainder of the manual is organized as follows:

- **Section 2.0** provides an overview of the possible water quality impacts of storm water runoff.
- **Section 3.0** discusses the requirements of a Storm Water Quality Management Plan (SWQMP) including considerations for the selection of structural and non-structural BMPs.
- **Section 4.0** provides information for various structural and non-structural BMPs including planning considerations, design criteria and maintenance requirements.
- **Section 5.0** provides information on obtaining copies of the City of Houston ordinance and Harris County regulations pertaining to the control of storm water discharges from new development and significant redevelopment.
- **Appendix A** - Guidance for Plan Submittal and Implementation Review
- **Appendix B** - Inspection Checklists for Non-Structural (Source Control) Best Management Practices
- **Appendix C** - Inspection Checklists for Structural and Vegetative Best Management Practices
- **Appendix D** – Proposed Comprehensive Master Plans for New Development and Significant Redevelopment **(Superseded by City of Houston Ordinance and Harris County Regulations)**
- **Appendix E** – Recommended Plant List
- **Appendix F** – Acronyms and Terms
- **Appendix G -** References

1.4 Disclaimer

This guidance manual is intended to provide general guidance in managing post-construction storm water discharge from sites of new development and significant redevelopment. The technical and guidance data included in this manual have come from a number of sources. (See Appendix G.) Careful consideration must be given to selecting the most appropriate control measures based on project-specific features. Additional information from professionals, agencies, organizations, and institutions with expertise in a particular area may be required in selecting, designing, and installing the BMPs.

This guidance manual does not describe all of the requirements for storm water quality management. It is the responsibility of project sponsors, designers, and operators to have a thorough understanding of the storm water quality regulations and guidelines as they are adopted and promulgated by the agency or agencies with jurisdiction.

As stated in the Purposes of the Guidance Manual, this document was prepared as a guidance manual and is not intended to replace the need for a site-specific plan for post-construction project activities. Use of information in this document is at the sole risk of the users. Harris County, Harris County Flood Control District, the City of Houston, Texas Department of Transportation and their agents and consultants do not represent that material contained in this document is adequate for compliance with local storm water quality requirements or that it is accurate in all respects. Note that TxDOT is developing its own guidance manual for highway development.

1.5 Acknowledgements

This guidance manual contains information provided from manuals developed in other cities and states. A reference list is included in Appendix G. Permission to use material from their handbooks/manuals was granted by the Florida Department of Environmental Regulation, Metropolitan Washington Council of Governments, Lower Colorado River Authority Environmental Quality Division, Washington State Department of Ecology, and the Galveston Bay National Estuary Program, and is gratefully acknowledged. The Metropolitan Washington Council of Governments has an information number for their publications and other information, at (202) 962-3256, or write to: Information Center, Metropolitan Washington Council of Governments, 777 North Capitol Street N.E., Suite 300, Washington, D.C. 20002-4201.

The preliminary draft of this manual, published in October 1992, was distributed to more than 40 organizations and public groups for review. A second draft was published on April 29, 1993 for submittal to EPA. EPA accepted the April 1993 draft with the approval of the JTF's NPDES permit in 1998. The April 1993 draft was distributed for public comment in April 1999. The Storm Water Management Joint Task Force Technical Advisory Committee (TAC) also provided input to this manual and reviewed comments from the public. The Joint Task Force is grateful to members of the TAC and to various organizations for their effort in reviewing the draft document. As this manual continues to be updated, public input will be an important part of the revision process.

Technical Advisory Committee:

Representative	Organization
Mr. Ronnie Mullinax, P.E. (Chairperson)	Association of Consulting Municipal Engineers (ACME)
Mr. Don Conrad	Houston Contractors Association (HCA)
Mr. Theo Glanton, P.E.	Water Environment Association of Texas (WEAT)
Mr. Michael Schaffer	Greater Houston Builders Association and Houston Real Estate Council (GHBA/HREC)
Mr. Gary Struzick, P.E.	American Society of Civil Engineers (ASCE)
Mr. Robert Taylor, A.I.A., P.E.	American Institute of Architects (AIA)
Ms. Mary Ellen Whitworth, P.E.	Bayou Preservation Association (BPA)

Joint Task Force Agencies:

City of Houston	Harris County Flood Control District
Harris County	Texas Department of Transportation

Consultant to the Joint Task Force:

Turner Collie & Braden Inc.

2.0

WATER QUALITY IMPACTS OF STORM WATER RUNOFF

2.0 WATER QUALITY IMPACTS OF STORM WATER RUNOFF

2.1 Urbanization and Surface Water Quality

Urbanization tends to increase runoff from previously undeveloped areas. Surface area for infiltration is reduced by removing vegetation and increasing the extent of impervious areas. Reduced vegetation also reduces evapotranspiration. Natural surface depressions which previously provided storm water storage are cleared and graded smooth. As a result, runoff volumes, flow rates and flow velocities may increase significantly. The impacts and control measures for increased storm water quantities are addressed in drainage design manuals prepared by Harris County Flood Control District and the City of Houston.

Urban development generates short-term land disturbance and long-term land use intensification. These factors can contribute to reduced water quality. Storm Water pollutants can be generated during construction and after construction from the operation and activities of urban land use. Urban land uses include residential, commercial, industrial, transportation, public and other uses. Urban land use activities may generate wastes and residuals that, if handled improperly, can pollute storm water runoff. Increased runoff volumes and velocities from impervious areas also can increase offsite pollutant transport, further impacting receiving waters. This guidance manual focuses on the storm water quality impacts of urban land use activities after site stabilization, and the development of appropriate control measures.

2.2 Types of Storm Water Pollutants

Pollutants generated by urban land uses can be classified as floatables, sediment, nutrients, oxygen demand, oil and grease, heavy metals, toxic chemicals and bacteria. The causes and effects of these pollutants are summarized below.

Floatables:

Floatable debris includes plastic and paper products, yard refuse, metal and glass containers, tires, etc. These pollutants are relatively large, decompose slowly and degrade the visual aesthetics of the receiving waters and shorelines. They present a physical danger to vegetation and wildlife, through habitat congestion, entangling or ingestion. These pollutants originate from litter and improperly disposed refuse.

Sediment:

Suspended sediment in high concentrations can cause multiple impacts. Impacts in receiving streams may include increased turbidity, reduced light penetration, reduced prey capture for sight feeding predators, clogging of gills/filters of fish and aquatic invertebrates, and reduced angling success. Impacts in slower receiving waters such as lakes and estuaries include siltation, with subsequent smothering of benthic communities, changes in bottom substrate composition, and decreased depth (creating a need for dredging). Sediment with high clay or organic content efficiently carries trace metals and toxicants, posing a risk to benthic life upon resuspension.

Sedimentation impacts are affected by a number of interrelated site factors, including soil types, topography, surface cover and climate. The predominantly clayey soils in the Houston region have low permeability, which can result in increased runoff rates and velocities. While the flat topography of the area helps reduce the scouring effects of higher velocities, it does, however, encourage siltation. Generally, the climate of the area promotes the establishment of vegetative cover which can shield the soil and promote infiltration. However, the climates of coastal regions in Texas are subject to storms ranging from localized showers and intense thunderstorms to hurricanes.

Nutrients:

Increased phosphorus and nitrogen levels can accelerate eutrophication in downstream fresh and tidal waters. Eutrophication can lead to surface algal scums, water discoloration, odors, depressed oxygen levels, and release of toxins.

Nutrients tend to build-up on impervious surfaces. Runoff from these areas can lead to high nutrient loads. Intensively landscaped areas and wash water from outdoor cleaning activities are also potential sources of nutrients.

Oxygen Demand:

Dissolved oxygen (DO) is an indicator of water quality impact. To support aquatic life, sufficient DO must be available. Decomposition of organic matter by microorganisms depletes DO levels, especially in slower moving streams, lakes and estuaries. Rising temperature from changing weather can also deplete DO by decreasing the solubility of oxygen in water.

The degree of potential DO depletion from organic matter and microorganisms is measured by either the biochemical oxygen demand (BOD) test or the chemical oxygen demand (COD) test. Urban runoff can depress DO levels after large storms. BOD solids can accumulate in bottom sediment during storms causing anoxic (zero oxygen) conditions in shallow, slow-moving or poorly flushed receiving waters.

Generally, the greatest export of BOD is from leaking sanitary sewer systems (i.e., sewage overflow) and is therefore more often found in highly populated areas with older infrastructure. Even newer, low density suburban residential development can export moderate levels of BOD.

Oil and Grease:

Oil and grease contain a wide variety of hydrocarbons, some of which are toxic to aquatic life at low concentrations. Surface sheen is usually an indication of the presence of hydrocarbons. However, some hydrocarbons, especially weathered crankcase oil, appear in solution or emulsion and have no sheen. Hydrocarbons have a strong affinity for sediment, and much of the hydrocarbon load adsorbs onto particles and settles out. If not captured, hydrocarbons tend to accumulate in bottom sediments of lakes and estuaries.

The major source of hydrocarbons is leakage from crankcase oil and other lubricating agents from the automobile. Hydrocarbon levels generally are highest in runoff from parking lots, roads and service stations. Residential land uses typically generate less hydrocarbon export, with the exception of illegal dumping of used oil in storm sewers.

Heavy Metals:

Trace heavy metals are a concern because of their toxicity to aquatic life and the possibility of water supply contamination. The heavy metals with the highest concentrations in urban runoff are copper, lead, zinc, and cadmium. Other heavy metals may be found when inappropriate connections between sanitary and storm sewers are present. Most heavy metals adsorb to particulates, which settle out and reduce the metals immediately available for biological uptake.

Substantial sources of lead in the past have been leaded gasoline and lead-based paints. As alternative fuels and paints have been developed, lead has become less common.

Toxic Chemicals:

Other toxic chemicals present in urban runoff include pesticides, herbicides and synthetic organic compounds. Concentrations of these substances in runoff from residential and commercial areas rarely exceed current safety criteria. However, relatively little sampling of runoff has been reported from industrial areas, which might be a greater source of toxicants. Sources of pesticides, herbicides and other toxic compounds include illegally disposed or applied household hazardous wastes, such as waste oil, paint thinners, pesticides, herbicides and preservatives. (USEPA 1992a, MWCOG 1987)

Bacteria:

Bacteria levels in undiluted urban runoff usually exceed public health standards for water contact recreation. Bacteria multiply faster during warm weather, and substantial differences in bacteria populations are to be expected between summer and winter. The bacteria test, however, is a count of coliform bacteria, which are an indirect and often imprecise indicator of pathogens and viruses which may be present. Thus, the health implications may be unclear. Nonetheless, while most urban land uses export enough bacteria to exceed health standards, older and more intensively developed urban areas generally produce the greatest export. The problem is especially significant in areas that experience sanitary sewer overflows that export bacteria derived from human wastes. Areas with improperly maintained or failed septic tank systems are also potentially significant.

Sources: USEPA 1992a, MWCOG 1987, Wanielista, GBNEP 1991, Harris County, Harris County Flood Control District, City of Houston, USEPA 1980 and Winslow & Associates (1986).

2.3 Urban Land Use and Impacts on Storm Water

The impacts on storm water runoff from urban land use depend on the extent of land development, and the operations and activities of the land use. Storm water pollutant loads vary depending on the duration, intensity and frequency of individual rainfall events and more generally, on the regional climate. Studies indicate a high variability of loading rates in relation to land use and within land use categories. Table 2.1 provides data on Event Mean Concentrations (EMC) from several sources. EMCs represent average pollutant concentrations in the runoff from a storm event. The data are from the City of Houston, Harris County, and Harris County Flood Control District Part 2 NPDES permit application. The City of Houston, Harris County and Harris County Flood Control District will be conducting further studies on EMCs as part of their NPDES permit.

Table 2.1 - Range of Event Mean Concentrations and Land Use (mg/l)

Land Use	BOD_5	Total Suspended Solids	Total Nitrogen	Total Phosphorus	Oil and Grease
Undeveloped	2-13	22-565	0.66-50.20	0.10-.35	1.0-2.0
Residential	2-24	8-1340	0.72-49.70	0.08-.98	1.0-6.0
Commercial/ Industrial	4-36	5-459	0.44-33.00	0.06-.47	1.0-12.0

Source: City of Houston, Harris County and Harris County Flood Control District Part 2 NPDES permit application addendum, April 1993.

3.0

STORM WATER QUALITY MANAGEMENT PLANS

3.0 STORM WATER QUALITY MANAGEMENT PLANS (SWQMPs)

As required by the NPDES permit, the City of Houston prepared the *Proposed Comprehensive Master Plan for New Development and Significant Redevelopment in the City of Houston* (the "Master Plan" for the City of Houston), and Harris County/Harris County Flood Control prepared the *Proposed Comprehensive Master Plan for New Development and Significant Redevelopment in Harris County (Unincorporated Areas)*, (the "Master Plan" for Harris County). The master plans were the basis for the City of Houston ordinance and Harris County regulations. The ordinance and regulations require controls to reduce pollutants in discharges to the municipal separate storm sewer system (MS4) after the construction of a development is completed.

Under the ordinance and regulations, proposed new development and significant redevelopment of 5 or more acres will be required to submit **Storm Water Quality Management Plans (SWQMPs)** that propose structural, non-structural or vegetative controls to reduce pollutants in storm water runoff. The overall goal of the ordinance and regulations and the goal of SWQMPs is to reduce the discharge of pollutants into the municipal separate storm sewer system to the Maximum Extent Practicable (MEP). This manual is intended to provide guidance on the preparation of SWQMPs.

This section describes general planning and implementation procedures for SWQMPs for residential development, commercial development, light industrial development, public facility development, and significant redevelopment of five or more acres. These are general guidelines, and specific site conditions may require additional or modified measures or approaches. The SWQMP requirements discussed here address pollution arising from post-construction activities. The intended function of an SWQMP is to improve storm water quality from the normal daily operating activities of a site for the life of the development. The preparation of Storm Water Pollution Prevention Plans (SWPPPs) for storm water pollution prevention during construction is addressed in a separate guidance document, the *Storm Water Management Handbook for Construction Activities.* Other types of development/redevelopment projects for facilities that are regulated by EPA's industrial storm water permitting program should provide storm water quality control measures as required by the EPA.

3.1 Storm Water Quality Management Plan Requirements

The SWQMP functions as a mitigation plan for the potential impacts of pollution from storm water discharge from the normal operating activities of a site for the life of the development. The SWQMP should contain a site description, planned controls, and procedures for maintenance and inspection. The contents of an SWQMP are described below.

3.1.1 Site Description

A. *Site location.*

B. *Names, addresses and phone numbers of owner and contact person.*

C. *Type of development or redevelopment.*

D. *Nature of activities (Including Standard Industrial Classification Codes).*

E. *Give any existing NPDES storm water permit numbers or provide a copy of the General Permit Notice of Intent (NOI) or NPDES permit application. If the NPDES permit application or NOI is not available, a statement of intent to file an NOI or*

NPDES permit application should be provided, and a copy of the NPDES permit or NOI, when it is available, should be submitted.

F. *Estimates of the total site area and the total area affected by the development.*

G. *Site map(s).*

1. Vicinity map.
2. Areas of development.
3. Areas not to be developed.
4. Drainage areas and their acreage, patterns and approximate slopes anticipated after development.
5. Wetlands and surface waters.
6. Locations and listing of activities which may generate pollutants and potential discharge, including hazardous materials treatment, storage or disposal facilities, parking areas, loading areas, etc.
7. Locations and listing of structural controls, and non-structural controls as applicable, that are identified in the plan.
8. Locations where storm water is discharged to the MS4 and the name of the MS4 operator.

3.1.2 Controls

A. *Non-Structural Controls*

Describe non-structural best management practices (BMPs) and how they will be used at the site.

B. *Structural Controls*

Structural BMPs should be shown on construction drawings. Supporting data (e.g., specifications, calculations, etc.) should be provided upon request.

3.1.3 Maintenance

Describe procedures and qualified personnel to assure the timely maintenance of control measures.

3.1.4 Inspections

Describe inspection reporting and procedures.

3.2 Preparation of Storm Water Quality Management Plan (SWQMP)

The SWQMP should be developed in the early planning stages of a project so that the site plan can be prepared with provisions for water quality management. The SWQMP needs to be developed at a stage when site data and preliminary site plan(s) are available as background and working information. Pollution prevention principles to consider when developing the physical site plan for the project include the following:

- Use vegetation and ground cover as a method of natural filtration of runoff.
- Minimize the amount of land disturbance (i.e., clearing, grading and excavation).
- Avoid disturbing sensitive areas such as wetlands, steep or unstable slopes, and areas with erodible soils.
- Coordinate the permanent BMPs with those used during construction (e.g., swales, basins, vegetated areas, etc.)

- Reduce or alter activities to those that minimize the potential of storm water pollution.
- Enclose or cover pollution-causing activities to minimize the potential of storm water pollution.

At the heart of the SWQMP is the selection and implementation of a BMP or set of BMPs for water quality management.

BMPs are generally grouped into two categories:

- Non-structural Controls
- Structural Controls

Non-structural controls are primarily management-based activities that are generally designed to prevent or reduce the potential of storm water runoff contact with pollution-causing activities. Selection of non-structural controls is then based on land use activity.

Structural controls are constructed facilities or vegetative practices that are generally designed to reduce pollutant levels in storm water runoff. Targeted pollutants include: particulates, pollutants that bond to particulates (heavy metals), nutrients (phosphorus, nitrogen), oil and grease, oxygen demand, and to a limited extent, bacteria. Initial consideration of structural controls is based on site area. If the site drainage area(s) is less than 10 acres, vegetative practices may be used. If the drainage area(s) is 10 or more acres, vegetative practices may be used with other needed structural controls. The water quality detention basin is the primary structural control method for areas of 10 or more acres. For any site of 5 or more acres, a program of non-structural controls may be used on a case-by-case basis as an alternative to structural controls.

A general process for preparing a SWQMP is as follows.

Step 1 Collect site information.

Step 2 Develop the preliminary site map.

Step 3 Measure the site area and drainage area(s) to determine the type of controls needed.

Step 4 Select non-structural and structural controls.

Step 5 Prepare the final site map and narrative.

Step 6 Prepare the inspection and maintenance plan.

Each step is discussed in detail below.

3.2.1 Collect Site Information

Collect information related to the site which will be developed. The following items are suggested.

A. Map of Existing Conditions

A map of existing conditions at the site should be prepared. The map should be topographic and to scale. The map should indicate existing activities at the site as well as the locations of surface waters at or near the site. The map scale should be adequate to allow important features such as grassed swales and control measures to be distinguished easily.

B. Location of Discharge Point(s)

The MS4 which will receive runoff from the proposed development site should be identified.

3.2.2 Develop the Preliminary Site Map(s)

Develop a preliminary site map or maps. This may involve evaluation and refinement of the site plan for the proposed development.

When the preliminary site map or maps are complete, the following information should be included:

- Building outlines and impervious areas.
- Locations of activities which may generate pollutants.
- Locations of outfalls and possible discharges.
- Drainage areas, drainage patterns and contours. Approximate slopes after grading. Locations of sheet flow and concentrated flow should be shown.
- Proposed drainage facilities, including channels, pipes and detention basin(s). Indicate existing surface water and wetlands.
- Landscaping areas and preserved vegetation.
- Larger facilities that will be used during construction for the construction pollution prevention plan, and to be built early in the construction sequence such as sediment basins, sediment traps, etc.

3.2.3 Measure the Site Area and Drainage Areas

Estimate the total site area and the drainage areas. The total area of the site should include the area inside the project's property boundaries, easements, and rights-of-way. The size of the drainage area for each point where concentrated flow will leave the site should be determined. If the site drainage area(s) is less than 10 acres, vegetative practices may be used. If the drainage area is 10 or more acres, other structural controls are needed. For any site of 5 or more acres, a program of non-structural controls may be used on a case-by-case basis as an alternative to vegetative or structural controls.

3.2.4 Select Controls

Determine areas of potential storm water pollution and the feasibility of using structural or non-structural controls. General practices for structural and non-structural controls are listed below, and are addressed in detail in Section 4.0. For certain types of development as specified in the Master Plan, a program of non-structural controls may be used as an alternative to or in addition to structural controls. Site conditions should be carefully evaluated before applying these practices. Conditions specific to a site will require adaptation, or may restrict use of some of the practices. Site conditions may allow other practices not included in this list, and innovation is encouraged in developing such technologies for storm water quality management.

Structural Controls:

Storm Water Quality Facilities:

1. Dry basin
2. Wet basin
3. Wetland treatment
4. Other site-specific alternative

Catchment Facilities:

1. Catch basins
2. Oil/grit separator
3. Other site-specific alternative

Vegetative Practices:

1. Vegetated filter strip
2. Grassed swale
3. Other site-specific alternative

Non-Structural Controls:

1. Household hazardous materials storage/disposal
2. Litter control
3. Landscaping practices
4. Fertilizer and pesticide use
5. Fueling station practices
6. Vehicle/equipment washing and steam cleaning practices
7. Liquid materials loading and unloading practices
8. Liquids storage in aboveground tanks
9. Container storage of liquids, food wastes, and hazardous wastes
10. Spill Prevention and Response plan
11. Outdoor storage practices
12. Street sweeping
13. Inlet Stenciling
14. Other Controls (activities, programs, etc.)

3.2.4.1 Selection of Structural Controls

Structural controls are constructed facilities or vegetative practices that are designed to reduce pollutant levels in storm water runoff. Structural controls may be preliminarily selected based on drainage area. However, drainage area is only one of the factors to consider in selecting BMPs. Other considerations that may be important to the selection of structural controls include area requirements for the water quality facility, soil type and condition, vegetative and impervious cover, and type of expected pollutant from the site. Vegetative practices may be used for drainage areas of less than 10 acres. For drainage areas of 10 acres or more, water quality basins (i.e., dry basins, wet basins, etc.) are the main forms of structural control and should be used where attainable.

Impervious cover changes replace natural vegetation and open space with built facilities and manmade landscapes. This can affect site hydrology and biofiltration and processing mechanisms, which ultimately impact storm water quantity and quality. The result may be increased pollutants from the site due to more intense activity and larger storm water flows which transport the pollutants off the site.

Impervious cover may contribute to reduced habitat value of streams. Pollutants are deposited from the atmosphere, oil drips from cars on parking lots, and organic matter accumulates and runs off. Also, heavy metals that are common components of impervious covers such as metal roofing, downspouts, and galvanized pipes can corrode, leach out, and runoff into streams. Once introduced into the waterways, the pollutants can be carried downstream and can have adverse impacts on aquatic species.

When combined with intense rainfall events, the flat regional topography can produce high storm water runoff volumes. A relatively large amount of land could then be needed for the water quality basin, even when the actual pool area may be small. The different types of water quality basins have different benefits and costs. For example, wet basins typically have high amenity value but may be vulnerable to high sediment loads. Wetland treatment may be appropriate with large, level areas, and have high habitat value. Structural BMP applications are summarized in Table 3.1.

For planning purposes, an important consideration is whether detention will be required in addition to storm water quality control. It may be possible to design detention facilities to capture and release the first flush (the first 0.5-inch of runoff) over a 24 to 48 hour period and also provide effective storm water quantity control. Preliminary volume and surface area requirements of structural controls can be estimated from the drainage area and required runoff storage.

TABLE 3.1

STRUCTURAL BMP APPLICATION

BMP	Drainage Area Guidelines	Other Considerations	Section Number
Dry Basin	N/A	• Large surface area. • Potentially extensive excavation in flat areas. • Sediment testing and removal required.	4.2.1
Wet Basin	N/A	• Potential amenity value. • Large surface area. • Potentially extensive excavation in flat areas. • Affected by high sediment loads. • Sediment testing and removal required.	4.2.2
Wetland Treatment	N/A	• Potential habitat value. • Large surface area. • Affected by high sediment loads. • Requires careful design by wetland specialist. • Sediment testing and removal required.	4.2.4
Catch Basins	(N/A -included with sewer inlet design)	• Not a stand-alone BMP but may be used with other BMPs • Frequent maintenance.	4.4.1
Oil/Grit Separators	≤ 5 acres	• High cost relative to size of drainage area served. • Frequent inspection and maintenance. • For small drainage areas (maximum 5 acres). • Particularly vulnerable to high sediment loads.	4.4.2
Grassed Swales	≤ 10 acres (>10 acres will require additional structural control(s).)	• Unsuitable for slopes > 5%. • Requires careful design when near foundation. • Particularly vulnerable to high sediment load. • Less effective in areas with high water table, due to less exfiltration.	4.5.1
Vegetated Filter Strips	≤ 10 acres (>10 acres will require additional structural control(s).)	• For 10% or flatter slopes. • Requires careful design when near foundation. • Particularly vulnerable to high sediment load. • Less effective in areas with high water table, due to less exfiltration.	4.5.2

3.2.4.2 Selection of Non-Structural Controls

Table 3.2 lists typical pollutant-causing activities that could after development along with potential non-structural controls that may be appropriate to address those activities. This could be used as preliminary aid to evaluate applicable non-structural controls.

Table 3.3 lists different land use categories and possible applicable non-structural controls, based on generalized cases contained in the referenced sources in Appendix G. The purpose of the table is to show how non-structural controls can be used in these cases. The appropriateness and specific application of a control or set of controls will depend on site conditions. The table is not exhaustive and additional land uses and controls could be included.

Table 3.2 – Applicable Non-Structural Controls

Potential Pollutant-Causing Activity	Activity Located on Site (✓)	Applicable Non-Structural Control	Ref. #
Uncovered vehicle parking	____	Street Sweeping	4.1.12
Trash disposal	____	Litter Control	4.1.2
Washing of vehicle or equipment	____	Vehicle/Equipment Washing and Steam Cleaning	4.1.6
Vehicle or equipment fueling	____	Fueling Station	4.1.5
Loading or unloading of liquid materials	____	Liquid Materials Loading and Unloading	4.1.7
Storage of raw materials, by-products or products of manufacturing processes	____	Outdoor Storage Outdoor Manufacturing Spill Prevention and Response Plan	4.1.11 4.1.12 4.1.10
Above-ground bulk storage of fuel, petroleum or chemicals	____	Liquids Storage in Aboveground Tanks Liquid Materials Loading and Unloading Spill Prevention and Response Plan	4.1.8 4.1.7 4.1.10
Underground tanks	____	Liquid Materials Loading and Unloading Spill Prevention and Response Plan	4.1.7 4.1.10
Use of pesticides or fertilizers	____	Household Hazardous Materials Storage/Disposal Landscaping Practice Fertilizer and Pesticide Use	4.1.1a 4.1.2 4.1.4
Temporary storage of liquid or solid wastes	____	Liquids Storage in Aboveground Tanks	4.1.8
Type of waste:			
Hazardous waste	____	Container Storage of Liquids Spill Prevention and Response Plan	4.1.9 4.1.10
Food waste	____	Container Storage of Liquids Spill Prevention and Response Plan	4.1.9 4.1.10
Used oil/antifreeze	____	Container Storage of Liquids Spill Prevention and Response Plan	4.1.9 4.1.10
Underground drainage system	____	Household Hazardous Materials Storage/Disposal (recycling oil/antifreeze) Inlet Stenciling	4.1.1a 4.1.13
ANY OTHER ACTIVITIES NOT COVERED ABOVE: ______________________			

TABLE 3.3: NON-STRUCTURAL CONTROL MATRIX

	Household Hazardous Materials Storage/Disposal (4.1.1)	Litter Control (4.1.2)	Landscaping Practices (4.1.3)	Fertilizer and Pesticide Use (4.1.4)	Fueling Station Practices (4.1.5)	Vehicle/Equipment Washing and Steam Cleaning Practices (4.1.6)	Liquid Materials Loading and Unloading Practices (4.1.7)	Liquids Storage in Above Ground Tanks (4.1.8)	Container Storage of Liquids, Food Wastes, Hazardous Wastes (4.1.9)	Spill Prevention and Response Plan (4.1.10)	Outdoor Storage Practices (4.1.11)	Street Sweeping (4.1.12)	Inlet Stencilling (4.1.13)
LAND USE:													
MANUFACTURING BUSINESSES:													
Cement		●				●	●	●	●	●	●	●	●
Chemicals		●				●	●	●	●	●	●	●	●
Concrete Products		●			●	●	●	●	●	●	●	●	●
Electrical Products		●				●	●	●	●	●	●	●	●
Food Products		●				●	●	●	●	●	●	●	●
Glass Products		●				●	●	●	●	●	●	●	●
Machinery And Equipment		●			●	●	●	●	●	●	●	●	●
Metal Products		●				●	●	●	●	●	●	●	●
Paper And Pulp Mills		●			●	●	●	●	●	●	●	●	●
Paper Products		●				●	●	●	●		●	●	●
Petroleum Products		●			●	●	●	●	●		●	●	●
Printing And Publishing		●				●	●	●	●	●		●	●
Rubber And Plastic Products		●				●	●	●	●	●	●	●	●
Ship And Boat Building/Repair Yards		●				●	●	●	●	●		●	●
Wood Products		●				●	●	●	●	●	●	●	●
Wood Treatment		●		●		●	●	●	●	●	●	●	●
TRANSPORTATION AND COMMUNICATION:													
Airfields/Aircraft Maintenance		●			●	●	●	●	●	●		●	●

TABLE 3.3: NON-STRUCTURAL CONTROL MATRIX, continued

	Household Hazardous Materials Storage/Disposal (4.1.1)	Litter Control (4.1.2)	Landscaping Practices (4.1.3)	Fertilizer and Pesticide Use (4.1.4)	Fueling Station Practices (4.1.5)	Vehicle/Equipment Washing and Steam Cleaning Practices (4.1.6)	Liquid Materials Loading and Unloading Practices (4.1.7)	Liquids Storage in Above Ground Tanks (4.1.8)	Container Storage of Liquids, Food Wastes, Hazardous Wastes (4.1.9)	Spill Prevention and Response Plan (4.1.10)	Outdoor Storage Practices (4.1.11)	Street Sweeping (4.1.12)	Inlet Stencilling (4.1.13)
Fleet Vehicle Yards		●			●	●	●	●	●	●		●	●
Railroads		●		●	●	●	●	●	●	●	●	●	●
Private Utility Corridors		●	●						●			●	●
Warehouses And Miniwarehouses		●					●		●	●		●	●
WHOLESALE AND RETAIL BUSINESSES:													
Gas Stations		●			●	●	●	●	●	●		●	●
Recyclers And Scrap Yards		●				●	●	●	●	●		●	●
Restaurants/Fast Food		●					●		●	●		●	●
General Merchandise		●			●	●			●	●		●	●
Vehicle And Equipment Dealers		●			●	●	●	●	●	●		●	●
Nurseries And Building Materials		●		●	●	●			●	●	●	●	●
Chemicals And Petroleum		●		●	●	●						●	●
Foods And Beverages		●			●	●	●	●	●	●		●	●
SERVICE BUSINESSES:													
Commercial Car And Truck Washes		●			●	●				●		●	●
Equipment Repair		●			●	●	●		●	●		●	●
Laundries And Cleaning Services		●					●	●	●	●		●	●
Marinas And Boat Clubs		●			●	●	●	●	●	●		●	●
Professional Services		●				●	●	●	●	●		●	●
Vehicle Maintenance/Repair		●			●	●	●	●	●	●		●	●
Construction Businesses		●				●	●	●	●	●		●	●
SINGLE FAMILY RESIDENCES	●	●	●	●									●

TABLE 3.3: NON-STRUCTURAL CONTROL MATRIX, continued

	Household Hazardous Materials Storage/Disposal (4.1.1)	Litter Control (4.1.2)	Landscaping Practices (4.1.3)	Fertilizer and Pesticide Use (4.1.4)	Fueling Station Practices (4.1.5)	Vehicle/Equipment Washing and Steam Cleaning Practices (4.1.6)	Liquid Materials Loading and Unloading Practices (4.1.7)	Liquids Storage in Above Ground Tanks (4.1.8)	Container Storage of Liquids, Food Wastes, Hazardous Wastes (4.1.9)	Spill Prevention and Response Plan (4.1.10)	Outdoor Storage Practices (4.1.11)	Street Sweeping (4.1.12)	Inlet Stencilling (4.1.13)
MULTIFAMILY RESIDENCES	●	●	●	●		●			●			●	●
PUBLIC FACILITIES													
Public Buildings And Streets		●			●		●		●	●		●	●
Vehicle And Equipment Maintenance Facilities		●			●	●	●	●	●	●	●	●	●
Maintenance Of Open Space		●	●	●									●
Maintenance Of Public Storm Water Facilities		●										●	●
Maintenance Of Roadside Vegetation/Ditches		●	●	●									
Maintenance Of Public Utilities Corridors		●	●	●					●				
Maintenance Of Water And Sewer Facilities									●				●
Port Districts		●			●	●	●	●	●	●	●	●	●
INSTITUTIONAL													
Schools		●	●	●					●			●	●
Hospitals		●	●				●		●			●	●
Sports Facilities (Stadia)		●	●	●		●			●		●	●	●
OPEN SPACE													
Golf Courses		●	●	●					●		●	●	●
Parks		●	●	●								●	●

3.2.5 Prepare the Final Site Map and Narrative

After the preliminary evaluation of non-structural and structural controls, the final site map can be prepared. Structural control measures and non-structural measures, where feasible, should be indicated on the site map. Describe in narratives those non-structural control measures that are not shown on the site map. Coordination with the construction pollution prevention plan may be discussed as appropriate.

3.2.6 Prepare the Inspection and Maintenance Plan

The owner of the control measures will be responsible for inspecting and maintaining the controls that are used. When construction is completed, all structural and non-structural controls should be inspected, at a minimum, according to the schedules specified in Section 4.0.

It is important to plan for the inspection and maintenance of the structural and non-structural measures that are part of the plan. Control measures must be in good working condition to serve their pollution control function. Improperly maintained controls may become nuisances and lose their ability to remove pollutants or to protect against pollution. Analytical testing should be conducted on material prior to removal from structural or non-structural controls to plan for proper disposal. The plan should address testing and disposal of material to be removed during maintenance activities. Testing requirements from disposal facilities and TNRCC regulations should be consulted to ensure that the appropriate analytical tests are included in the plan.

It is recommended that an inspection and maintenance checklist which addresses each of the control measures proposed for the project be developed and included with the SWQMP. The inspector should complete a copy of the checklist during each inspection. Sample checklists are given in Appendices B and C.

The maintenance plan should include provisions for continued implementation. Provisions for funding the maintenance plan should be well documented.

4.0

BEST MANAGEMENT PRACTICES

4.0 BEST MANAGEMENT PRACTICES (BMPs)

This section provides descriptions of various structural and non-structural best management practices (BMPs) that based on current information are the most applicable to and feasible in the Houston region. The material presented is intended to provide general guidance only and is a compilation of available information from many sources (See Appendix G). Careful consideration must be given to selecting and sizing the most appropriate control measures based on site-specific features. Additional input from professionals, agencies, organizations, and institutions with expertise in a particular area may be required in selecting, designing and installing the BMPs.

The BMPs contained herein were screened and modified for their applicability and feasibility in this region considering the largely clayey soils and flat topography constraints. It is expected that new BMPs and additional information based on local experience will be added as they become available. Construction-related control measures are not included in this document, but are discussed in a separate volume, *Storm Water Management Handbook for Construction Activities* prepared by Harris County/Harris County Flood Control District and the City of Houston.

The following groups of BMPs are covered:

4.1 Non-Structural Controls
4.2 Storm Water Quality Basins
4.3 Infiltration/Filtration Facilities
4.4 Catchment Facilities
4.5 Vegetative Practices
4.6 Low Impact Development

4.1 Non-Structural Controls

Non-structural control BMPs are primarily management-based practices that are designed to prevent or reduce the potential of storm water runoff contact with pollution-causing activities. This contrasts with vegetative and structural practices, which are generally designed to reduce pollutant levels in storm water runoff. Where applicable, these management-based practices can be and are encouraged to be used by owners of individual residences, residential developments, commercial/institutional developments, and various industries.

Various applicable non-structural controls are described in the following sections:

4.1.1 Household Hazardous Materials Storage/Disposal
4.1.2 Litter Control
4.1.3 Landscaping Practices
4.1.4 Fertilizer and Pesticide Use
4.1.5 Fueling Station Practices
4.1.6 Vehicle/Equipment Washing and Steam Cleaning Practices
4.1.7 Liquid Materials Loading and Unloading Practices
4.1.8 Liquids Storage in Aboveground Tanks Practices
4.1.9 Container Storage of Liquids, Food Wastes, Hazardous Wastes
4.1.10 Spill Prevention and Response Plan
4.1.11 Outdoor Storage Practices
4.1.12 Outdoor Manufacturing Practices
4.1.13 Street Sweeping
4.1.14 Recycling (Oil/Anti-Freeze)
4.1.15 Inlet Stenciling

4.1.1 Household Hazardous Materials Storage/Disposal

A. Description

Storage and disposal of household chemicals, cleaners, polishes, solvents, paints, etc. using alternative products where feasible.

B. Purpose

Eliminate hazardous substances by using nontoxic products where feasible, and to prevent storm water runoff contact with toxic or hazardous substances through proper storage and disposal.

C. Planning Considerations and Guidelines

The following are adapted from the Galveston Bay Area Resident's Handbook.

Storage:

General storage directions for household hazardous products:

- Keep products in their original containers with original labels
- Store in a cool, dry place
- Keep products out of reach of children and pets
- Regularly check containers; place a leaky container inside another container and label accordingly

- Store incompatible chemical products separately
- Secure lids tightly

Alternatives and Disposal:

Tables 4.1 and 4.2 provide guidelines for alternatives to various common household hazardous materials, and for their proper disposal.

Table 4.1 - Alternatives to Household Hazardous Materials

Products	Alternatives
Paints:	
• Enamel and oil based paints (*flammable and toxic*)	Latex or water based paint
• Latex or water based paints (*toxic*)	Limestone-based whitewash casein-based paints
• Stains/finishes (*flammable and toxic*)	Latex paint or natural earth pigment finishes
Cleaning Products:	
• Oven Cleaners (*corrosive and toxic*)	Baking soda, water, and steel wool pads
• Toilet cleaners (*corrosive, toxic, irritant*)	Toilet brush and baking soda mild detergent
• Disinfectants (*corrosive and toxic*)	1/4 to 1/2 cup borax in one gallon hot water
• Drain cleaner (*corrosive and toxic*)	Plunger or snake; flush with boiling water, 1/4 cup baking soda, and 2 ounces vinegar
• Ammonia and all purpose cleaners (*corrosive, toxic, irritant*)	For surfaces: vinegar, salt, and water mix; For bathroom: baking soda and water Also: 1/2 cup borax, 1/2 teaspoon liquid soap, 2 teaspoon TSP (a mineral available in hardware stores) in two gallons of water
• Rug and upholstery cleaners (*corrosive and toxic*)	Sprinkle baking soda on rug, then vacuum
• Floor and furniture polish (*flammable and toxic*)	One part lemon juice and two parts olive or vegetable oil
• Laundry bleach (*corrosive and toxic*)	1/2 cup white vinegar, baking soda, or borax
• Mothballs (*toxic*)	Cedar chips, newspapers, lavender flowers
• Metal polishes (*toxic*)	For brass and copper: lemon and salt or lemon and baking soda For chrome: apple cider vinegar For silver: Paste of calcium carbonate (a powder available at drug stores) and olive oil - allow to dry before polishing with a soft, white cloth

Adapted from Galveston Bay National Estuary Program (GBNEP)

TABLE 4.2 - DISPOSAL CHART

➘ Products that could be poured down your drain when diluted with plenty of water. **(*Always check label first: Household hazardous wastes that are not designed for disposal into the sanitary system should be properly disposed by other means).**

■ Materials than can be safely dumped only in a sanitary landfill

● Hazardous wastes that should be properly disposed of by a licensed hazardous waste operator.

▲ Recyclable materials

Type of Waste	➘ (Drain*)	■ (Landfill)	● (Hazardous)	▲ (Recycle)
KITCHEN:				
Aerosol cans (empty)		■		
Aluminum cleaners	➘			
Ammonia based cleaners	➘			
Bug sprays			●	
Drain cleaners	➘			
Floor care products			●	
Furniture polish			●	
Metal polish with solvent			●	
Window cleaner	➘			
Oven cleaner (lye base)		■		
BATHROOM:				
Alcohol based lotions (aftershaves, perfumes, etc.)	➘			
Bathroom cleaners	➘			
Depilatories	➘			
Disinfectants	➘			
Permanent lotions	➘			
Hair relaxers	➘			
Medicine (expired)	➘			
Nail polish (solidified)		■		
Toilet bowl cleaner	➘			
Tub and tile cleaners	➘			
GARAGE:				
Antifreeze			●	▲
Automatic transmission fluid			●	
Auto body repair products				▲
Battery acid (or battery)			●	▲
Brake fluid			●	
Car wax with solvent			●	
Diesel fuel			●	▲
Fuel oil			●	▲
Gasoline			●	▲
Kerosene			●	▲

Type of Waste	➘ (Drain*)	■ (Landfill)	● (Hazardous)	▲ (Recycle)
Metal polish with solvent			●	
Motor oil			●	▲
Other oils			●	
Windshield washer solution	➘			
WORKSHOP:				
Aerosol cans (empty)		■		
Glue (solvent based)			●	
Paint brush cleaner with solvent			●	▲
Paint brush cleaner with TSP	➘			
Paint-auto			●	
Paint-latex (dried)		■		
Paint-model			●	
Paint-oil based			●	
Paint stripper			●	
Paint thinner			●	▲
Primer			●	
Turpentine			●	▲
Varnish			●	
Wood preservative			●	
GARDEN LANDSCAPING:				
Fertilizer		■		
Fungicide			●	
Herbicide			●	
Insecticide			●	
Rat poison			●	
Weed killer			●	
MISCELLANEOUS:				
Ammunition			●	
Artists' paints, mediums			●	
Fiberglass epoxy			●	
Gun cleaning solvents			●	
Lighter fluid			●	
Batteries			●	
Mothballs			●	
Photographic chemicals (unmixed)			●	
Photographic chemicals (mixed and properly diluted)	➘			
Shoe polish		■		
Swimming pool acid			●	

Adapted from Galveston Bay Residents' Handbook, Galveston Bay National Estuary Program (1992).

4.1.2 Litter Control

A. Definition

Removal of litter from developed areas before runoff or wind moves these materials to receiving waters.

B. Purpose

To prevent litter from becoming storm water pollution primarily as floatables in receiving waters as well as improving the aesthetics of the development and receiving waters.

C. Planning Considerations and Guidelines

Major sources of litter, which should be the target of an effective litter control program are listed below.

1. *Household Waste*: Routine wastes in residential areas should be securely contained in garbage can, dumpster, bags, etc. Reduction of solid wastes through recycling should be promoted.
2. *Commercial and Industrial Wastes*: Wastes should be securely contained. Frequent inspection is recommended for day-to-day cleanliness of the immediate area around storage areas. Clean up material that may be spilled during pickups. Litter containers should be conveniently placed and dumped frequently to prevent overflow.
3. *Hauling Vehicles*: Haulers of any loose material should cover the load in transit. Trucks and other hauling equipment should have sealed bottoms to prevent leaks or seepage.
4. *Loading Docks*: Loading docks can generate large volumes of litter. Docks should be swept on a daily basis when in use, with a minimum frequency of once a month when not in use. Sweeping should avoid generating dust to minimize airborne particles. Sweeping should include capture and proper disposal of debris swept.
5. *Construction Site*: Construction activities yield large amounts of solid waste. Use the practices listed in the *Storm Water Management Handbook for Construction Activities*, and other sources.
6. *Motorists and Pedestrians*: Vacant lots and other vegetated areas should be made secure as feasible against illegal dumping. Litter bags or baskets can be provided for use in vehicles. Periodic site clearing should be provided as needed.

There are four major components of a good litter control program.

1. Technology: In addition to collection equipment and personnel, a secure and safe means must be provided for proper disposal including land-filling the collected litter or transferring it to users who will recycle it.
2. Periodic Cleanup Campaigns: To ensure continuing results, clean up campaigns should be conducted periodically.
3. Education: If users remain apathetic or do not comply with the program, it is doomed to failure. Information programs should be developed to educate users of the importance of the program. Signs can be posted on curbside inlets to

encourage litter prevention.

4. Monitoring and Reinforcement: Compliance with the program guidelines is basic to the success of any litter control program. Checkups and special recognition or rewards conducted promptly in the wake of special cleanup campaigns may be particularly effective for establishing a climate of acceptance.

Sources: Florida Department of Environmental Regulation, Minnesota Pollution Control Agency, Environmental Protection Agency 1992b, and Harris County, Harris County Flood Control District and City of Houston.

4.1.3 Landscaping Practices

A. Definition

Lawn care and landscaping practices using native species, where feasible.

B. Purpose

Reduce maintenance requirements such as fertilizer, pesticide and water by using native or low maintenance species resulting in a reduction of exports of nutrients and toxics.

C. Planning Considerations and Guidelines

If possible for new developments, plan for retention of existing vegetation and use of native species in the site design stage. This can be initiated with the construction site erosion and sediment control plan.

Watering and Mowing Guidelines: The most effective, cost-saving approach is to water deeply, yet not more than every five or six days. This allows lawns and plants to develop deep roots which provide greater resistance to disease, periods of drought, and freezing weather. Lawns should be watered until the soil is damp five to six inches below the surface. Generally this requires about an inch of water. An inch of water takes the average sprinkler about three hours to produce.

Morning hours before 10:00 are ideal for watering. Less evaporation occurs because the air temperature and ground are cool and sunlight is not intense. Avoid midday or late afternoon watering as up to a third of water is lost to evaporation. Avoid evening watering as lawns and plants become more disease prone when left wet at night.

For the first mowing in the spring, cut the grass fairly short. This will clear out old thatch which can prevent new growth from emerging. Don't bag clippings if possible. Leave them on the lawn to provide nutrients, use a mulching blade or mulching mower if possible.

For later mowings, mow grasses so they remain relatively high (two to four inches). Taller grass helps the soil retain moisture. Lawns that are cut short require more water because they do more growing than mature grass left taller. Once a “taller” lawn is established, mowing time is reduced by about one-third.

Maintain lawn equipment in good condition. A dull mower blade will tear rather than cut grass, leaving it ragged and stressed.

Practice good housekeeping with general lawn maintenance. Bag trash and refuse.

Do not dispose of clippings and leaves into storm inlets.

Suggested plants: See Appendix E for lists of open water/deep marsh plants, shallow emergent marsh plants, dry prairie grasses, wildflowers, trees, and shrubs.

4.1.4 Fertilizer and Pesticide Use

A. Definition

Proper application of fertilizers and pesticides so as to minimize the potential of storm water pollution.

B. Purpose

Fertilizer Practice: Reduce the loadings of phosphorus and nitrogen into receiving waters.

Pesticide Practice: Reduce the loadings of toxics into receiving waters.

C. Planning Consideration and Guidelines

Fertilizer:

General Guides:

1. Landscaping: Native or low maintenance landscaping is strongly encouraged to minimize the need for fertilizers and pesticides and to reduce water usage. Native or low maintenance landscaping of new developments will minimize the needs for fertilizer.
2. Testing: A soil test is recommended, especially for new lawns, to assure the use of optimum fertilizer application rates.
3. Season for Application: The kind of turf being maintained should determine the time for fertilizing. Cool season turf (ryegrass) should be fertilized in the fall and early winter. Warm season grasses (Bermudas, St. Augustine) should be fertilized in the spring and summer.
4. A supplemental application of low nitrogen is also usually recommended in the fall. Once again, the rate of application should be determined according to a soil test whenever possible. When possible, use the minimal amount of fertilizer needed and apply small, frequent applications. For example, apply two pounds of fertilizer five times a year, rather than five pounds two times a year.
5. Timing the Application: In fertilizing lawns with chemicals, the habit of many is to "wait until the storm clouds gather" and then spread the material just ahead of the rain. The effect can be precisely the reverse of what is desired, and the worst result for water quality. However, applying fertilizer under dry weather conditions is dangerous as salt injury to the vegetation could result. Make the application when there is already adequate soil moisture and little likelihood of immediate heavy rain -- then sprinkle the lawn. Thus the material will have been incorporated into the soil before the next rain can take it away.
6. Spill Prevention: When watering after fertilizing, do not allow water to runoff from grassed areas. Any fertilizer spilled on impervious areas should be promptly cleaned up.
7. Specific suggestions from Texas Agricultural Extension Service (TAEX) are

given below for nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) for bermuda and other perennial grasses. Existing soil nutrient levels should be obtained from a reliable soil test or from some other available soil data (e.g. soil type).

Table 4.3 - Fertilizer Suggestions

Minimum rates of N, P_2O_5 and K_2O for Bermuda grasses, St. Augustine, and other summer perennial grasses.			
	Pounds per acre		
Soil level*	N**	P_2O_5	K_2O
VL, L	40	40	40
M	0	20	20
H, VH	0	0	0

*VL = very low; L = low; M = Medium; H = high; VH = very high;
**Very few soils are medium or above in available Nitrogen.
Source: Texas Agricultural Extension Service (TAEX)

Soil should be aerated with a coring machine before fertilizer is applied.

Pesticides:

General Guides:

1. Choose vegetation that is resistant to pests.
2. Weak plants are susceptible to pests. Reduce the temporary stress to grass caused by mowing by keeping the mower blade sharp and adjusted to a high setting.
3. Avoid using pesticides on a "prevention" schedule basis. Learn to identify insects and monitor them, detect pest problems early by inspecting regularly. Small numbers of pests are tolerable and indeed unavoidable. Often natural predators will limit pest populations.
4. If pests are present in large numbers, use mechanical, biological, or cultural controls. For example, some bugs can be dislodged merely by forcefully spraying them with a stream of water.
5. Other factors being equal, use the least toxic chemical that will accomplish the purpose. For example, safer soap used with monitoring can be highly effective for spot and small area treatment.
6. Pesticides that degrade rapidly are less apt than others to become storm water pollutants. Effective pesticides are available that have little adverse water quality effect once it reaches the ground.
7. Pesticides with low solubility in water are less apt than others to cause water pollution through drainage and runoff.
8. Some pesticide formulations have a broad spectrum of activity. These should be used when there are multiple pests instead of serial applications of highly specific materials. Even then, they should be used only when other less toxic alternatives are infeasible.
9. Follow the instructions on the pesticide label. "The label is the law."

10. Apply pesticides only on affected areas and under windless conditions.
11. Store pesticides safely and properly dispose of empty containers.
12. Never dispose pesticides into the storm or sanitary sewer system.
13. Do not rinse equipment or used containers on impervious areas.

Table 4.4 - Household Alternatives to Toxic Pesticides

Product	Alternatives
Fungicides (toxic)	Do not over-water, keep areas clean and dry
Synthetic products (toxic)	Botanical (naturally derived) pesticides such as pyrethun, rotenone, sabadilla, nicotine
House plant insecticide (toxic)	Mixture of bar soap and water, spray on leaves then rinse
Flea collars and sprays (toxic)	Herbal collar/ointment (eucalyptus or rosemary) or brewer's yeast in pets' diets
Roach and Ant killers (toxic)	For roaches: Traps or baking soda and powdered sugar mix For ants: chili powder to hinder entrance; boiling water on mounds; logic for fire ants
Rat and mouse poison (toxic)	Live traps, remove food supply.

Source: Home and Garden Environmental Guide by Clean Texas 2000.

D. Disposal

Follow the label! Excess pesticides should never be disposed of:

- In a manner inconsistent with the product label or labeling directions.
- So as to cause or allow open dumping of a pesticide
- So as to cause or allow open burning of a pesticide
- So as to cause or allow water dumping or ocean dumping except in accordance with established regulations

Contact the Texas Department of Agriculture for information on proper disposal of used containers for bulk pesticides.

E. Integrated Pest Management (IPM)

Integrated pest management or IPM is an approach that seeks to combine the best features of biological, chemical, cultural, and mechanical control. The objective is acceptable pest control with minimum use of chemical pesticides.

The major components of IPM are:

- Selection of landscape species based on soil type, function and minimum application of chemicals and fertilizers. Only EPA approved chemicals are allowed.
- Identification of potential pests
- Monitoring and record keeping system for observation of pests
- Cultural maintenance practices such as irrigation, drainage, mowing, pruning, etc.
- Record and monitor treatments for pests and fertilizer schedule including amounts, locations, chemicals used and application rates

Sources: Florida Department of Environmental Regulation, Clean Texas 2000, Minnesota

Pollution Control Agency, Washington State Department of Ecology, Galveston Bay National Estuary Program, Lower Colorado River Authority, Texas Dept. of Agriculture 1989, Texas Dept. of Agriculture 1990, Texas Dept. of Agriculture 1991, Texas Structural Pest Control Board.

4.1.5 Fueling Station Practices

A. Definition

Practices to improve storm water runoff water quality from fueling stations.

B. Purpose

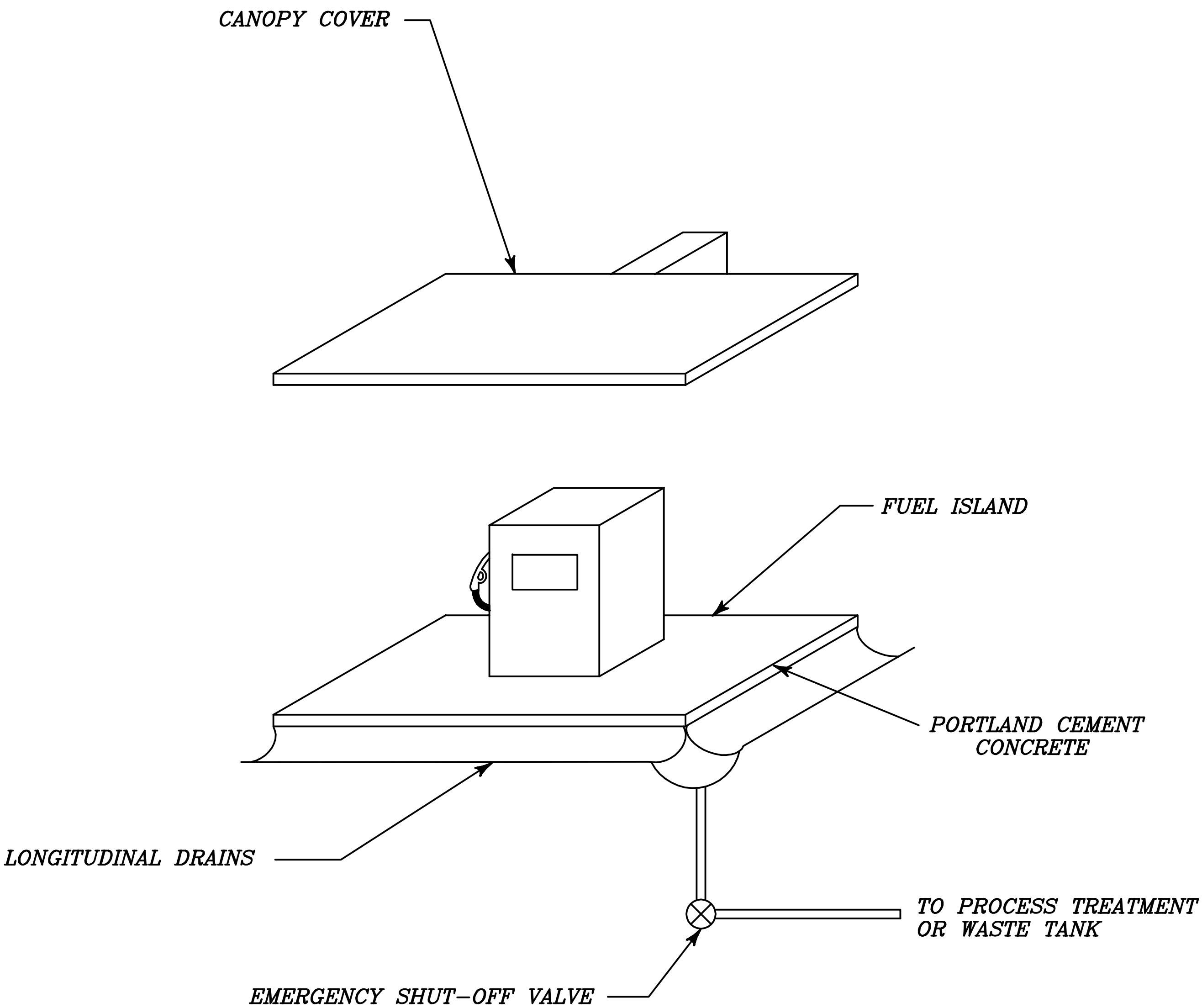
Prevent storm water runoff contact with contaminated surfaces and capture of runoff that is contaminated.

***C. Planning Considerations and Guidelines* (Refer to *Figure 4.1*)**

The following recommendations and guidelines are consistent with EPA guidance in *Storm Water Management for Industrial Activities (USEPA 1992c)*, pp. 3-2 to 3-5. The owner and/or responsible parties must also comply with applicable federal, state or local regulations.

1. The fuel island should be covered with a canopy to prevent direct contact with precipitation.
2. Longitudinal drains should be located at the perimeter along the "downhill" side of the island. This drain should be connected to the process treatment or a waste tank. The drain must have a valve to allow shutoff in the event of a large fuel spill.
3. The island must be paved using Portland cement concrete, not asphalt.
4. Spills should be prevented whenever possible. Keep suitable cleanup materials onsite to allow prompt cleanup should a spill occur.
5. Educate employees and customers by posting signs. "Topping off" gas tanks causes spillage and vents gas fumes to the air. Make sure that the automatic shutoff on the gas nozzle works.
6. Temporary fuel tanks used to fuel vehicles in the field should be placed in a bermed, impervious (using heavy mil plastic or Portland cement) area. The bermed area should be large enough to contain 110 percent of the tank's total volume.
7. In industrial complexes where very large mobile equipment is used, the fuel island need not be covered. However, the pad should be designed in manner that prevents the run-on of storm water from adjacent areas. The pad should also be designed in a manner that allows the collection of all rain that falls on the pad.

Sources: Environmental Protection Agency 1992c, Washington State Department Of Ecology.



ADAPTED FROM WSDOE

FIGURE 4.1
BMP 4.1.5: DETAILS OF FUEL ISLAND,

4.1.6 Vehicle/Equipment Washing and Steam Cleaning Practices

A. Definition

Practices to improve storm water runoff water quality from equipment washing and steam cleaning activities.

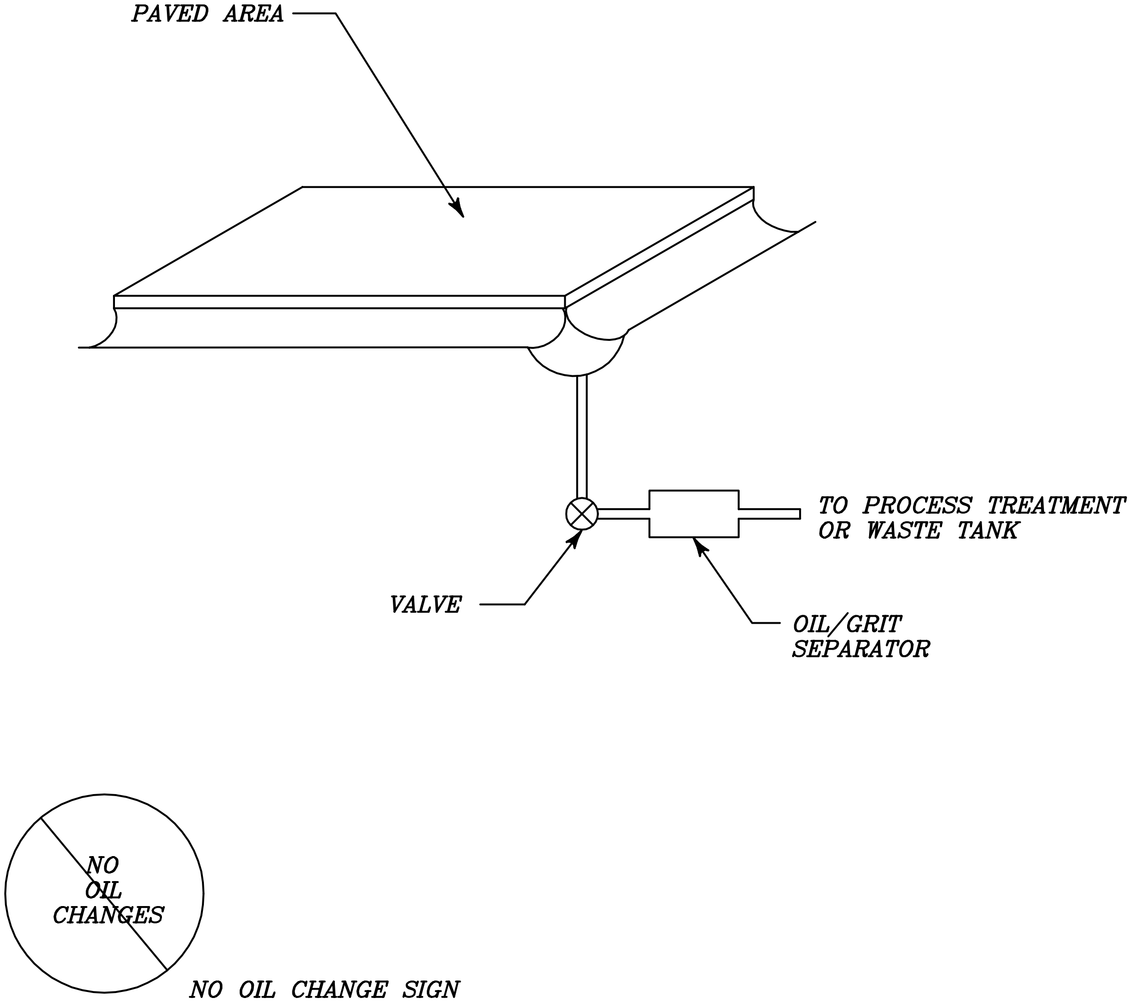
B. Purpose

Reduce pollutants (oil and grease, suspended solids, heavy metals, organics and nutrients) in wash water and to restrict wash water entry into the storm water system.

C. Planning Considerations and Guideline (Refer to *Figure 4.2*)

1. Washing of highway vehicles, equipment, and parts such as construction equipment should occur in a building or in a designated area that does not drain into the storm water system. This requirement refers to all methods of washing in which water is used including low-pressure water, high-pressure water and steam.
2. Wash water from washing facilities should be contained and discharged to a treatment facility or be discharged into and treated by a closed-loop recycling system.
3. Uncovered wash areas must be paved, protected from storm water run-on from adjacent areas, and drain into a process treatment or a waste tank.
4. To protect against deliberate dumping, discharge should pass through a well-maintained oil-grit separator. For uncovered wash areas, the discharge pipe should have a positive control valve that is shut when washing is not occurring, to prevent storm water entry.
5. The uncovered wash area should be well marked. Included in the posting should be a statement forbidding the changing of oil in the wash area. The location of the nearest oil recycling facility should be posted.
6. Car washing should, if possible, use water only. If soap must be used, use only a mild biodegradable, low phosphate soap in the least amounts necessary. Use a bucket of water or a hose with a shutoff nozzle, rather than a constant stream of water.

Sources: Environmental Protection Agency 1992c, Washington State Department of Ecology.



ADAPTED FROM WSDOE

FIGURE 4.2
BMP 4.1.6 REQUIREMENTS FOR AN, UNCOVERED WASH AREA,

4.1.7 Liquid Materials Loading and Unloading Practices

A. Definition

Practices for outside loading and unloading of liquid materials.

B. Purpose

To prevent spills and contact between liquid materials and storm water runoff.

C. Planning Considerations and Guidelines **(Refer to *Figure 4.3*)**

To the extent possible, unloading or loading of liquid materials should occur in the manufacturing building so that any spills not completely retained can be discharged to the sanitary sewer, treatment process or a waste tank in accordance with sanitary sewer or other permit requirements.

For outdoor unloading and loading of liquid materials, the following practices can reduce or prevent storm water runoff contact with liquid materials.

Guidelines for Loading and Unloading Docks

1. Loading/unloading docks should be covered or protected, such as with overhangs or door skirts that enclose the trailer end.
2. The loading/unloading area should be designed to prevent run-on of storm water.
3. The owner should retain onsite the necessary materials for rapid cleanup of spills.

Guidelines for Bulk Loading and Unloading

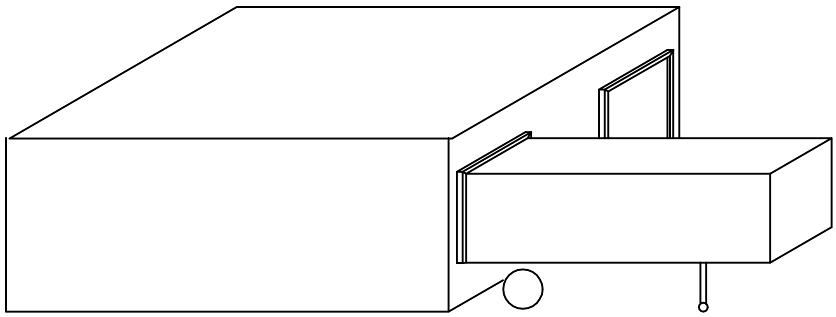
1. To minimize the risk of accidental spillage, the owner should have a written "operations plan" that describes procedures for loading and/or unloading. Employees should be trained in its execution and it should be posted or otherwise made easily available to employees.
2. As a part of the operations plan, or as a separate document, the owner or operator should have a spill response plan (see Section 4.1.10). The requirement for a spill response plan may be met by an existing voluntary or required SPCC Plan, Oil Spill Contingency Plan, Facility Response Plan, or Texas General Land Office Oil Spill Prevention and Response Plans, as applicable. If the facility is not required to have one of these plans, an equivalent spill response plan should be developed.
3. Drip pans should be placed at locations where spillage may occur such as hose connections, hose reels and filler nozzles. Drip pans should always be used when making and breaking connections.
4. The area on which the transfer takes place should be paved, where practicable. If the liquid is reactive with asphalt (for example, gasoline), Portland cement concrete should be used.
5. The transfer area should be designed to prevent the run-on of storm water from adjacent areas.
6. The transfer area should be designed to prevent the runoff of any spilled liquids from the area. This can be accomplished by sloping the area to a drain. The drain should be connected to a waste tank or to the process treatment system. A positive control valve should be installed to prevent accidental spillage of large

amounts of liquids into the system.

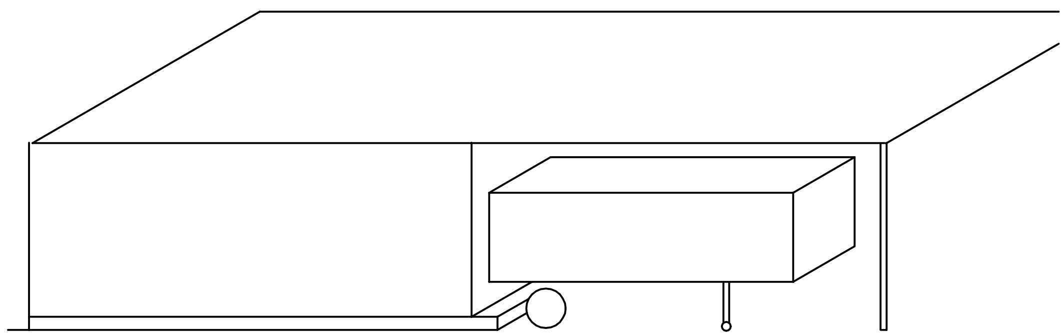
7. An employee trained in spill control and cleanup should be present during loading/unloading.

Source: Washington State Department of Ecology, Environmental Protection Agency 1992c.

A. DOCK WITH DOOR SKIRT



B. DOCK WITH OVERHANG



ADAPTED FROM WSDOE

FIGURE 4.3
BMP 4.1.7: LIQUID MATERIALS LOADING AND UNLOADING PRACTICES

4.1.8 Liquids Storage in Aboveground Tank Practices

A. Definition

Practices for storing liquids in aboveground tanks.

B. Purpose

To reduce, contain, and cleanup spills from aboveground tanks, thereby reducing or preventing storm water run-off contact with spilled liquids.

***C. Planning Considerations and Guidelines* (Refer to *Figure 4.4*)**

Storage of oil and hazardous materials must meet specific standards set by Federal and State laws. These standards include SPCC plans, secondary containment, installation, integrity and leak detection monitoring, and emergency preparedness plans. Federal regulations set specific standards for preventing runon and collecting runoff from hazardous waste storage, disposal, or treatment areas. These standards apply to container storage areas and other areas used to store, treat, or dispose of hazardous waste.

To minimize the spread of spilled material and to prevent contact with storm water, dry clean up methods should be used for response to oil spills. Material Safety Data Sheets (MSDS) should be maintained at a readily accessible location as a suitable information source for appropriate clean up of specific chemicals.

Storage of reactive, ignitable, or flammable liquids must comply with the fire code. The following practices are to complement, not conflict with, the fire code.

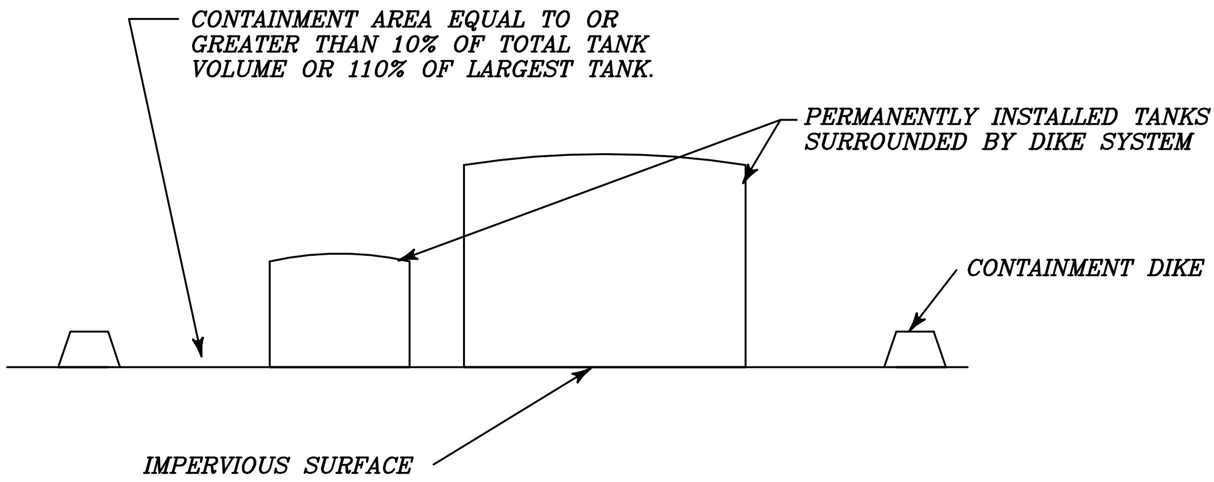
Guidelines for Permanent Tank Storage

1. The tank should include an overfill protection system to minimize the risk of spillage during loading.
2. Permanently installed tanks should be surrounded by dikes. The dike should be of sufficient height to provide a volume in the diked area equal to 10 percent of the total tank storage or 110 percent of the largest tank, whichever is greater.
3. The dikes and the surface within the dike area should be sufficiently impervious to prevent loss of the stored material in the event of spillage.
4. Outlets from the tank area should have positive control to prevent uncontrolled discharge from the tank area of spilled chemicals or petroleum products.
5. The outlet should have a dead-end sump for the collection of small spills. It should be cleaned as required to minimize the potential for contamination of storm water.
6. During rainy periods, accumulated storm water from within the dike area should be released frequently if not exposed to the stored liquids.
7. For petroleum tank farms or other heavy use area the storm water should pass through an oil/grit separator prior to discharge to the storm sewer system.

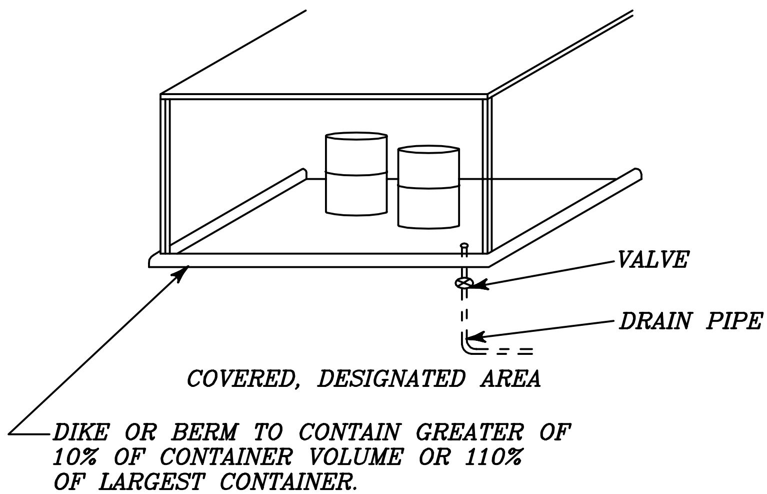
Guidelines for Small Portable Tank Storage

1. Temporary fuel tanks used to fuel vehicles in the field should be placed in a bermed, impervious (using heavy mil plastic or Portland cement) area.
2. The bermed area should be large enough to contain 110% of the tank's total volume.

Source: Environmental Protection Agency 1992c, Washington State Department of Ecology.



A. CONTAINMENT DIKING FOR LARGE STORAGE AREAS



B. SMALL STORAGE AREA WITH DIKE/BERM AND COVER

ADAPTED FROM USEPA 1992C

FIGURE 4.4

BMP 4.1.8: LIQUIDS STORAGE IN ABOVEGROUND TANK PRACTICES

4.1.9 Container Storage of Liquids, Food Wastes, Hazardous Wastes

A. Definition

Practices for temporary container storage of liquids, food wastes, or hazardous wastes.

B. Purpose

Prevent storm water runoff contact with contaminated materials and capture of storm water that is contaminated.

***C. Planning Considerations and Guidelines* (Refer to *Figure 4.5*)**

These guidelines address only storm water quality aspects of container storage. The owner and/or responsible parties are ultimately responsible for compliance with RCRA and SARA. The following guidelines are the minimum necessary for storm water quality management.

Containers used to store liquid, food waste, or hazardous waste should be kept inside a building where practicable.

If outdoor storage is necessary, steps should be taken to protect and secure the storage area and containers against the potential of storm water runoff.

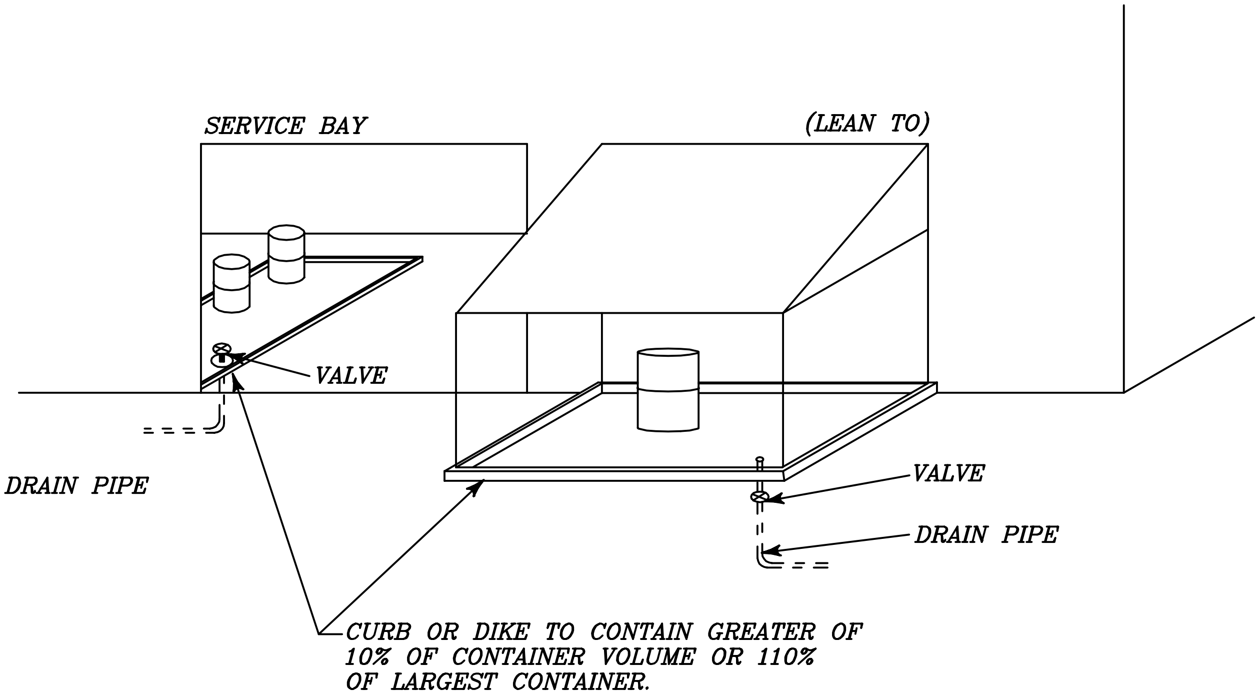
Reactive, ignitable, or flammable liquids are subject to further regulation under the fire code.

Guidelines

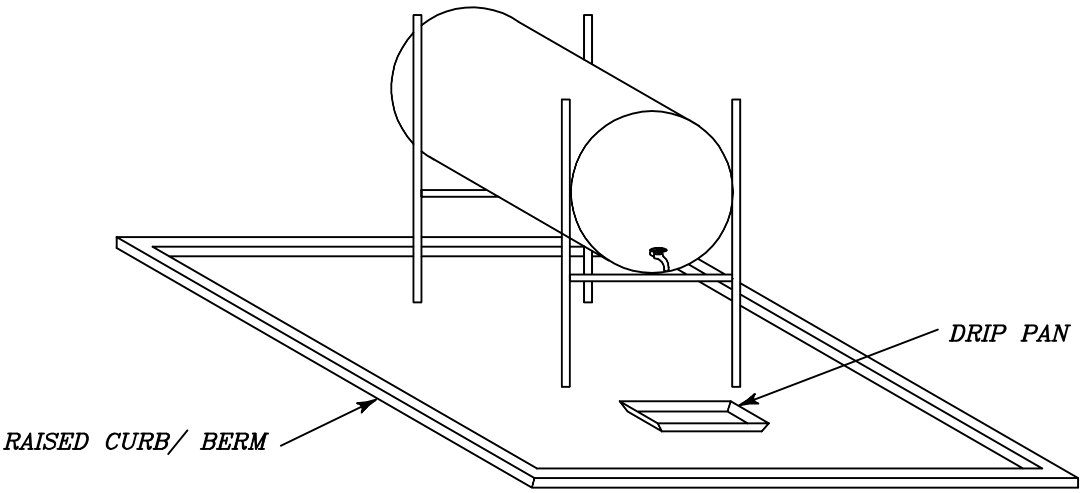
1. Dumpsters used to store food waste awaiting transfer to a landfill should be placed in a lean-to structure. A lean to is not necessary if the dumpsters have tight covers that are sloped to drain water off the dumpster. Dumpsters should be in good condition without corrosion or leaky seams.
2. If waste container drums are stored aboveground, they should be kept in an area such as a service bay where practicable. If drums are kept outside, they should be stored in a lean-to type structure to reduce the potential of storm water runoff contact.
3. Containers with liquid wastes should be stored in a covered designated area with an impervious pad or flooring, surrounded by a curb or dike. The curb or dike should have a storage volume of 10 percent of all the containers or 110 percent of the largest container, whichever is greater. Filets may be used to facilitate movement of roll-containers (e.g., dumpsters).
4. Drainage in the storage area should be directed to a process treatment, or well maintained dead-end sump. A dead-end sump is required for hazardous waste, used oil, or other fire code regulated materials. The drain must have positive control (locked drainage valve or plug) to prevent release of contaminated liquids.
5. A drip pan should be used for containers with valves or spigots for direct removal of liquids.
6. When loading or unloading dangerous wastes, liquid chemicals, or other wastes, an employee trained in emergency spill cleanup should be present. Spill cleanup equipment should be maintained at a readily accessible location. Any spills or

leaks should be handled in accordance with all local, state or federal regulations (See Sections 4.1.7, 4.1.10).

Source: Washington State Department of Ecology, Environmental Protection Agency 1992c.



A. COVERED AND BERMED CONTAINMENT AREA



B. MOUNTED CONTAINER WITH DRIP PAN

ADAPTED FROM WSDOE

FIGURE 4.5

BMP 4.1.9: CONTAINER STORAGE OF LIQUIDS, FOOD WASTES, HAZARDOUS WASTES

4.1.10 Spill Prevention and Response Plan

A. Definition

Spill prevention and response plan.

B. Purpose

To prevent, contain, and cleanup accidental spills to reduce the potential of storm water runoff contact with spilled material.

C. Planning Considerations and Guidelines

Facilities used for storing, processing, or refining oil and/or oil products with 1,320 gallons of above ground storage or 42,000 gallons of underground storage are required by federal regulations to have a Spill Prevention Control and Countermeasure (SPCC) plan. Facilities similarly used for processing or distribution of chemicals or other hazardous liquids should also provide for spill prevention and emergency spill response. General guidelines for spill prevention and response plans are provided below. USEPA regulatory requirements for SPCC plans are provided in 40CFR112.

Guidelines

1. The spill prevention and response plan should be prepared as a document submitted for review and approval by the fire department, health department, EPA and/or other agencies with jurisdiction.
2. The plan should contain a description of the facility, owner's name and address, description of the activity, and types of chemicals or hazardous liquids used.
3. The plan should have a site plan showing storage areas, shut-off and containment features, storm drain location, and direction of slopes.
4. The plan should describe notification procedures to be used in the event of a spill, such as key personnel, and agencies. Immediate notification should be provided if the spill may reach sanitary or storm sewers, or surface water.
5. The plan should provide instructions regarding cleanup procedures.
6. The owner should have an identified spill response team with spill response cleanup responsibility.
7. Key personnel should be trained in the use of this plan. All employees should have basic knowledge of spill control procedures.
8. A summary of the plan should be written and posted at appropriate points in the building, identifying the spill cleanup coordinators, location of cleanup kits, and phone numbers of regulatory agencies to be contacted in the event of a spill.
9. Cleanup of spills should begin immediately. No emulsifier or dispersant should be used. Clean up methods should be dictated by the chemicals released with primary concern for human health. Dry clean-up methods should be used for oil spills. Material Safety Data Sheets (MSDS) should be at a readily accessible location as a suitable information source for appropriate clean-up of chemicals.
10. Emergency spill and cleanup kit(s) should be located at the facility site. The contents of the kit should be appropriate to the type and quantities of chemical liquids stored at the facility. The kit might contain appropriately lined drums,

absorbent pads, and granular or powdered materials for neutralizing acids or alkaline liquids. Kits should be deployed in a manner that allows rapid access and use by employees. The kits should be maintained in good condition. This plan should be updated regularly. Following any spills, the spill prevention and response plan should be evaluated for effectiveness and how it can be improved.

Source: Environmental Protection Agency 1992c, Washington State Department of Ecology.

4.1.11 Outdoor Storage Practices

A. Definition

Outdoor storage practices for solid materials.

B. Purpose

To prevent leaching of chemicals, suspended solids, erosion, and sedimentation.

***C. Planning Considerations and Guidelines* (Refer to *Figure 4.6*)**

The following types of materials are considered.

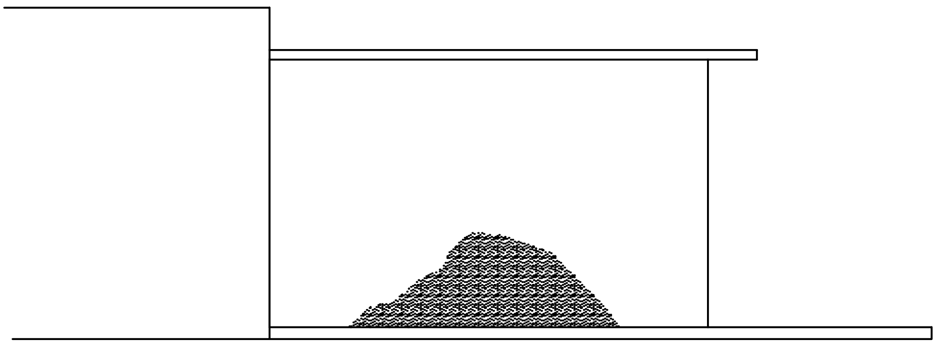
1. Raw materials such as gravel, sand, topsoil, compost, sawdust, wood chips, which are subject to leaching and transport by erosion and sedimentation.
2. Building materials, including lumber, piling, which are subject to leaching.
3. Concrete and metal products which are subject to chemical erosion and corrosion and leaching.

Guidelines

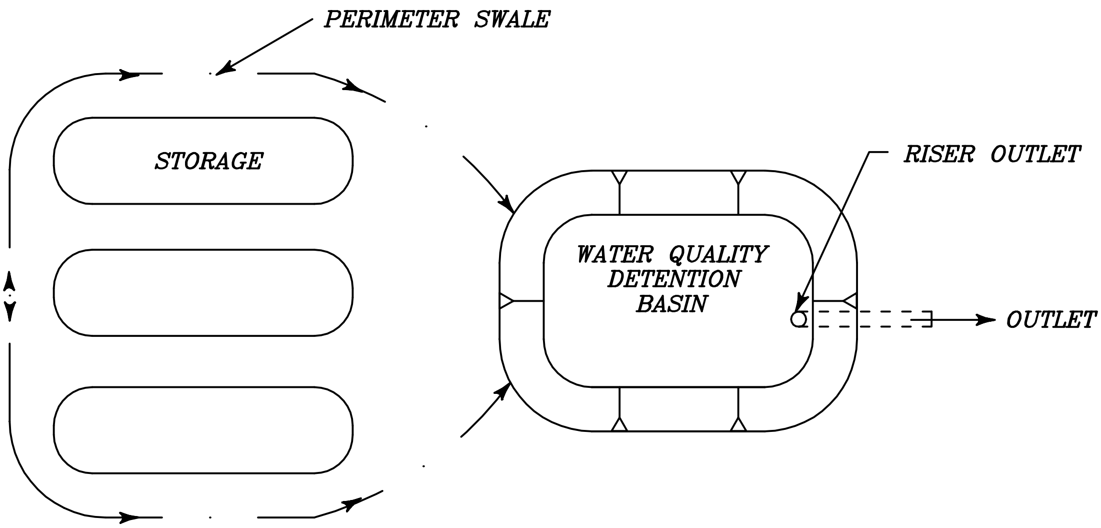
One or more of the following practices should be used, appropriate to the type of material and protection needed:

1. Where practicable, store materials under a covered area on a paved surface.
2. Place a tarpaulin or temporary plastic sheeting over the material.
3. Where covering outdoor storage areas is not practicable, install a drainage system that directs storm water runoff from the area to one or more of the systems presented in Sections 4.2 (basin facilities), 4.3 (infiltration filtration facilities), 4.4 (catchment facilities), or 4.5 (vegetative practices).

Source: Washington State Department of Ecology, Environmental Protection Agency 1992c.



A. COVERED STORAGE AREA FOR RAW MATERIALS



B. OUTDOOR STORAGE DRAINAGE SYSTEM

FIGURE 4.6
BMP 4.1.11: OUTDOOR STORAGE PRACTICES

4.1.12 Street Sweeping

A. Definition

Street sweeping and/or vacuuming including surface parking.

B. Purpose

Remove solids, trash, and floatables from paved areas.

C. Planning Consideration and Guidelines

Street sweeping is traditionally done with broom sweepers for aesthetic reasons, to remove leaves, trash, coarse particles and similar wastes. Street sweeping by broom sweepers can actually worsen street runoff quality by dislodging or breaking up sediment clumps, making them easier to wash away. To counter this negative effect requires vacuum-type or regenerative (blower/vacuum) type sweeper. The effectiveness of street sweeping is affected by frequency of sweeping, and interval between storms that flush pollutants. The frequency of sweeping will depend on the frequency and intensity of usage of the affected facilities.

The following are the recommended street sweeping practices:

- Use of vacuum-type or regenerative sweepers.
- Sweeping frequency of at least bi-weekly (once every two weeks)
- Sweeping speed not to exceed 6 mph
- At least two sweeping passes should be made.
- Sweepings are disposed at an approved landfill site

For facilities such as shopping centers and similar activity centers, street-sweeping should be done during non-operating hours and dry conditions.

Sources: Lower Colorado River Authority, Environmental Protection Agency (Pitt), Minnesota Pollution Control Agency, Florida Department of Environmental Regulation.

4.1.13 Inlet Stenciling

A. Definition

Marking storm sewer inlets with a painted or inset message to discourage illicit dumping of wastes into storm sewers.

B. Purpose

Prevent oil, grease, wash water, solids, trash and floatables from entering the storm sewer system.

C. Planning Considerations and Guidelines

The following should be considered:

1. Permission should be obtained, and coordination should be effected with the appropriate county or city agency having jurisdiction over the storm sewer system (MS4 operator).
2. Inlet stenciling is most effective when:
   a. The stenciling is conducted over a large area.

   b. The stenciling is done in connection with an information campaign and/or volunteer effort to do the stenciling.
   c. The message being stencilled is on or next to the storm sewer inlet.
   d. The message is simple and clear.
   e. The message is not obscured or worn away over time. This can be accomplished through either a stenciling maintenance program for painted stencils, or, through a permanent method of stenciling (cast concrete blocks, cast-iron plates, inset lettering using a contrasting color, etc.).
3. Two example stencils are given in Figures 4.7a and 4.7b. Figure 4.7a shows a text and graphic stencil, with a message in the form of a directive. Figure 4.7b shows a text-only stencil, with a message in the form of a request. The recommended method of stenciling in either case would be cast concrete blocks or cast-iron plates. Other methods could also be used (painting, inset lettering, etc.).
4. Figure 4.8 shows a manhole cover with bilingual message.

Sources: Storm Water Management Joint Task Force Technical Advisory Committee, Houston Audubon Society.

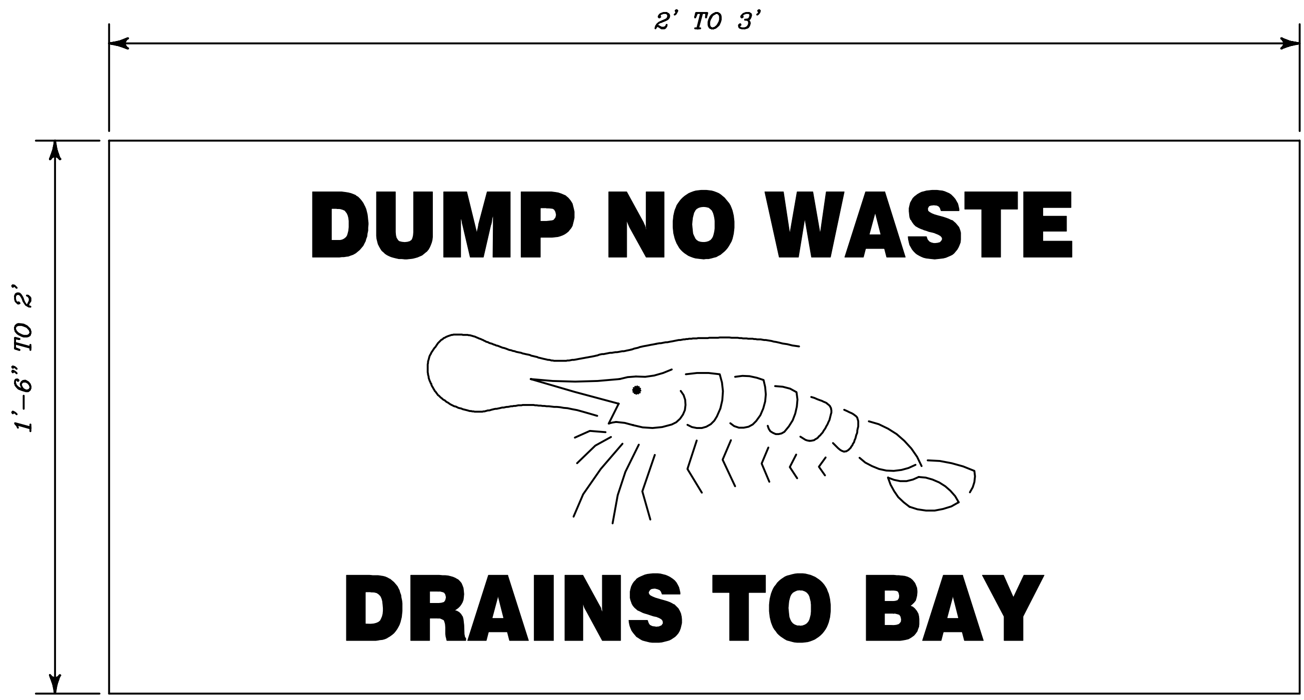


FIGURE 4.7a

BMP 4.1.15: INLET STENCILING

(TEXT AND GRAPHIC)

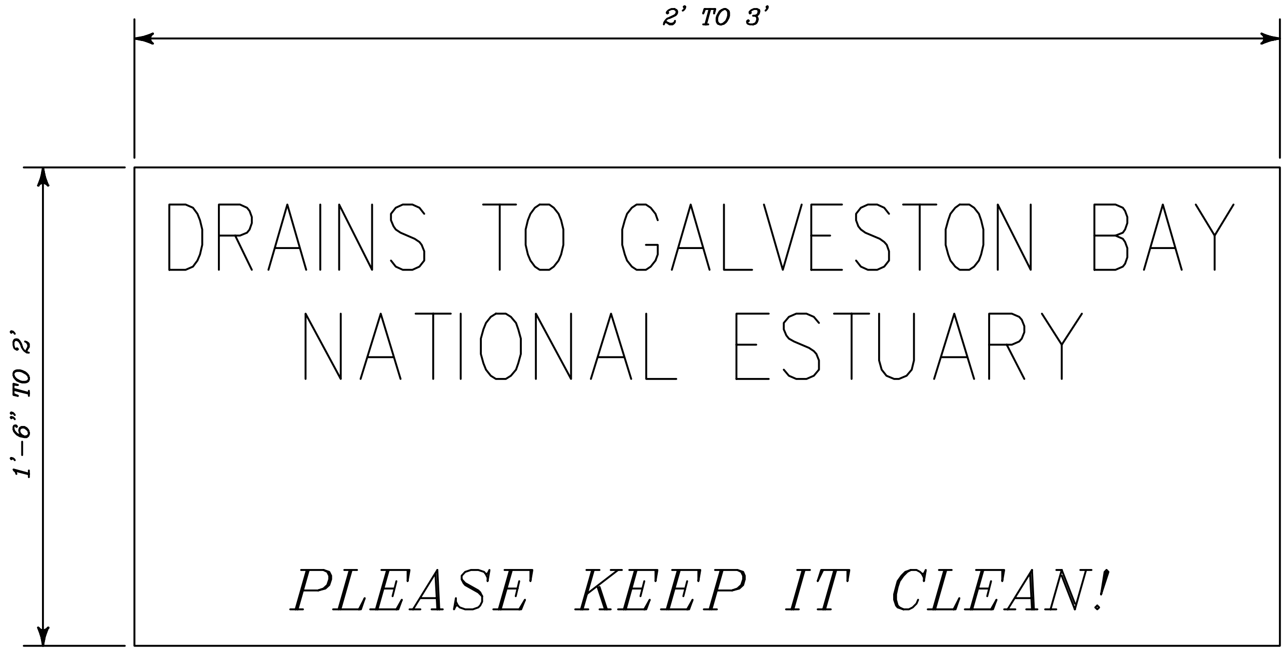
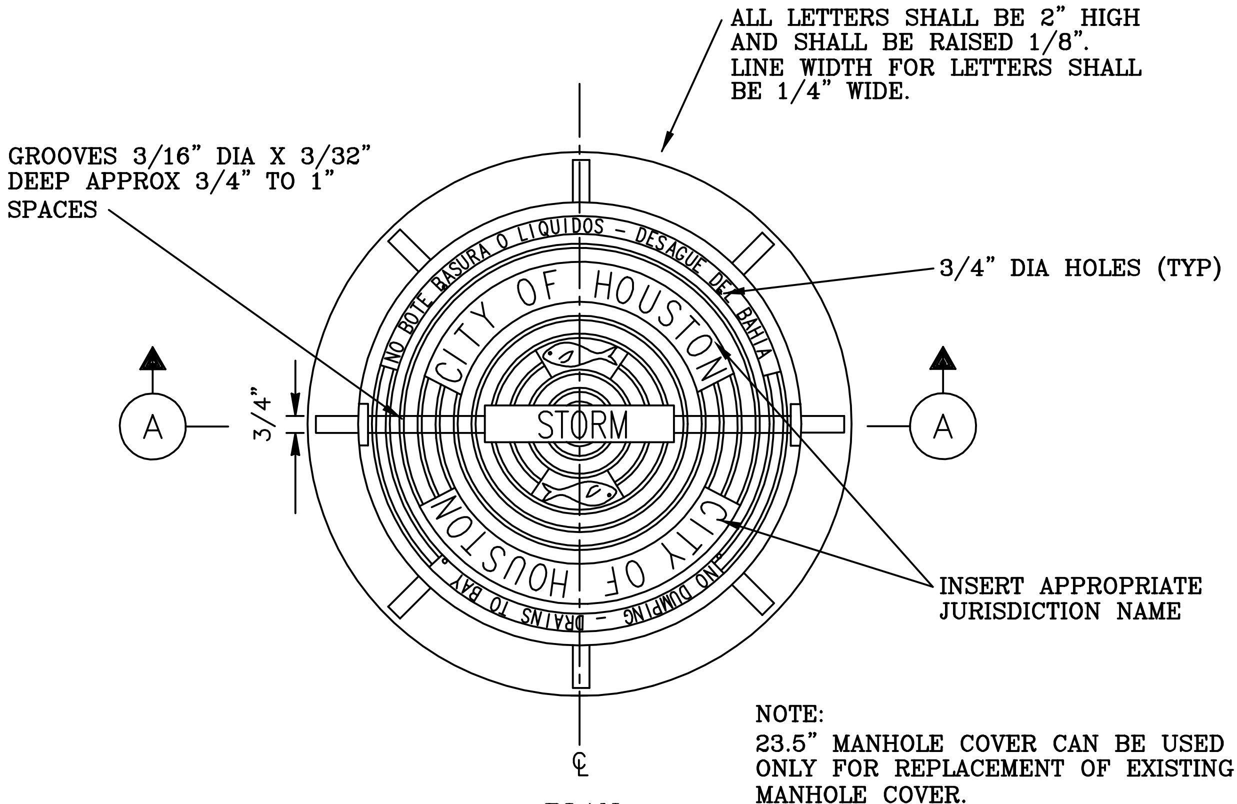


FIGURE 4.7b

BMP 4.1.15: INLET STENCILING



PLAN

23.5" AND 32" MANHOLE COVER WITH FRAME

FIGURE 4.8

BMP 4.1.15: INLET STENCILING: CLASS "E" AND "H-2" MANHOLE COVER

4.2 Storm Water Quality Basins

Storm water quality basins can be considered as a best management practice in urban areas where the drainage area equals or exceeds 10 acres in size. In the context of water quality enhancement, the purpose of storm water quality basins is to reduce runoff velocity to a level that promotes debris and suspended solids to settle in the basin rather than in the receiving stream. The outflow structure from the basin may be configured to trap floating material, oils and grease that will not settle despite reduced velocity.

The objective of the basin for water quality differs greatly from the objective of storm water detention for flood control. In the former, the objective is to control nonpoint source stream pollution. This is most effectively accomplished by capturing and holding the first flush of runoff. In the latter, the objective is to control the increase in peak rate of runoff by diverting and storing water until the peak of the flood hydrograph is past. This usually means capturing that portion of the runoff flood hydrograph that occurs much later than, and an amount well in excess of, the first flush of runoff.

A second difference between the water quality basin and the flood control basin is the method of operation. Flood control detention basins are typically designed to attempt to discharge the captured runoff as quickly as permissible following passage of the flood hydrograph peak. The water quality basin should be designed to discharge its contents slowly over a period of 24 hours or longer.

Until a value for the Houston/Harris County region has been established, the first flush of runoff is defined as the drainage area multiplied by 0.5 inch. When a design criteria manual is developed for this region, the value may change. The total volume of runoff from a drainage area that should be captured can be calculated using the following equation:

$$V = 1800\ S \qquad \text{(Eq.1)}$$

where "V" is the storage required for the first half inch of runoff (cubic feet), "S" is the site drainage area (acres), and 1800 is the conversion factor (cubic feet/acre).

The basins addressed in this manual are designed for the purposes of water quality. For proper basin design, the existing drainage criteria for flood control purposes must also be considered. Other uses for water quality basins may also be considered, such as public open spaces, recreation centers, and wildlife habitats.

Several options exist for designing water quality basins. These are discussed in the following subsections and include:

4.2.1 Dry Basins
4.2.2 Wet Ponds
4.2.3 Dual Use Flood Control/Water Quality Basins
4.2.4 Wetland Treatment

Although the specific design characteristics will be dependent on the individual site considerations, the basin should consider the following as basic minimal criteria:

1) The basin should capture the first flush of runoff.
2) For dry basins, the design runoff volume should drain over a 24 to 48 hour period.

3) In regard to design frequency and tail water effects, the water quality basin should be designed so that it does not conflict with other design criteria of the applicable agency, such as the City of Houston design criteria for storm sewers, Harris County Flood Control District design criteria for channels, and Harris County criteria for their flood plain mitigation programs.

In most cases in the City of Houston and Harris County, the flat topography combined with intense rainfalls require that the large diameter pipes (> 36 inches) be designed to drain relatively small areas. The actual pipe diameter and basin depth depend on a number of factors including watershed size and shape, slope, land use, soil type, and design water depth in the receiving channel.

The basin design will generally be governed by the depth of the storm sewer. This will result in a ***total volume*** for the basin well in excess of the ***effective volume*** required to capture the first flush of runoff. The selection of the design option should consider the cost-effective solution that minimizes the land area required but meets the objectives of the water quality basin (capturing first flush of runoff and reducing the pollutants entering the receiving stream).

Further definition of the design consideration of the basin options is provided in sections 4.2.1 through 4.2.4. Design examples are given in these sections. However, they are for illustration purposes only and should be modified using the applicable agency's design criteria to reflect actual site conditions. **Creativity in the design of these structures is encouraged as a means of advancing the engineering knowledge of this area of practice.**

Sediment testing and removal as part of maintenance should also be considered. Appropriate waste classification measures should be followed, including testing and analysis where needed. A determination will need to be made whether the removed material is municipal waste or hazardous waste under the regulations of the Texas Natural Resource Conservation Commission (TNRCC). (Municipal waste regulations are at 30 TAC 330, and Hazardous Waste regulation are at 30 TAC 335.) Additional information on testing and disposal can be obtained from the TNRCC website (www.tnrcc.state.tx.us), the TNRCC local office, Harris County Pollution Control, or the City of Houston Health Department (Public Health Engineering).

4.2.1 Dry Basins

A. Definition

Dry basins temporarily detain the design storm water runoff for a specified length of time, typically for 24 to 48 hours, and release the storm water slowly. An average detention time of 24 hours is desired and may be achieved by using the full basin drain time of at least 48 hours with no more than 50% of the water quality volume draining in the first 24 hours. These basins are dry except for a period ranging from hours to several days following the storm event.

B. Purpose

The required draw down time allows some physical settling of pollutants. The basin is intended to reduce the load of suspended solids and associated pollutants as well as oil and grease. Dry basins also reduce peak discharge and reduce downstream flooding.

C. Planning Considerations

1. Dry basins may be used for sites that are 10 acres or more in area. The basin should be sized to store 1,800 cubic feet per drained acre. A bypass or spillway may be needed for larger runoff events. Note that the storage volume is intended for water quality purposes only and does not address flood protection.
2. Dry basins can be designed for the following applications:
   4.2.1.1 In-line storm sewer basin
   4.2.1.2 Off-line storm sewer basin
   4.2.1.3 In-line channel basin
   4.2.1.4 Off-line channel basin
3. In most cases, the basin is likely to be located immediately upstream of the outfall into the receiving channel. However, they also may be located at an intermediate upstream point, which is more efficient in terms of land use, provided that the objective of the basin can be achieved.
4. The basin should be designed to minimize resuspension of sediment during high intensity storms, by isolating sedimentation areas, diverting excess runoff using a bypass, or other means.
5. The basin should be designed to facilitate sediment clean out. Inspection and maintenance access should be provided.
6. Because of the flat terrain in this region, substantial area may be required for the basin.

   Table 4.5 gives storm sewer sizes and depths which can be considered typical in the Houston area:

Table 4.5
Typical Storm Sewer Sizes and Depths

Drainage Area (acres)	Pipe Diameter (inches)	Depth (feet)
10	36	7
20	48	8
50	72	10
100	96	12

For an in-line storm sewer basin, the bottom of the basin must be as deep or deeper than the invert of the storm sewer. The depth of the basin, combined with the necessary side slopes required for soil stability and maintenance, will result in a basin volume well in excess of that required to capture the first flush volume.

Table 4.6 extrapolates the information for pipe diameter and depth presented in Table 4.5 to give approximate sizes for a rectangular basin (2:1 proportions) with 3:1 and 4:1 side slopes. The table assumes 2 feet effective depth, in other words, the first half-inch of runoff is stored at the bottom 2 feet of the basin. The invert of the incoming sewer is assumed to be 2 feet above the bottom of the basin while the invert of the outlet pipe is assumed to be one foot above the bottom of the receiving channel. This assumes at least a 3 foot drop in elevation from the invert of the inlet pipe to the bottom of the drainage channel, and that the water quality basin will completely drain by gravity flow to the downstream water body. The table *does not include maintenance berm or access areas*.

Table 4.6
Dry Basin Area Requirements*

Drainage Area (acres)	**Basin Area (acres) 3:1 side slope**	**Basin Area as a percentage of Drainage Area (%)**	**Basin Area (acres) 4:1 side slope**	**Basin Area as a percentage of Drainage Area (%)**
10	0.44	4.4	0.54	5.4
20	0.78	3.9	0.93	4.6
50	1.7	3.5	2.0	4.0
100	3.2	3.2	3.7	3.7

* Does not include area for maintenance and access. Based on data in Table 4.5.

7. Land area requirements for the storm sewer dry basins could be reduced by allowing the water surface elevation in the pond to rise to some level above the invert of the incoming storm sewer. However, in this case, the standing water left in the storm sewers following a storm could result in sedimentation in the pipes, and a greater need for maintenance. It may also impact the carrying capacity of upstream storm sewers because of the backwater effect.

   The hydraulics of the contributing drainage system must be carefully evaluated to minimize adverse effects of backwater from the basin and discharge mechanism. The design of the basin should not conflict with the storm sewer design criteria as described below:

   a. The storm sewer should be sized to current design criteria as adopted by the applicable agency.
   b. The storm sewer must be able to convey the design flow based on current criteria as adopted by the applicable agency.

8. As in the case of storm sewer basins, the channel basins should be as deep or deeper than the invert of the incoming channel, but still be able to drain by gravity to a downstream channel. For this reason, channel basins may advantageously be located next to drop structures, to achieve greater basin depth and storage. Some savings in excavation may be achieved with in-line basins, at the cost of less protection for settled sediments in the basin, from channel flows.

D. Design Considerations

Design considerations for four (4) different options of dry basins are given in the following sections:

4.2.1.1 In-line storm sewer basin
4.2.1.2 Off-line storm sewer basin
4.2.1.3 In-line channel basin
4.2.1.4 Off-line channel basin

E. Maintenance

1. Maintenance and inspection access to the basins should be provided.
2. Sediment should be removed from pond or reservoir areas when accumulations exceed one-third the design depth of the pond or reservoir.
3. Accumulated paper, trash and debris should be removed every 6 months or as necessary.
4. The vegetation should be mowed at least twice a year to discourage woody growth and control weeds.
5. A visual check inspection should be conducted after each rainfall event of 1 inch or more in 24 hours until the pond and drainage system are stabilized. Thereafter, visual checks should be conducted as needed to inspect for damage and any necessary repairs.
6. It is recommended that a comprehensive inspection be conducted at least annually.
7. Standing water left after 72 hours indicates clogging of drain pipes or drainageways, and need for inspection and maintenance. Provisions should be made for occasional dewatering as necessary for maintenance work and to control nuisances which may arise, such as mosquitoes, flies and odors.

Sources: Turner Collie & Braden, Lower Colorado River Authority, City of Austin, Association of Consulting Municipal Engineers, Metropolitan Washington Council of Governments 1987, Brater & King.

4.2.1.1 Dry Basin (In-Line Storm Sewer)

The in-line storm sewer dry basin discussed in this subsection is the first of four design options under dry basins.

A. General Design Considerations

The in-line storm sewer basin is defined as a basin located at some point of the storm sewer system prior to its outfall into a storm sewer or receiving channel. All runoff flowing in the storm sewer also flows through the in-line storm sewer basin. The receiving channel may be either man made or a watercourse.

Three designs are given in the following pages:

Figure	Description
4.9a, b, c	In-Line Storm Sewer Basin - Weir Discharge
4.10a, b, c	In-Line Storm Sewer Basin - Internal Channel Discharge
4.11a, b, c	In Line Grass Linear Dry Ponds

The first two designs reflect basins located next to or near a lateral open channel. As illustrated in Figures 4.9a and 4.9b, the first 0.5 inch of runoff is stored in the basin; excess runoff is discharged either through a weir at the end of the basin or through an internal channel, leaving most of the first flush undisturbed. Figure 4.11a illustrates the design applying to typical commercial sites with a drainage area of 10 acres or more, with grass linear ponds for water quality detention.

General design considerations of the in-line storm sewer basin include the following:

1. While no restriction is given for size of drainage area, a 10-acre minimum is recommended. A cost-effective design should consider land use in the development.
2. The hydraulics of the contributing drainage system must be carefully evaluated to minimize adverse effects of backwater from the basin and discharge mechanism. The design of the basin should not conflict with the storm sewer design criteria as described below:
   a. The storm sewer should be sized to current design criteria as adopted by the applicable agency.
   b. The storm sewer must be able to convey the design flow based on current criteria as adopted by the applicable agency.
3. The basin configuration should be such that the first flush is captured and held for release slowly over a 24 to 48 hour period while the remainder of the flood hydrograph may pass through the basin. The recommended draw down time is 36 hours.
4. The first approach to controlling the draw down time is using the perforated riser without an internal orifice plate as shown in Figure 4.11b (*Option A*).

   The perforated riser (*Option A* in Figure 4.11b) is a simpler design than the slotted slow release riser discussed below (*Option B*). With the perforated riser, the total area of all the holes regulates the outflow to achieve the required draw down time for the design runoff volume, and can be obtained from the following equation.

   (Eq.2) $$A_P = \frac{V}{120.3 \Delta t \sqrt{\Delta H}}$$

   where "A_P" is the perforation area (square inches), "V" is the design volume (cubic feet), "Δt" is the draw down time (hours), and "ΔH" is the maximum storage depth of the pond in (feet). To obtain the number of half-inch diameter perforations or holes, divide the area A_P by 0.196 square-inch, which is the area of a half-inch diameter hole. (Metropolitan Washington Council of Governments 1987, LCRA).

   A wire mesh screen or filter cloth jacket is used to help prevent clogging. The perforated riser design has some disadvantages compared with the slotted/perforated riser with an internal orifice. The hydraulics of flow through the perforations and jacket are not well understood, and the filter cloth jacket and lower perforations are more prone to clogging. For sites under 20 acres in area, the total surface area of the perforations tends to be low. For these reasons, the perforated riser is only recommended for drainage area of 20 acres or more.
5. The second type of riser for slow release is the slotted slow release riser with an internal orifice plate (*Option B* in Figure 4.11b). This is an improved design, being more resistant to clogging, and is recommended over the perforated riser (*Option A*). The slotted slow release riser pipe may have rectangular slots or round perforations which allow water to flow in freely to an internal orifice plate that controls the discharge rate. The slotted slow release riser pipe can be selected from the following table:

Table 4.7 Slotted Slow Release Riser Pipes (Option B)

Riser Pipe Nominal Dia. (Inches)	Vertical Spacing Between Rows (Center to Center, in inches)	Number of Perforations per Row	Diameter of Perforations (Inches)
6	2.5	9	1
8	2.5	12	1
10	2.5	16	1

Source: City of Austin

The riser inlet has a 1-inch thick plate at its base with the appropriate orifice in its center. The plate should be made of a durable and non-corrosive product such as a metal or plastic. Recommended total perforation area in the riser pipe should be equal to or greater than twice the area of the orifice in the base plate to account for some flow reduction due to clogging of the perforations. Brater and King give a method for deriving the orifice area. (Brater and King, *Handbook of Hydraulics*, 6th ed. 1976, p. 4-5).

For prismatic vessels (vertical walled basins), taking "≅H" (feet) as the difference in depth between the initial water surface and the orifice plate, the following equation may be used:

$$\textit{(Eq.3)} \qquad A_o = \frac{A_T \sqrt{\Delta H}}{100.3 \quad c\,\Delta t}$$

where A_o is the orifice area (square inches), "A_T" is the area of the basin (square feet), "c" is the average orifice discharge coefficient, "Δt" is draw down time in hours, and 100.3 is a conversion factor.

For drainage areas of 10 or more acres, an oblong basin (2:1 proportions) with 2-foot depth and 3:1 to 4:1 side slope, equation (3) may be used with A_T equal to the pool surface area, averaged for trapezoidal shape. The following table provides various diameter orifices for varying drainage areas using equation (3). This table used two feet for the head loss "ΔH", a "c" value of 0.6, and a "Δt" of thirty-six hours.

Table 4.8
Orifice Plate Diameters*

Drainage Area (Acres)	Orifice Diameter (Inches)
10	2.4
20	3.5
50	5.8
100	8.3

* See preceding discussion for assumptions.

6. Excess runoff can be discharged into the storm sewer system using a tandem overflow riser as shown in the Option B concept of Figure 4.11b. Alternately, excess runoff can discharge through the open top of the riser pipe in Option A.
7. The need for an emergency spillway should be evaluated.

B. Design Examples

Figure 4.9a, b In-Line Storm Sewer Basin - Weir Discharge

Figure 4.9a, b, and c provide basin plan and profile information and general notes for construction.

Based on Figures 4.9a and b, an example basin design was developed as follows.

A drainage area of 50-acres and basin effective depth of two feet require a basin bottom area of almost one acre. This area's basin bottom has a calculated length to width (L:W) ratio of 288':144'. The side slopes assumed a 4:1 horizontal to vertical (H:V) ratio. Depth from the pipe invert to ground surface was ten feet giving a total depth to the basin bottom of twelve feet. Total area required for the basin was 2.1-acres and represents 4.2% of the total drainage area, not including maintenance berms or access.

A 10-year storm event is estimated to generate a peak flow of 138 cubic feet per second (cfs). For this flow and a one foot head height above the weir, the weir length required was 53 feet.

A 3-year storm event is estimated to generate a peak flow of 102 cubic feet per second (cfs). For this flow and a one foot head height above the weir, the weir length required was 39 feet.

Figure 4.10a, b, c In-Line Storm Sewer Basin - Internal Channel Discharge

Figures 4.10a, b, and c provide basin plan and profile information and general notes for construction.

Based on Figures 4.10a, b and c, an example basin design was developed as follows.

A drainage area of 50 acres and basin effective depth of two feet require a basin bottom area of 1.39 acres. The basin bottom has a calculated length to width ratio of 288':210', including the internal channel. The side slopes assumed a 4:1 (H:V) ratio. Depth from the pipe invert to ground surface was ten feet giving a total depth to the basin bottom of twelve feet. Total area required for the basin was 2.7-acres and represents 5.4% of the total drainage area, not including maintenance berms or access.

A 10-year storm peak flow is estimated to be 138 cfs. For this flow and a one foot head height above the weir, the weir length required was 53 feet. The internal channel bottom had a width of 20 feet for a concrete paved 4:1 (H:V) trapezoidal channel, weir height of two feet, and channel slope of 0.1%.

A 3-year storm peak flow is estimated to be 102 cfs. For this flow and a one foot head height above the weir, the weir length required was 39 feet. The internal channel bottom had a calculated width of 15 feet for a concrete paved 4:1 (H:V) trapezoidal channel, weir height of two feet, and channel slope of 0.1%.

Figure 4.11a, b In-Line Grass Linear Dry Ponds

Figures 4.11a and b provide basin plan and profile information and general notes for construction.

Based on Figures 4.11a and b, an example basin design was developed as follows.

A drainage area of 10-acres and ponding effective depth of one foot provided a total ponding area of 0.67-acres. Perimeter linear ponds and two interior linear ponds were designed with 4:1 (H:V) side slopes in a triangular shape. Parking lot aisles assumed a 20'-25'-20' of parking-aisle-parking configuration. A total of 18,736 cubic feet (cu. ft.) is provided for 24- to 48-hour detention of the 18,000 cu. ft. required for a 10-acre site. For one inside linear dry pond, the area drains approximately 4,400 square feet (sq. ft.) and the calculated orifice diameter is 1.6 inches for a coefficient of discharge of 0.644 and a draw down time of 36 hours. The four perimeter riser pipes have approximately 4,950 sq. ft. to drain and the calculated orifice diameter is 1.7 inches using the same inside linear dry pond parameters.

Sources: Turner Collie & Braden, Brater and King, *Handbook of Hydraulics*, 6th ed., City of Austin Department of Environmental Protection, Metropolitan Washington Council of Governments 1987, Lower Colorado River Authority.

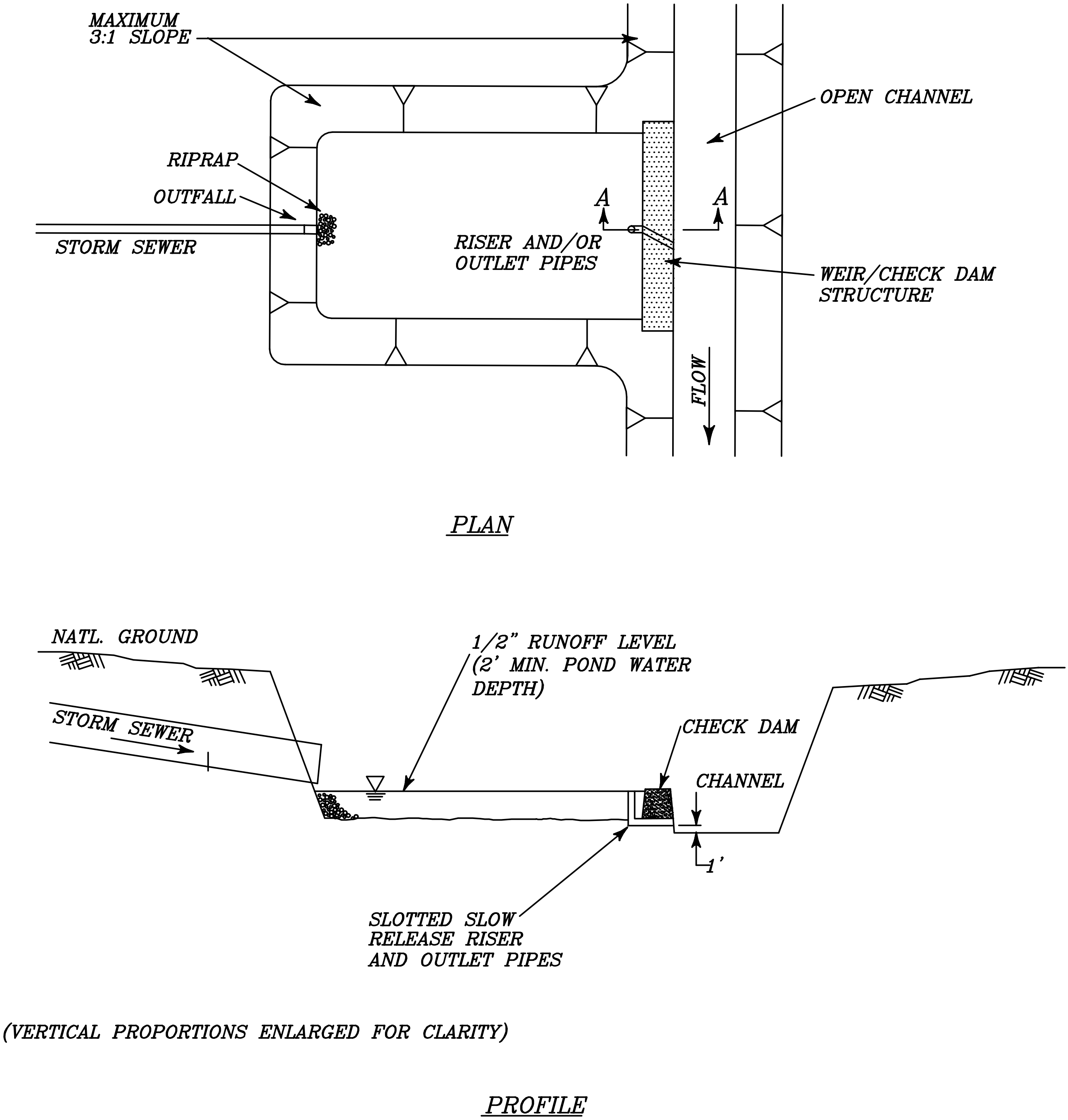
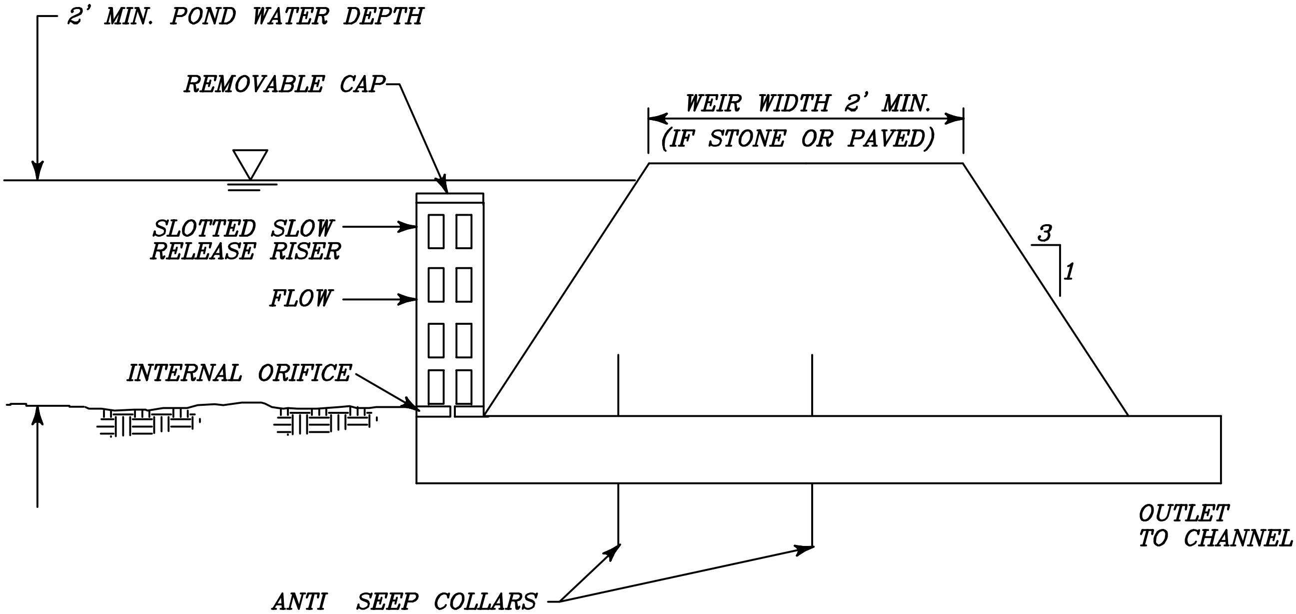


FIGURE 4.9a
BMP 4.2.1.1: IN-LINE STORM SEWER BASIN:
WEIR DISCHARGE



GENERAL NOTES:

1. BASIN STORAGE VOLUME IS 1800 CUBIC FEET PER DRAINED ACRE (1/2 INCH RUNOFF VOLUME). EXCESS RUNOFF SPILLS OVER WEIR INTO CHANNEL.

2. WEIR HEIGHT IS AT 1/2 INCH RUNOFF LEVEL. WEIR LENGTH SHOULD BE SUFFICIENT TO PASS THE DESIGN STORM WITH NO ADVERSE BACKWATER EFFECT ON STORM SEWER SYSTEM.

3. DIMENSIONS – LIMIT OF EXCAVATION, WEIR AND RISER HEIGHTS, AND PIPE DIAMETER SPECIFIED ON THE CONSTRUCTION DRAWINGS.

4. SIDE SLOPES – 3:1 OR FLATTER.

5. SLOTTED SLOW RELEASE RISER – SPECIFY SLOTTED SLOW RELEASE RISER ON THE CONSTRUCTION DRAWINGS. SLOTTED SLOW RELEASE RISER IS A PVC PIPE OR CORRUGATED METAL PIPE WITH AN INTERNAL ORIFICE TO ACHIEVE 24 TO 48 HOUR DRAW DOWN TIME FOR 1/2-INCH RUNOFF VOLUME. SLOTS ARE ALL SPACED VERTICALLY ABOVE THE ORIFICE PLATE SO THAT THE SEDIMENT DEPOSITED AROUND THE STANDPIPE WILL NOT IMPEDE THE SUPPLY OF WATER TO THE ORIFICE PLATE.

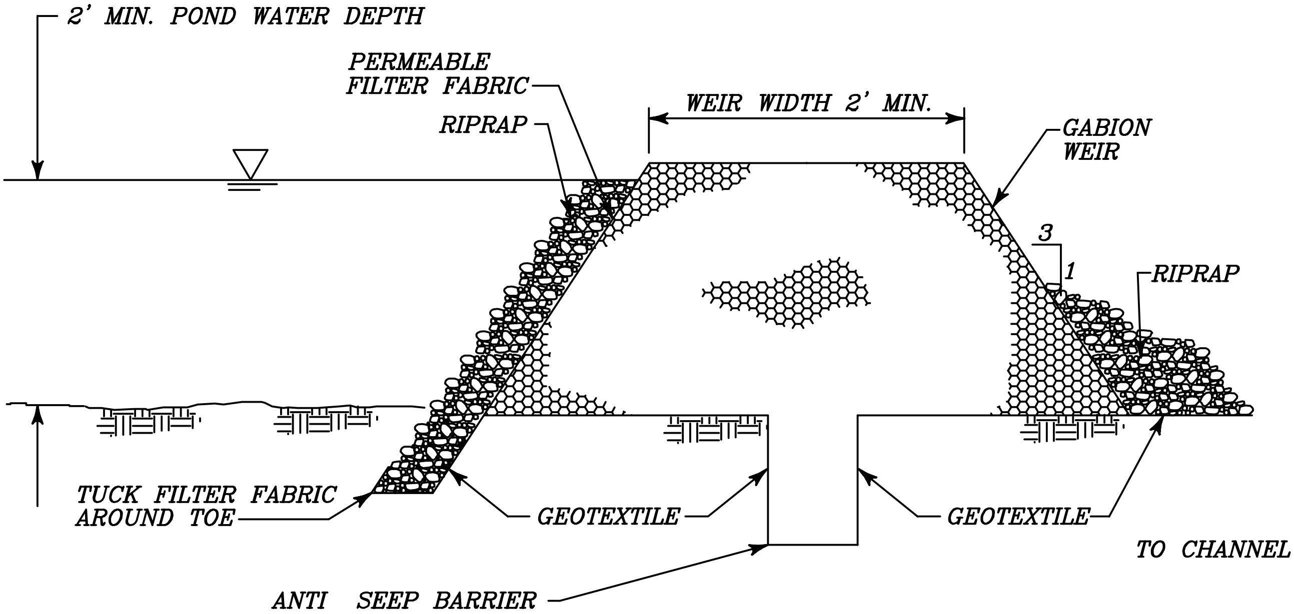
6. ALL PIPE CONNECTIONS SHALL BE WATERTIGHT. OUTLET PIPE MATERIAL – PVC OR CORRUGATED METAL PIPE

7. FILL MATERIAL AROUND PIPE SHALL BE COMPACTED TO 95% STANDARD PROCTOR OR CONSIST OF CEMENT STABILIZED SAND. A MINIMUM OF 2 FEET OF COMPACTED BACKFILL SHALL BE PLACED OVER THE PIPE BEFORE CROSSING IT WITH CONSTRUCTION EQUIPMENT.

8. PONDING OF RUNOFF IN BASIN ACCOMPLISHED BY EMBANKMENT OR EXCAVATED DEPENDING ON TERRAIN. INDICATE BASIN TYPE AND DIMENSIONS ON CONSTRUCTION DRAWINGS.

FIGURE 4.9b

BMP 4.2.1.1: IN–LINE STORM SEWER BASIN: WEIR DISCHARGE SECTION A–A



GENERAL NOTES:

1. BASIN STORAGE VOLUME IS 1800 CUBIC FEET PER DRAINED ACRE (1/2 INCH RUNOFF VOLUME). EXCESS RUNOFF SPILLS OVER WEIR INTO CHANNEL.

2. WEIR HEIGHT IS AT 1/2 INCH RUNOFF LEVEL. WEIR LENGTH SHOULD BE SUFFICIENT TO PASS THE DESIGN STORM WITH NO ADVERSE BACKWATER EFFECT ON STORM SEWER SYSTEM.

3. DIMENSIONS – LIMIT OF EXCAVATION, WEIR AND RISER HEIGHTS, AND PIPE DIAMETER SPECIFIED ON THE CONSTRUCTION DRAWINGS.

4. SIDE SLOPES – 3:1 OR FLATTER.

5. SLOW RELEASE GABION WEIR WITH PERMEABLE FILTER FABRIC AND RIPRAP BARRIER – SPECIFY GABION WEIR RIPRAP AND FILTER FABRIC ON THE CONSTRUCTION DRAWINGS TO ACHEIVE 24 TO 48 HOUR DRAW DOWN TIME FOR 1/2-INCH RUNOFF VOLUME.

6. USE GEOTEXTILE UNDER GABION WEIR AND RIPRAP BASE.

7. FILL MATERIAL AROUND RIPRAP AND GABION WEIR SHALL BE COMPACTED TO 95% STANDARD PROCTOR OR CONSIST OF CEMENT STABILIZED SAND.

8. PONDING OF RUNOFF IN BASIN ACCOMPLISHED BY EMBANKMENT OR EXCAVATED DEPENDING ON TERRAIN. INDICATE BASIN TYPE AND DIMENSIONS ON CONSTRUCTION DRAWINGS.

FIGURE 4.9c

BMP 4.2.1.1: IN-LINE STORM SEWER BASIN: WEIR DISCHARGE ALTERNATE SECTION A-A

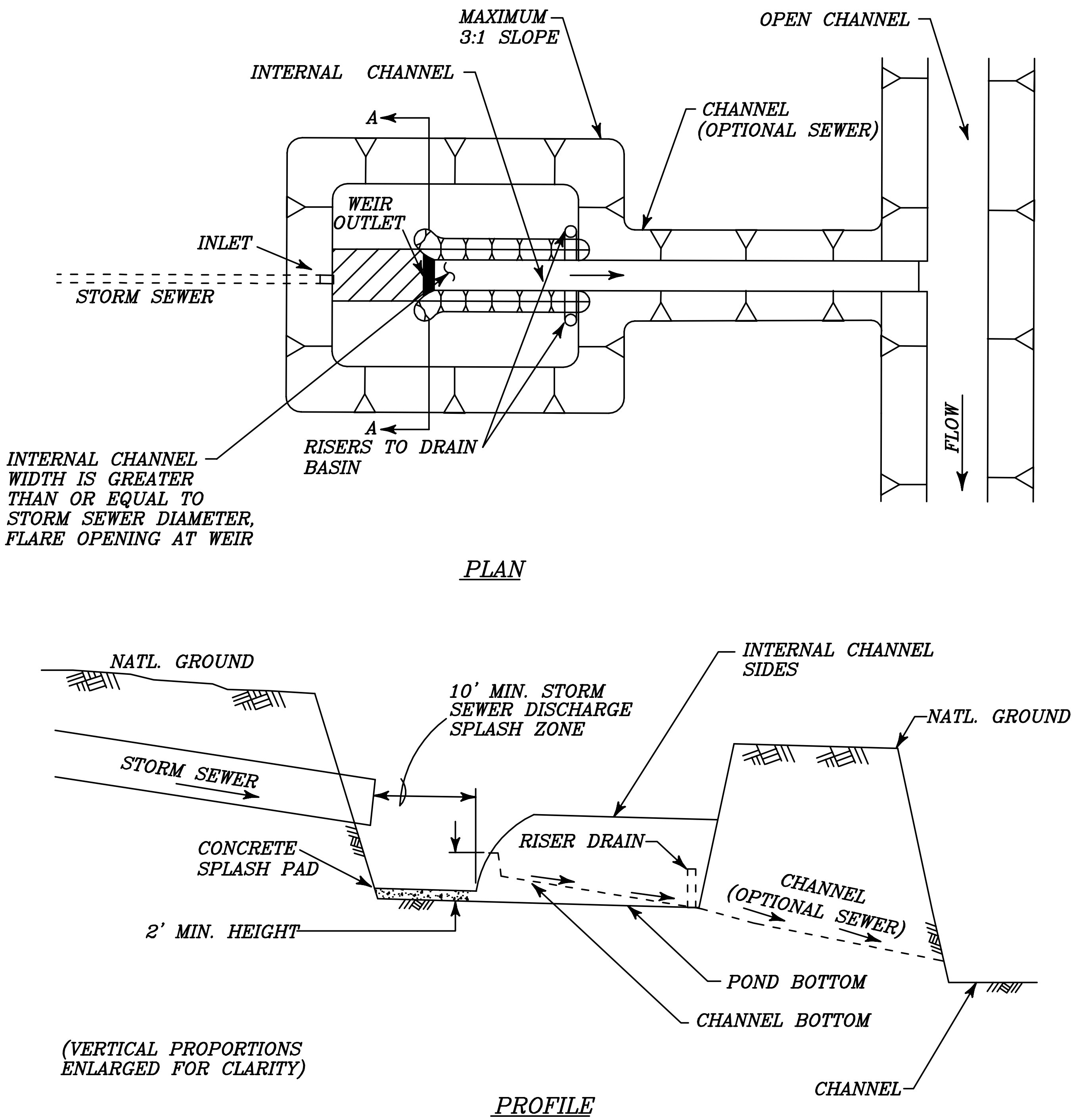
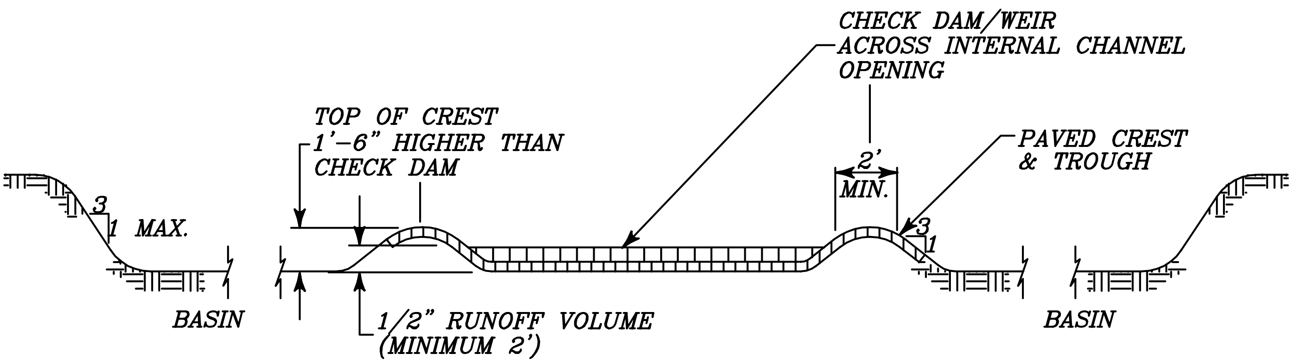


FIGURE 4.10a

BMP 4.2.1.1: IN-LINE STORM SEWER BASIN: INTERNAL CHANNEL DISCHARGE



SECTION A–A

FIGURE 4.10b

BMP 4.2.1.1: IN–LINE STORM SEWER BASIN:
INTERNAL CHANNEL DISCHARGE SECTION

GENERAL NOTES:

1. BASIN STORAGE IS 1800 CUBIC FEET PER DRAINED ACRE (1/2 INCH RUNOFF VOLUME). WHEN BASIN IS FULL, INCOMING RUNOFF FLOWS TO INTERNAL CHANNEL AND IS DISCHARGED.

2. OUTLET TO INTERNAL CHANNEL SHOULD BE FLARED AS WIDE AS NECESSARY TO PASS THE DESIGN STORM WITH NO ADVERSE BACKWATER EFFECT ON STORM SEWER SYSTEM. A STORM SEWER MAY BE USED INSTEAD OF A CHANNEL TO CONVEY FLOW FROM THE DETENTION BASIN TO THE OUTFALL CHANNEL.

3. DIMENSIONS – LIMIT OF EXCAVATION, RISER HEIGHT AND PIPE DIAMETER SPECIFIED ON THE CONSTRUCTION DRAWINGS.

4. SIDE SLOPES – 3:1 OR FLATTER.

5. SPECIFY SLOTTED SLOW RELEASE RISER OR WEIR DISCHARGE ALTERNATIVE SECTION AS SPECIFIED IN FIGURE 4.9c ON THE CONSTRUCTION DRAWINGS. RISER SHOULD BE FITTED WITH INTERNAL ORIFICE TO ACHIEVE 24 TO 48 HR. DRAW DOWN TIME FOR 1/2 INCH RUNOFF VOLUME. SEE SLOTTED SLOW RELEASE RISER SHOWN ON FIGURE 4.9b.

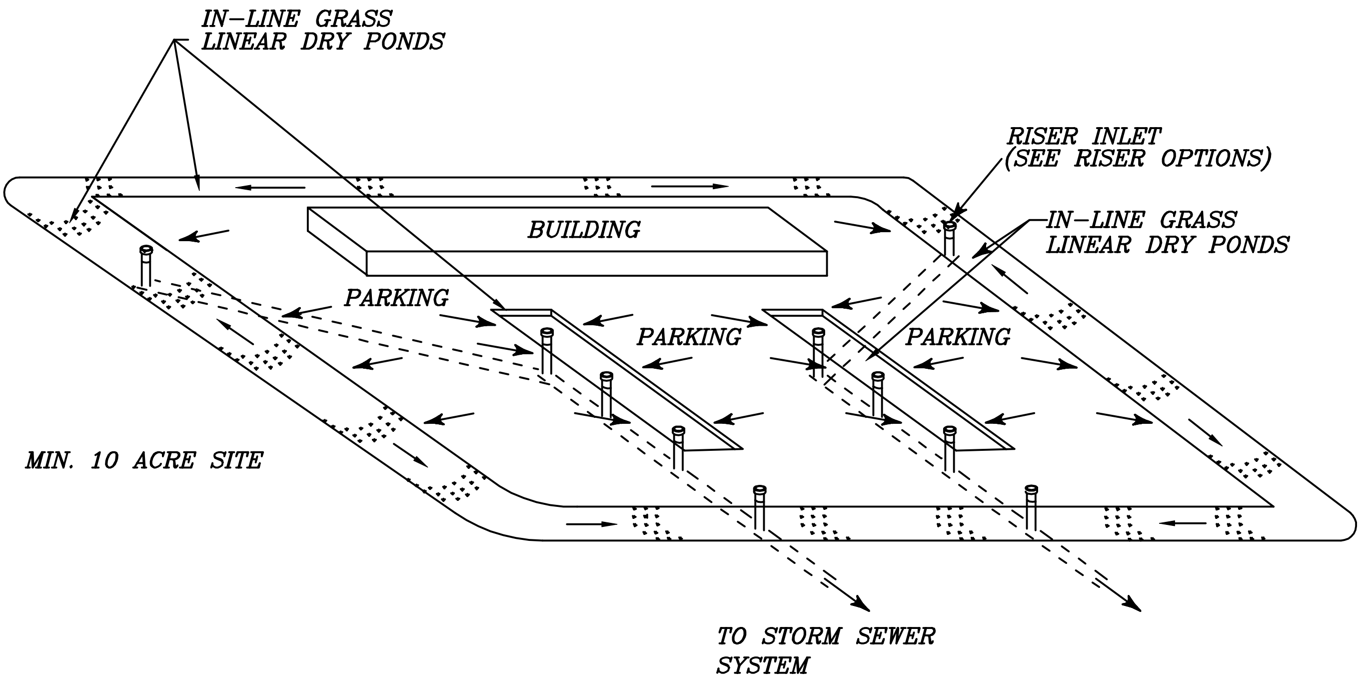
6. ALL PIPE CONNECTIONS SHALL BE WATERTIGHT. OUTLET PIPE MATERIAL – PVC OR CORRUGATED METAL PIPE

7. FILL MATERIAL AROUND PIPE SHALL BE COMPACTED TO 95% STANDARD PROCTOR OR CONSIST OF CEMENT STABILIZED SAND. A MINIMUM OF 2 FEET OF COMPACTED BACKFILL SHALL BE PLACED OVER THE PIPE BEFORE CROSSING IT WITH CONSTRUCTION EQUIPMENT.

8. PONDING OF RUNOFF IN BASIN ACCOMPLISHED BY EMBANKMENT OR EXCAVATED DEPENDING ON TERRAIN. REFERENCE CONSTRUCTION DRAWING FOR BASIN TYPE AND DIMENSIONS.

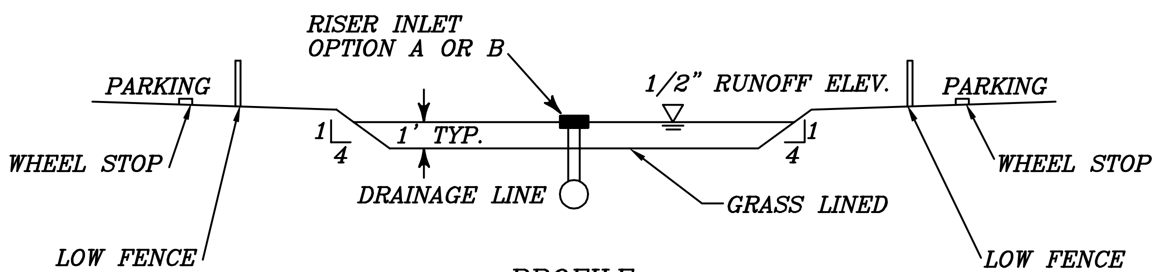
FIGURE 4.10c

BMP 4.2.1.1: IN–LINE STORM SEWER BASIN: INTERNAL CHANNEL DISCHARGE NOTES



PLAN

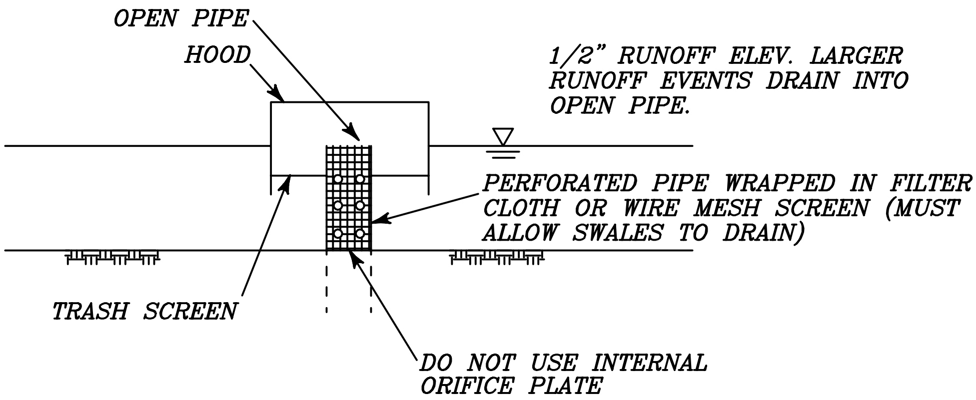
LINEAR DRY POND DETAIL



PROFILE

FIGURE 4.11a
BMP 4.2.1.1: IN–LINE GRASS LINEAR DRY PONDS:
MIN. 10 ACRE SITE

OPTION A: PERFORATED RISER WITH OVERFLOW OPENING



OPTION B: TANDEM RISERS
USE 1 SLOTTED SLOW RELEASE RISER PER POND TO CONTROL 1/2" RUNOFF TOGETHER WITH 1 OR MORE OVERFLOW RISERS PER POND TO DRAIN LARGER RUNOFF EVENTS.

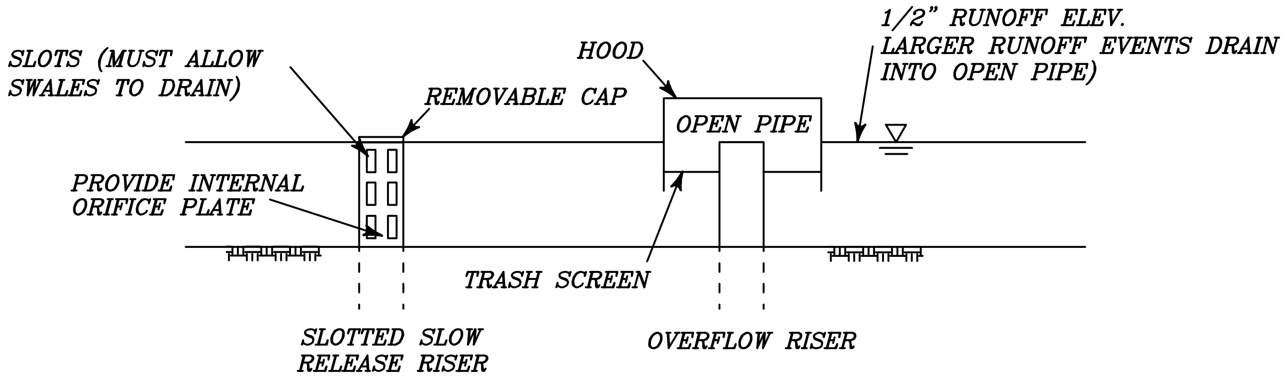


FIGURE 4.11b
BMP 4.2.1.1: IN-LINE GRASS LINEAR DRY PONDS: RISER OPTIONS

GENERAL NOTES:

1. *LINEAR PONDS PROVIDE STORAGE FOR 1800 CUBIC FEET PER DRAINED ACRE (1/2" RUNOFF VOLUME). EXCESS RUNOFF DISCHARGES INTO STORM SEWER. SLOW RELEASE RISERS RELEASE 1/2" RUNOFF VOLUME OVER 24–48 HOURS (SEE NOTE BELOW).*

2. *PONDS HAVE RISERS OR WEIR DISCHARGE ALTERNATIVE SECTION AS SPECIFIED IN FIGURE 4.9c TO PROVIDE EXTENDED DETENTION.*

3. *PERFORATED RISERS RELY ON PERFORATIONS FOR CONTROLLING RELEASE. FILTER CLOTH OR WIRE MESH SHOULD BE INSPECTED PERIODICALLY AND CLEANED OR REPLACED WHEN CLOGGED.*

4. *SLOTTED SLOW RELEASE RISER IS A PVC PIPE OR CORRUGATED METAL PIPE WITH AN INTERNAL ORIFICE TO ACHIEVE 24 TO 48 HR. DETENTION TIME FOR 1/2" RUNOFF VOLUME. SLOTS OR PERFORATIONS ARE ALL SPACED VERTICALLY ABOVE THE ORIFICE PLATE SO THAT THE SEDIMENT DEPOSITED AROUND THE STANDPIPE WILL NOT IMPEDE THE SUPPLY OF WATER TO THE ORIFICE PLATE.*

5. *PERIODIC MOWING NEEDED TO KEEP GRASS SHORT TO MEDIUM HEIGHT (APPROX. 3") DO NOT MULCH – BAG ALL CLIPPINGS.*

6. *OVERFLOW RISER INLET ALLOWS DIRECT DISCHARGE OF EXCESS RUNOFF TO STORM SEWER.*

7. *DIMENSIONS – LIMIT OF EXCAVATION AND PIPE DIAMETER SHALL BE AS SPECIFIED ON THE CONSTRUCTION DRAWINGS.*

8. *SIDE SLOPES – RECOMMEND 4:1 OR FLATTER*

9. *MAXIMUM DEPTH OF LINEAR PONDS – 1 FOOT, FOR SAFETY.*

10. *PROVIDE WHEEL STOPS AND LOW FENCING AROUND POND PERIMETER FOR SAFETY.*

11. *ALL PIPE CONNECTIONS SHALL BE WATERTIGHT.*

FIGURE 4.11c

BMP 4.2.1.1: IN–LINE GRASS LINEAR DRY PONDS: NOTES

4.2.1.2 Dry Basin (Off-line Storm Sewer)

The off-line storm sewer dry basin discussed in this subsection is the second of four design options under dry basins.

A. General Design Considerations

The off-line storm sewer basin is defined as a basin used to divert the first flush of runoff at some point of the storm sewer system prior to its outfall into a receiving channel. The majority of runoff flowing in the storm sewer bypasses the off-line storm sewer basin. The receiving channel may be either man made or a watercourse. Where site area is available, this option provides better water quality control than the in-line storm sewer basin and should be used.

Figure 4.12a, b, and c provide basin configuration and general notes for construction.

The general design considerations of the off-line storm sewer basin should include the following:

1. The hydraulics of the contributing drainage system must be carefully evaluated to minimize adverse effects of backwater from the basin and discharge mechanism. The design of the basin should not conflict with the storm sewer design criteria as described below:
   a. The storm sewer should be sized to current design criteria as adopted by the applicable agency.
   b. The storm sewer must be able to convey the design flow based on current criteria as adopted by the applicable agency.
2. Computations of the weir in a flow splitter box (see Figure 4.12b) should consider head loss associated with submerged conditions in the hydraulic analysis.
3. The basin configuration should be such that the first flush is captured and held for release slowly over a 24 to 48 hour period while the remainder of the flood hydrograph may pass through the basin. The draw down time should be controlled by the riser. See Section 4.2.1.1 for design detail.
4. While no restriction is given for size of drainage area, a 10-acre minimum is recommended. Larger drainage areas allow more efficient land use for the basin, as described in section 4.2.1.

B. Design Examples

Figure 4.12a, b, and c provide basin configuration and general notes for construction.

Based on Figures 4.12a, b, and c, an example basin design was developed as follows.

The example considers a 50-acre site with storm sewer drainage to a basin. The basin is located at some point upstream of a receiving channel. The first 0.5 inch of runoff is stored in the basin; excess runoff is discharged through a weir in a flow splitter box. The first flush of runoff is drained through a riser drain to the channel. The riser drain could optionally reconnect with the storm sewer at some lower elevation.

The purpose of this design is to illustrate how the storm sewer inlet can be located at some point lower than the half-inch runoff level in the basin. Therefore, the inlet will be submerged for some time following a storm until the basin drains to a level below the invert. This could allow sediments to build up in the inlet pipe. This design assumes that a maintenance program will be in place to keep the inlet pipe clear of sediments, possibly through periodic flushing. Maintenance costs for keeping the storm sewer inlet pipe would presumably be higher than for the case where the storm sewer invert is at or above the half-inch runoff level in the basin.

1. Design of Flow Splitter Box Based on 10-Year Storm

   One design of the flow splitter box weir assumed a 50-acre drainage area, 10-year storm event, a 3 foot high sharp crested weir 10 feet long, and a 2.5 foot calculated head over the weir. The basin bottom elevation was assumed to be the same as the storm sewer inlet invert. Therefore, the effective depth was 5 feet. The off-line basin bottom has a calculated length to width (L:W) ratio of 227':113'. The side slopes assumed a 4:1 horizontal to vertical (H:V) ratio. Basin depth from ground surface was 12 feet. Total area required for the basin was 1.55-acres and represents 3.1% of the total drainage area, not including maintenance berms or access.

2. Design of Flow Splitter Box Based on 3-Year Storm

   Another design of the flow splitter box weir made the same assumptions as above, but used a 3-year storm event to determine the length of weir. The weir length in this case reduced to 7.5 feet. Basin depth and total area required for the basin remained the same at 12 feet depth and 1.55-acres, not including maintenance berms or access.

Sources: Turner Collie & Braden, Association of Consulting Municipal Engineers, Lower Colorado River Authority.

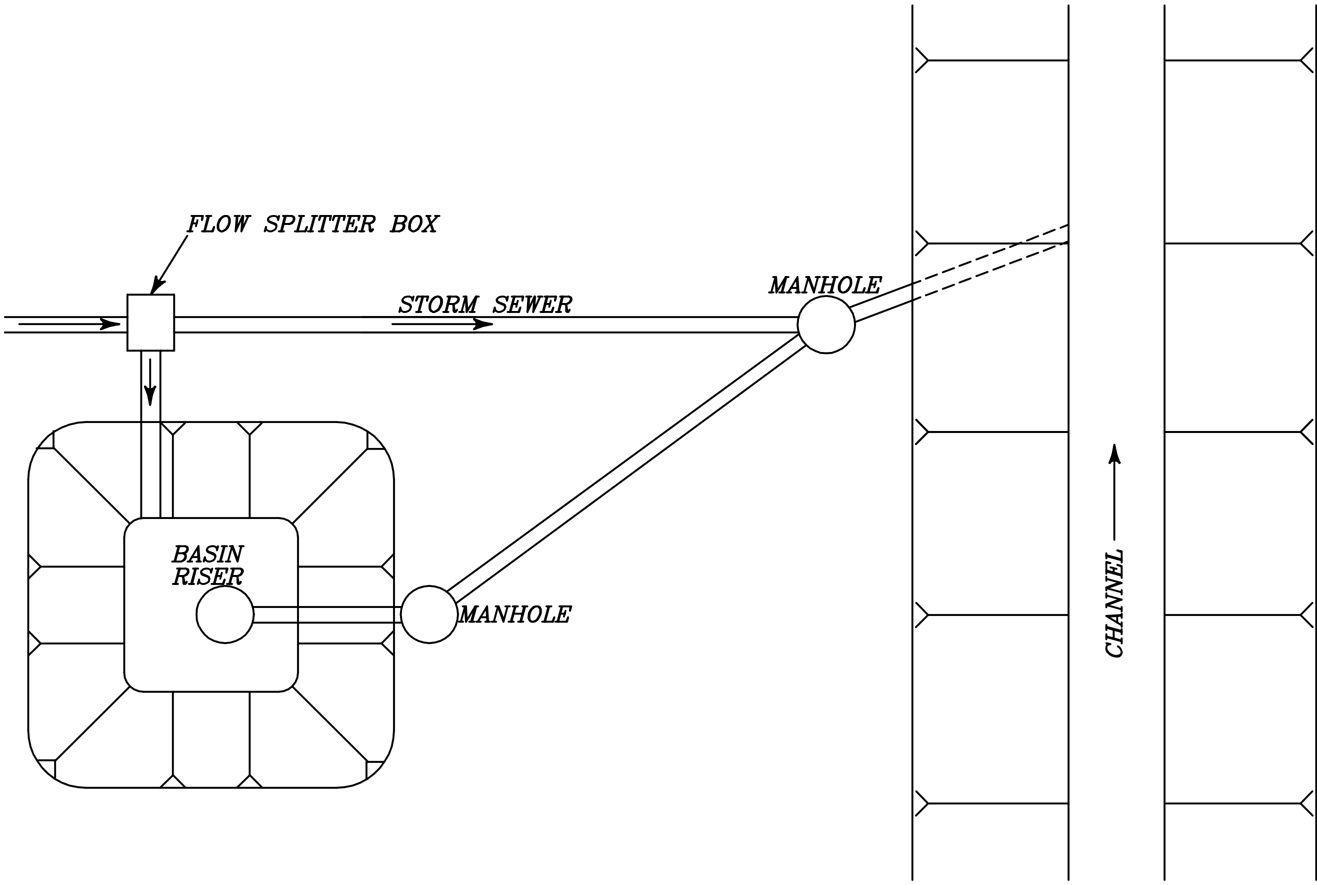
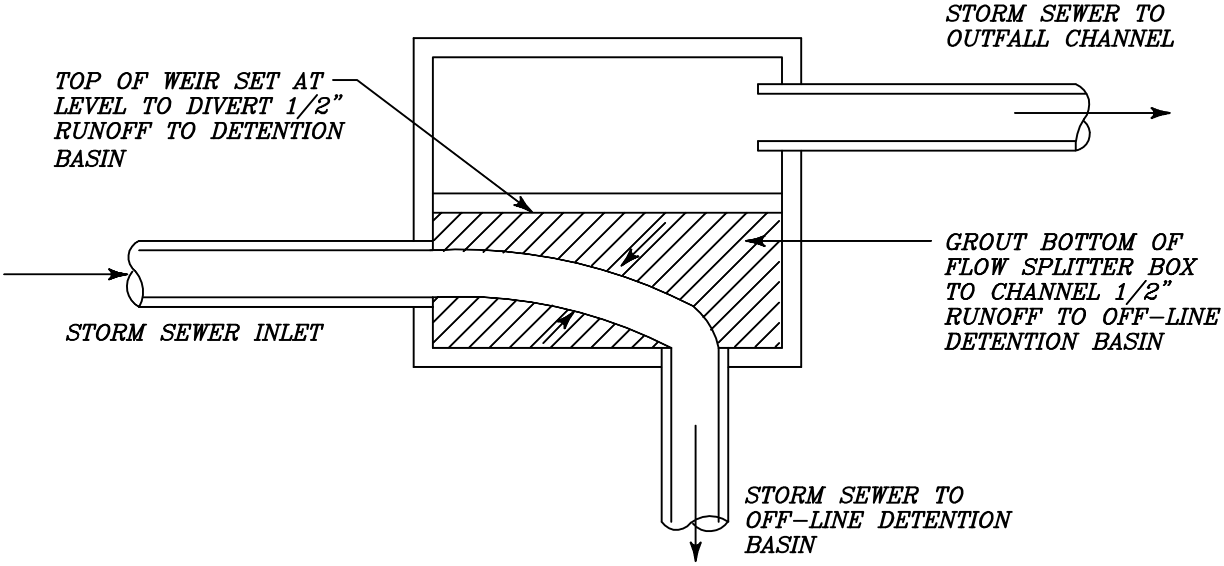
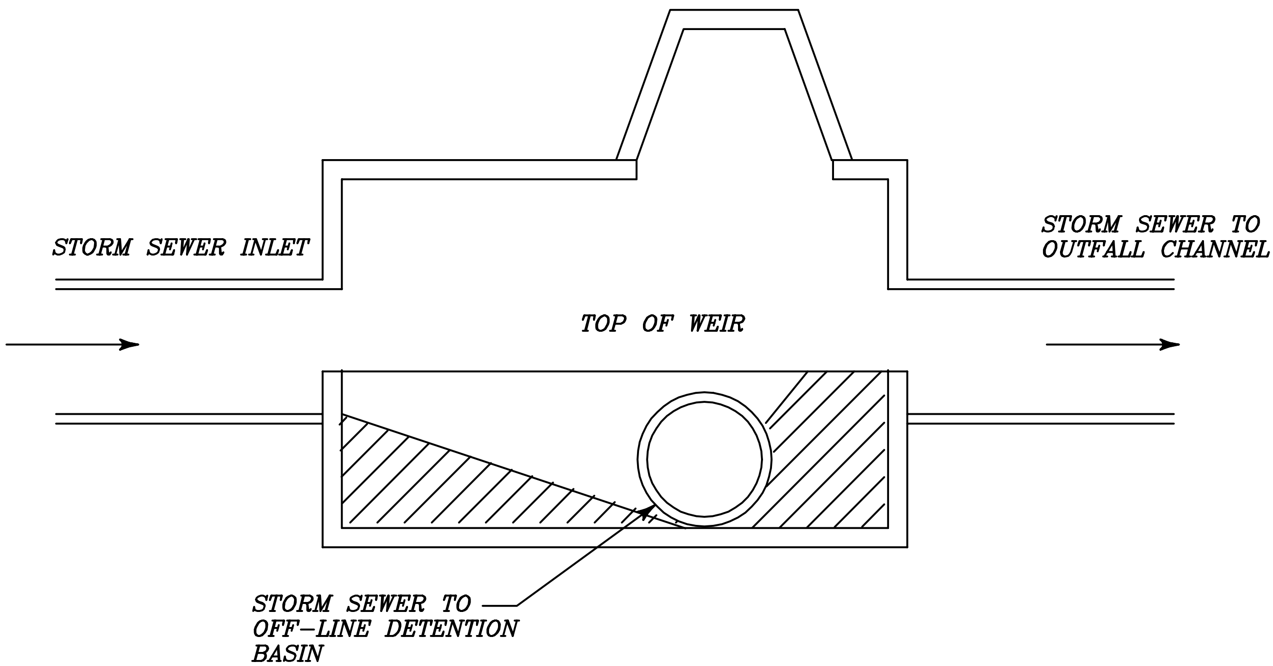


FIGURE 4.12a
BMP 4.2.1.2: STORM SEWER
OFF-LINE BASIN



PLAN



PROFILE

FIGURE 4.12b
BMP 4.2.1.2: STORM SEWER
OFF-LINE BASIN:
FLOW SPLITTER DETAIL

GENERAL NOTES:

1. TOP OF WEIR ELEVATION SHOULD BE ESTABLISHED TO CREATE BASIN STORAGE OF 1800 CUBIC FEET PER DRAINED ACRE (1/2 INCH RUNOFF VOLUME). EXCESS RUNOFF DISCHARGES OVER WEIR INTO PIPE. DRAIN PIPE OR RISER RELEASES 1/2 INCH RUNOFF VOLUME OVER 24–48 HOURS.

2. WEIR INSIDE FLOW SPLITTER SHOULD BE AS LONG AS NECESSARY TO PASS THE DESIGN STORM RUNOFF WITH NO ADVERSE BACKWATER EFFECT ON STORM SEWER SYSTEM.

3. FLOW SPLITTER BOX SHOULD BE CONSTRUCTED OF CONCRETE WITH WATERTIGHT FITTINGS.

4. DIMENSIONS – LIMIT OF EXCAVATION, FLOW SPLITTER BOX DIMENSIONS, RISER HEIGHT AND OUTLET PIPE DIAMETER SHOULD BE SPECIFIED ON THE CONSTRUCTION DRAWINGS.

5. SIDE SLOPES – 3:1 OR FLATTER.

6. SPECIFY SLOTTED SLOW RELEASE RISER ON THE CONSTRUCTION DRAWINGS. RISER HAS INTERNAL ORIFICE TO ACHIEVE 24 TO 48 HR. DRAW DOWN TIME FOR 1/2 INCH RUNOFF VOLUME. (SEE FIGURE 4.11b – SLOTTED SLOW RELEASE RISER).

7. OUTLET PIPE MATERIAL – PVC OR CORRUGATED METAL PIPE. ALL PIPE CONNECTIONS SHALL BE WATER TIGHT.

8. PROVIDE PILOT CHANNEL TO RISER DRAIN

9. FILL MATERIAL AROUND PIPE SHALL BE COMPACTED TO 95% STANDARD PROCTOR OR CONSIST OF CEMENT STABILIZED SAND. A MINIMUM OF 2 FEET OF COMPACTED BACKFILL SHALL BE PLACED OVER THE PIPE BEFORE CROSSING IT WITH CONSTRUCTION EQUIPMENT.

10. PONDING OF RUNOFF IN BASIN ACCOMPLISHED BY EMBANKMENT OR EXCAVATION DEPENDING ON TERRAIN. REFERENCE CONSTRUCTION DRAWING FOR BASIN TYPE AND DIMENSIONS.

FIGURE 4.12c

BMP 4.2.1.2: STORM SEWER

OFF–LINE BASIN: NOTES

4.2.1.3 In-line Channel Basin

The in-line storm sewer dry basin discussed in this subsection is the third of four design options under dry basins.

A. General Design Considerations

The in-line channel basin is defined as a basin constructed in the main flow stream of a man made drainage channel.

The application for the in-line channel basin is intended for larger drainage areas but may be used in any situation where it is cost effective and meets the objectives of water quality enhancement. This design may be feasible where a new channel is constructed. It is not intended that this solution be applied to an existing watercourse. The detention should occur before the runoff enters a watercourse and next to a drop structure.

Figures 4.13a and b provide basin plan and profile information and general notes for construction.

General design considerations of the in-line channel basin include:

1. The in-line channel concept requires approval of HCFCD to ensure that the flood control function of the channel is not impeded. This type of basin is applicable only in the upper reaches of the watershed.
2. Provision for access to the channel for maintenance should be made.
3. Basin storage volume should be 1800 cubic feet per drained acre, which is equal to the 0.5 inch runoff volume. The basin storage volume should not include any storage in the channel itself, since the purpose of the channel is conveyance, not impoundment of water.
4. The basin should drain over a 24 to 48 hour period. The draw down time should be controlled by the riser. See Section 4.2.1.1 for design detail.

B. Design Example

Figures 4.13a and b provide basin plan and profile information and general notes for construction.

Based on Figures 4.13a and b, the following illustrative basin was developed.

A drainage area of 100-acres and basin effective depth of two feet provided a basin bottom area of almost two acres. This area's basin bottom has a calculated length to width ratio of 412':206'. The side slopes assumed a 4:1 horizontal to vertical (H:V) ratio. Assuming a channel depth of 14 feet, total area required for the basin was 3.83-acres and represents 3.83% of the total drainage area, not including maintenance berms or access.

For illustration purposes, a 10-year storm was used in weir calculation. However, the basin design should not conflict with the HCFCD requirements for flood control purposes. The 10-year storm event generated a peak flow of 249 cfs. For this flow and a one foot head height above the weir, the weir length required was 96 feet. Computer backwater analysis would be required to determine the extent of backwater effects from the weir, and how much widening of the channel would be needed upstream of the basin, to reduce backwater effects.

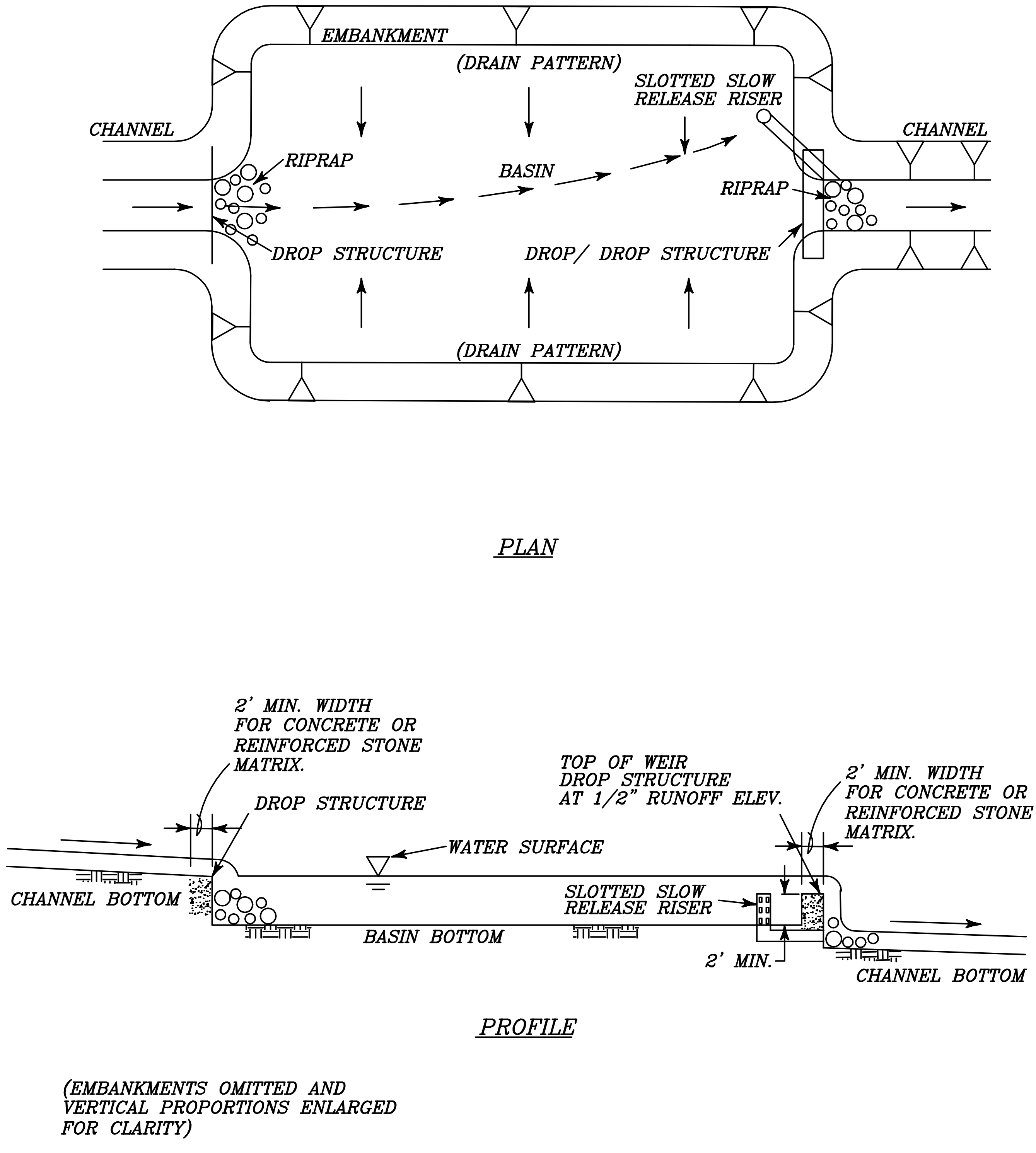


FIGURE 4.13a

BMP 4.2.1.3: IN-LINE CHANNEL BASIN

GENERAL NOTES:

1. BASIN STORAGE IS 1800 CUBIC FEET PER DRAINED ACRE (1/2 INCH RUNOFF VOLUME). EXCESS RUNOFF DISCHARGES OVER THE WEIR/DROP STRUCTURE INTO DOWNSTREAM CHANNEL. RISER DRAIN RELEASES 1/2 INCH VOLUME OVER 24–48 HOURS (SEE BELOW).

2. PROVIDE A PILOT CHANNEL TO RISER DRAIN

3. DIMENSIONS – LIMIT OF EXCAVATION, RISER HEIGHT, PIPE DIAMETER AND DROP STRUCTURE DIMENSIONS SHOULD BE SPECIFIED ON THE CONSTRUCTION DRAWINGS.

4. SPECIFY ON THE CONSTRUCTION DRAWINGS. RISER SHOULD BE FITTED WITH INTERNAL ORIFICE PLATE TO ACHIEVE 24 TO 48 HR. DETENTION TIME FOR 1/2 INCH RUNOFF VOLUME. (SEE FIGURE 4.9b – SLOTTED SLOW RELEASE RISER).

5. SIDE SLOPES – 3:1 OR FLATTER.

6. OUTLET PIPE MATERIAL – PVC OR CORRUGATED METAL PIPE. ALL PIPE CONNECTIONS SHALL BE WATERTIGHT.

7. FILL MATERIAL AROUND PIPE SHALL BE COMPACTED TO 95% STANDARD PROCTOR OR CONSIST OF CEMENT STABILIZED SAND. A MINIMUM OF 2 FEET OF COMPACTED BACKFILL SHALL BE PLACED OVER THE PIPE BEFORE CROSSING IT WITH CONSTRUCTION EQUIPMENT.

8. PONDING OF RUNOFF IN BASIN ACCOMPLISHED BY EMBANKMENT OR EXCAVATION DEPENDING ON TERRAIN. INDICATE BASIN TYPE AND DIMENSIONS ON CONSTRUCTION DRAWINGS.

9. DROP STRUCTURES SHALL BE DESIGNED TO HCFCD CRITERIA FOR FLOOD CONTROL AND DRAINAGE FACILITIES. MINIMUM WIDTH OF DROP STRUCTURE CONSTRUCTED OF CONCRETE OR REINFORCED STONE MATRIX SHOULD BE 2 FEET.

10. AREAS BELOW DROP STRUCTURES SHOULD BE REINFORCED AGAINST SCOURING WITH RIP RAP, CONCRETE OR OTHER ACCEPTABLE MATERIAL.

FIGURE 4.13b

BMP 4.2.1.3: IN–LINE CHANNEL BASIN: NOTES

4.2.1.4 Off-line Channel Basin

The off-line channel dry basin discussed in this subsection is the last of four design options under dry basins.

A. General Design Considerations

The off-line channel basin is defined as a basin constructed on the side of a man made channel designed to divert the first flush of runoff. This concept may be feasible where a new channel is constructed. The basin is not intended as a diversion on a watercourse. The application is intended for larger areas but may be used in any situation where it is cost effective. The off-line concept provides a water quality basin separated from the channel, and hence better protection for settled sediments than an in-line concept.

The off-line channel basin concept can also be adapted for use with a storm sewer inlet and a channel outlet. Either a box flow splitter (see Figure 4.12a, b, c) or a diversion dam (see Figure 4.14a, b) could be used to divert the first flush of runoff into the basin.

Design considerations for the off line channel system should include:

1. The off-line channel concept requires approval of HCFCD to ensure that the flood control function of the channel is not impeded.
2. Provision for access to the channel for maintenance should be made.
3. Basin storage volume should be 1800 cubic feet per drained acre, which is equal to the 0.5 inch runoff volume. The basin storage volume should not include any storage in the channel itself, since the purpose of the channel is conveyance, not impoundment of water.
4. The basin should drain over a 24 to 48 hour period. The draw down time should be controlled by the riser. See Section 4.2.1.1 for design detail.

B. Design Examples

Figures 4.14a and b provide basin plan and profile information and general notes for construction.

An example design is given as follows, based on Figure 4.14a and b.

The example considers a 100-acre site with open channel drainage to a basin. A diversion dam in the channel diverts runoff up to the 1/2" runoff level into the basin. When the basin is full, additional runoff spills over the dam and continues down the channel. The first flush of runoff drains through a riser drain to a lower point in the channel. The example shows a basin located next to a drop structure, to take advantage of a channel elevation change to create a deeper basin than might be possible otherwise.

A drainage area of 100-acres and basin effective depth of two feet provided a basin bottom area of almost two acres. This area's basin bottom has a calculated length to width ratio of 412':206'. The side slopes assumed a 4:1 horizontal to vertical (H:V) ratio. Assuming a channel depth of fourteen feet, total area required for the basin was 3.83-acres and represents 3.83% of the total drainage area, not including maintenance berms or access.

For illustration purposes, a 10-year storm was used in weir calculation. However, the basin design should not conflict with the HCFCD requirements for flood control purposes. The 10-year storm event generated a peak flow of 249 cfs. For this flow and a one foot head height above the diversion dam/weir, the weir length required was 96 feet. Computer backwater analysis would be required to determine the extent of backwater effects from the diversion dam, and how much widening of the channel would be needed upstream of the diversion dam, to reduce backwater effects.

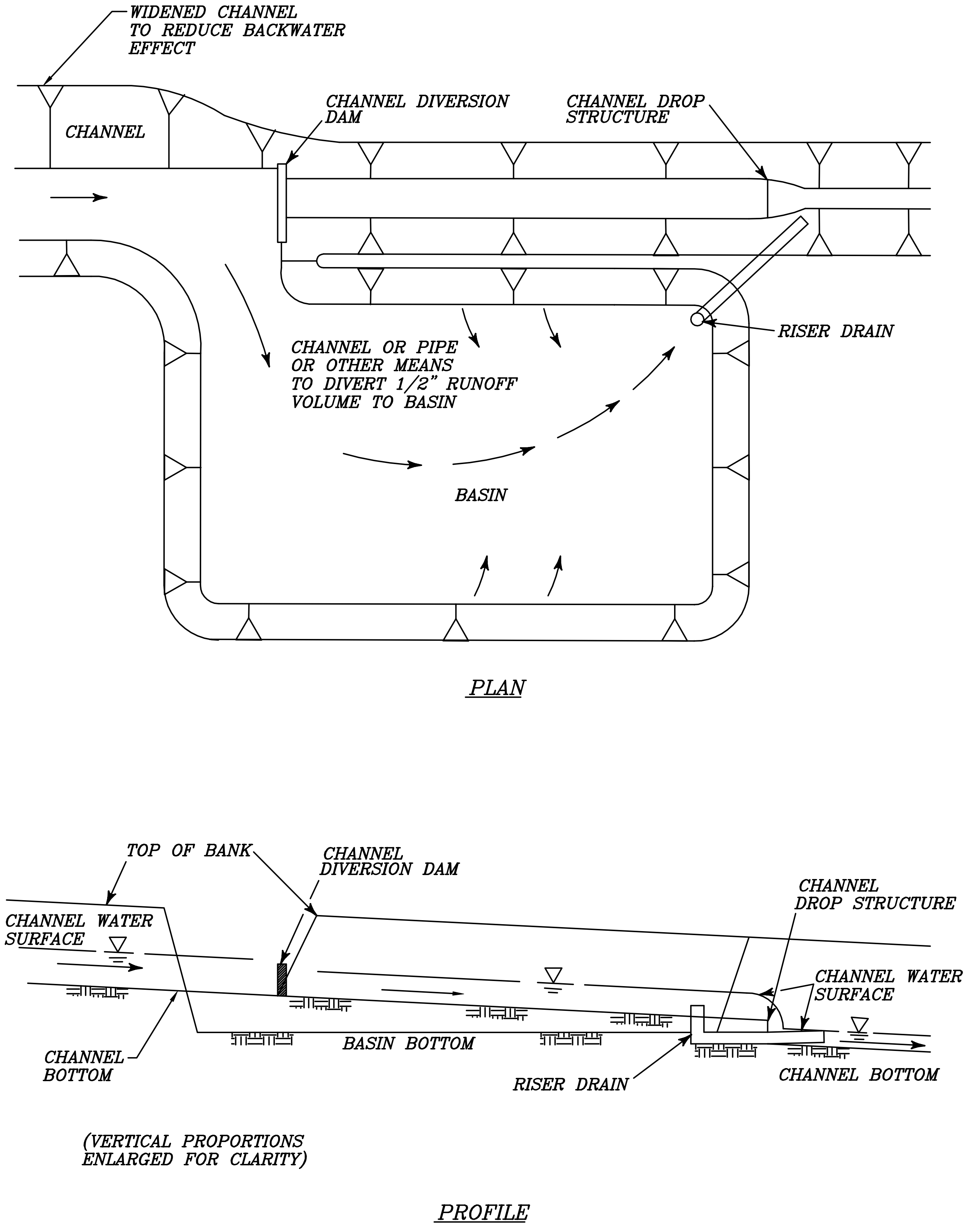


FIGURE 4.14a

BMP 4.2.1.4: OFF–LINE CHANNEL BASIN

GENERAL NOTES:

1. BASIN STORAGE IS 1800 CUBIC FEET PER DRAINED ACRE (1/2 INCH RUNOFF VOLUME). DIVERSION DAM DIVERTS 1/2 INCH RUNOFF TO BASIN. EXCESS RUNOFF SPILLS OVER DAM, AND THEN SPILLS OVER DROP STRUCTURE TO LOWER CHANNEL. RISER DRAIN RELEASES 1/2 INCH VOLUME OVER 24–48 HOURS (SEE BELOW).

2. DIVERSION DAM CREST IS AT 1/2 INCH RUNOFF VOLUME LEVEL.

3. DIVERSION DAM SHOULD BE DESIGNED SO AS TO NOT ADVERSELY AFFECT UPSTREAM DRAINAGE SYSTEM.

4. PROVIDE A PILOT CHANNEL TO RISER DRAIN

5. DIMENSIONS – LIMIT OF EXCAVATION, RISER HEIGHT, PIPE DIAMETER, DIVERSION DAM AND DROP STRUCTURE DIMENSIONS SHOULD BE SPECIFIED ON THE CONSTRUCTION DRAWINGS.

6. SPECIFY SLOW RELEASE RISER ON THE CONSTRUCTION DRAWINGS. RISER SHOULD BE FITTED WITH INTERNAL ORIFICE PLATE TO ACHIEVE 24 TO 48 HR. DRAW DOWN TIME FOR 1/2 INCH RUNOFF VOLUME. (SEE FIGURE 4.9B – SLOTTED SLOW RELEASE RISER)

7. SIDE SLOPES – 3:1 OR FLATTER.

8. OUTLET PIPE MATERIAL – PVC OR CORRUGATED METAL PIPE. ALL PIPE CONNECTIONS SHALL BE WATERTIGHT.

9. FILL MATERIAL AROUND PIPE SHALL BE COMPACTED TO 95% STANDARD PROCTOR OR CONSIST OF CEMENT STABILIZED SAND. A MINIMUM OF 2 FEET OF COMPACTED BACKFILL SHALL BE PLACED OVER THE PIPE BEFORE CROSSING IT WITH CONSTRUCTION EQUIPMENT.

10. PONDING OF RUNOFF IN BASIN ACCOMPLISHED BY EMBANKMENT OR EXCAVATION DEPENDING ON TERRAIN. INDICATE BASIN TYPE AND DIMENSIONS ON CONSTRUCTION DRAWINGS.

11. DROP STRUCTURES SHALL BE DESIGNED TO HCFCD CRITERIA FOR FLOOD CONTROL AND DRAINAGE FACILITIES.

12. AREAS BELOW DROP STRUCTURES SHOULD BE REINFORCED AGAINST SCOURING WITH RIP RAP, CONCRETE SLOPE PAVING, CELLULAR CONCRETE MATS, GABIONS, OR OTHER ACCEPTABLE MATERIAL.

FIGURE 4.14b

BMP 4.2.1.4: OFF–LINE CHANNEL BASIN: NOTES

4.2.2 Wet Ponds

A. Definition

A wet pond has a permanent pool to capture and treat the design storm water runoff from the drainage area. This system could function either on-line or off-line to the storm sewer system. The pond could be designed for storm water discharge control, with extra capacity to temporarily detain storm water runoff for later release. Wet ponds with extended detention storage above the permanent pool enhance pollutant removal and reduce downstream bank erosion.

The volume of the permanent pool of a wet pond is referred as *water quality volume or capture volume*. It is the volume of storm water runoff captured during the duration of the storm and treated for water quality enhancement through quiescent settling and biological uptake.

B. Purpose

Wet ponds accomplish two things. During a storm, polluted runoff enters the pond and displaces the existing “cleaner” water in the permanent pond. The displacement of treated storm water reduces the pollutant concentration of the outflow.

Suspended solids in the pond will have a relatively long period of time to settle out until the next storm occurs. In addition to efficient settling, this long detention time also allows removal of dissolved nutrients through biological uptake.

C. Planning Considerations

The wet pond is one of the more reliable and attractive BMPs, with relatively higher pollutant removal efficiency than dry basins, and multiple benefits and amenities. It also requires careful design, engineering, construction and maintenance.

1. The permanent pool should be designed to hold and treat the design runoff for water quality enhancements. The permanent pool should remain full at all times to provide a source of water for wetland plants and minimize resuspension of sediments. The degree of pollutant removal is a function of pool size in relation to contributing area. The permanent pool should be sized to store 1/2" of runoff from the contributing drainage area, which is equal to volume of 1800 cubic feet per drained acre. Pond water depth should be no greater than 8 feet to prevent thermal stratification. Basins with variable depths that contain both shallow areas of less than 2 feet and deeper areas of greater than 4 feet may be most beneficial for water quality improvements. The shallow areas can promote growth of vegetation that enhances nutrient and storm water pollutant uptake and the deeper areas can provide pollutant removal by gravitational settling of solids.
2. The inlet to the permanent pond may be an open channel or a storm sewer. If a storm sewer inlet is used, the storm sewer may use a drop structure or manhole to submerge the open end of the pipe. The advantages of a submerged pipe end include lack of visual impact and reduced pond bank erosion. The main disadvantage of a submerged pipe end is the possible need for periodic inspection and cleaning to prevent sediment build up in the submerged portion of the pipe. The problem of sediment build up can be reduced by minimizing the length of pipe that is submerged.

3. Excess runoff may be discharged using a weir, riser or pipe. Riser options are given in Figure 4.16b. A brief discussion follows on these riser options.

   Option A: Overflow Riser. This riser was introduced in Figure 4.11b as part of a tandem riser concept. Excess runoff discharges through a hooded open pipe.

   Option B: Negatively Sloped Pipe from Riser. This design was developed to allow for extended detention in wet ponds. The release rate is governed by the orifice of the pipe. The risk of clogging is largely eliminated by locating the opening of the pipe at least one foot below the water surface where it is well away from floatable debris. Also, the negative slope of the pipe reduces the chance that debris will be pulled into the opening by suction. As a final defense against clogging, the orifice can be protected by wire mesh.

   Option C: Hooded Riser. In this design, the extended detention orifice is located on the face of the riser near the top of the permanent pool elevation. The orifice is protected by wire mesh and a hood, which prevents floatable debris from clogging the orifice.

4. Studies to date indicate that for most residential developments, pond sediments meet sludge toxicity limits and can be safely landfilled (MWCOG 1992). However, it is the owner's responsibility to test and to properly dispose the sediment.
5. The basin should be designed to facilitate sediment removal. Inspection and maintenance access should be provided.

D. Design Considerations

Two design options are given in Figures 4.15a and b, and Figures 4.16a, b and c:

Figures	Description
4.15a, b	Wet Pond, In-Line Design
4.16a, b	In-Line Grass Swales, Wet Pond (Permanent Pool)

The figures provide basin plan and profile information and general notes for construction.

General design considerations include the following:

1. The engineer/developer should adhere to all applicable federal, State, and local rules regarding the impoundment of water.
2. The pond and storm sewer must be designed to assure some flushing of sediments from the pipe to minimize blockages.
3. Provision may be necessary to avoid debris from littering the pond.
4. An outlet structure for runoff greater than 0.5 inch should be provided. This could be in the form of a riser, weir, culverts, or other facility. The design must not impact the hydraulics of the upstream storm sewer or channel system under design conditions.
5. The areas below the inlet and outlet should be reinforced against scouring with stone, concrete or other lining.

6. A soil study and geotechnical analysis should be conducted to determine appropriate design for the basin, including measures against piping or groundwater seepage.
7. The minimum length-to-width ratio of the pond dimensions should be 3:1 to prevent short-circuiting. If a long, narrow pond is not possible, baffles or gabions can be placed within the pond to control the flow path.
8. Average pond water depth between 3 to 6 feet is recommended, and pond water depth should not exceed 8 feet to avoid stratification.
9. Native vegetation capable of thriving under the conditions of the wet pond should be planted. An assortment of vegetation should be planted to survive in the varied depths of the wet pond. For a partial list of vegetation, see Appendix E. For the permanent pool, species should be selected from the open water/deep marsh list and the shallow emergent marsh list.
10. The need for an emergency spillway should be evaluated.

E. Design Examples

Figures 4.15a and b, and Figures 4.16a, b, and c, provide basin plan and profile information and general notes for construction.

Figures 4.15a, b - Wet Pond - In-Line Design

The example based on Figures 4.15a, b considers a 50-acre site with storm sewer drainage to a permanent pool. The pool is located next to an open channel. The pool capacity is one-half inch of runoff. Runoff entering the pool mixes with the pool water and excess water is discharged through a pipe at the far end of the pool.

A drainage area of 50-acres and basin effective depth of three feet provided a basin bottom area of 0.43-acres. This area's basin bottom has a calculated length to width (L:W) ratio of 238':79'. The side slopes assumed a 3:1 (H:V) ratio for the first two feet of the bottom and a 10:1 (H:V) for the remaining one foot height. Two 3'X5' box culverts provided the inlet. Total depth from the pipe invert/basin bottom to the ground surface was twelve feet. Total area required for the basin was 1.5-acres and represents 3.0% of the total drainage area, not including maintenance berms or access.

Outlet was provided with a storm sewer pipe of equal or greater diameter than the inlet storm sewer pipe. Alternately, a weir could be provided for the outlet. For illustration purposes, a 10-year storm was used in weir calculation. However, the basin design should not conflict with the HCFCD requirements for flood control purposes. The 10-year storm event generated a peak flow of 138 cubic feet per second (cfs). For this flow and a one foot head height above the weir, the weir length required would be 53 feet.

Figures 4.16a, b, c - In-Line Grass Swales, Wet Pond Permanent Pool

The example based on Figures 4.16a, b and c applies to smaller sites with a minimum area of 10 acres. In this example, storm water is collected by grass swales and conveyed through storm sewers into a permanent pool. The example illustrates the use of grass swales for the dual purpose of landscaping and vegetative filtration.

A drainage area of 10-acres and basin effective depth of three feet provided a basin bottom area of 0.08-acres. This area's basin bottom has a calculated length to width ratio of 124':41'. The side slopes assumed a 3:1 horizontal to vertical (H:V) ratio. Depth from the pipe invert to ground surface was seven feet giving a total depth to the basin bottom of 7.5 feet. Total area required for the basin was 0.33-acre and represents 3.3% of the total drainage area, not including maintenance berms or access.

The grass swales were 8 feet wide with a 4:1 side slope, and 0.1% minimum slope, and required 0.48 acre of site area. The area dedicated to the storm water quality system (basin and swales), at 8.1%, is consequently more than double the area needed if only grated inlets were used for storm water collection (3.3%). These figures do not include maintenance and access area.

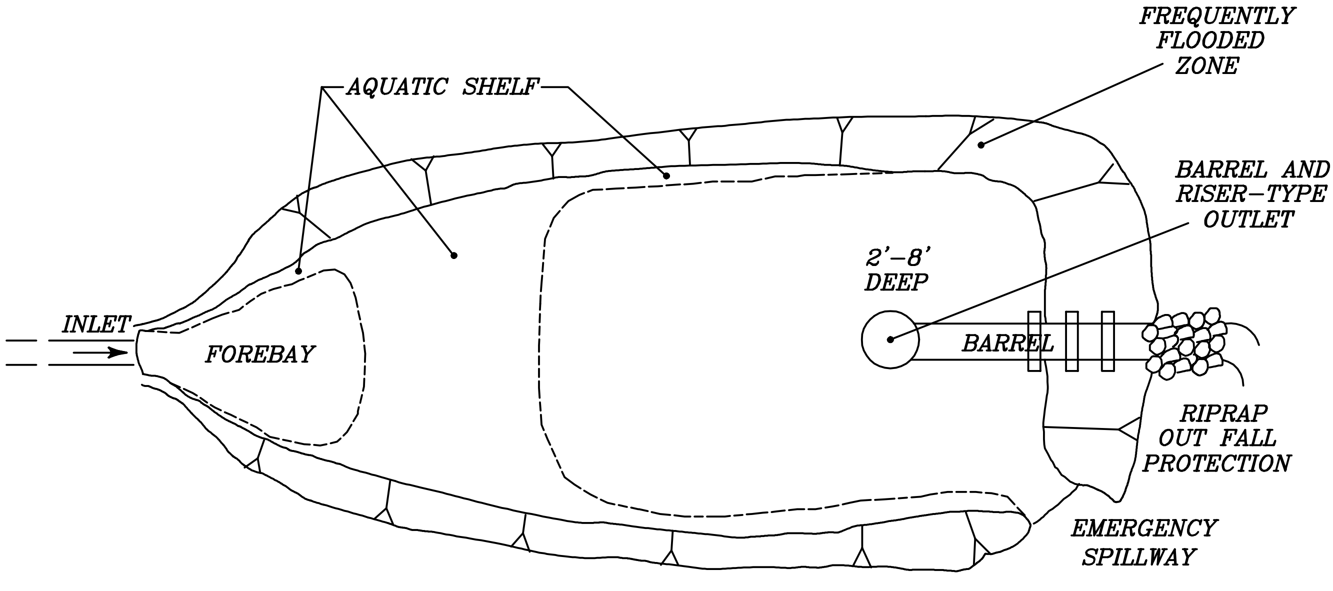
F. Maintenance

1. Maintenance and inspection access to the facility should be provided.
2. Sediment should be removed from the pond area when accumulations exceed one-third the design depth of the pond.
3. Accumulated paper, trash and debris should be removed every 6 months or as necessary.
4. The side-slope, embankments and spillway areas should be mowed at least twice a year to discourage woody growth and control weeds.
5. A visual check inspection should be conducted after each rainfall event of 1 inch or more in 24 hours until the pond and drainage system are stabilized. Thereafter, visual checks should be conducted as needed to inspect for damage and any necessary repairs.
6. It is recommended that a complete inspection be conducted at least annually.

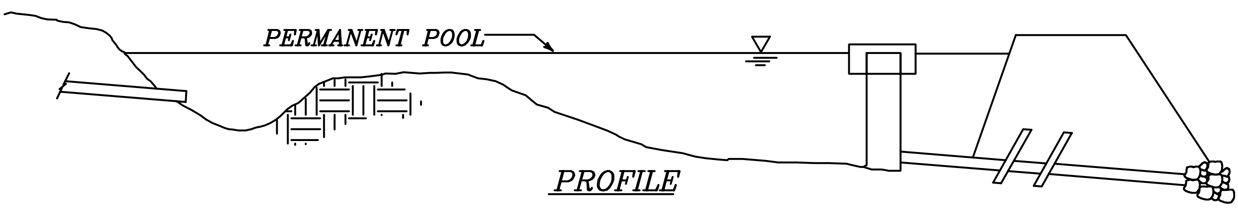
Sources: Turner Collie & Braden, Lower Colorado River Authority, Metropolitan Washington Council of Governments 1987, Metropolitan Washington Council of Governments, 1992, Minnesota Pollution Control Agency.

POTENTIAL WET POND DESIGN

(FOR SHALLOW INLET OR OPEN CHANNEL INLET)



PLAN



PROFILE

GENERAL NOTES:

1. WET POND PERMANENT POOL STORAGE VOLUME IS EQUAL TO 1800 CUBIC FEET PER DRAINED ACRE (1/2 INCH RUNOFF VOLUME). EXCESS DISCHARGE DRAINS INTO TOP OF RISER. IF NEEDED, EXTREME EVENTS DRAIN THROUGH SPILLWAY.

2. DIMENSIONS – LIMIT OF EXCAVATION, RISER HEIGHT AND PIPE DIAMETER SHOULD BE SPECIFIED ON THE CONSTRUCTION DRAWINGS.

3. RISER PIPE MATERIAL – PVC OR CORRUGATED METAL PIPE. ALL PIPE CONNECTIONS SHALL BE WATERTIGHT.

4. RISER OPTIONS – SEE FIGURE 4.16b – WET DETENTION POND RISER OPTIONS AND GENERAL NOTES.

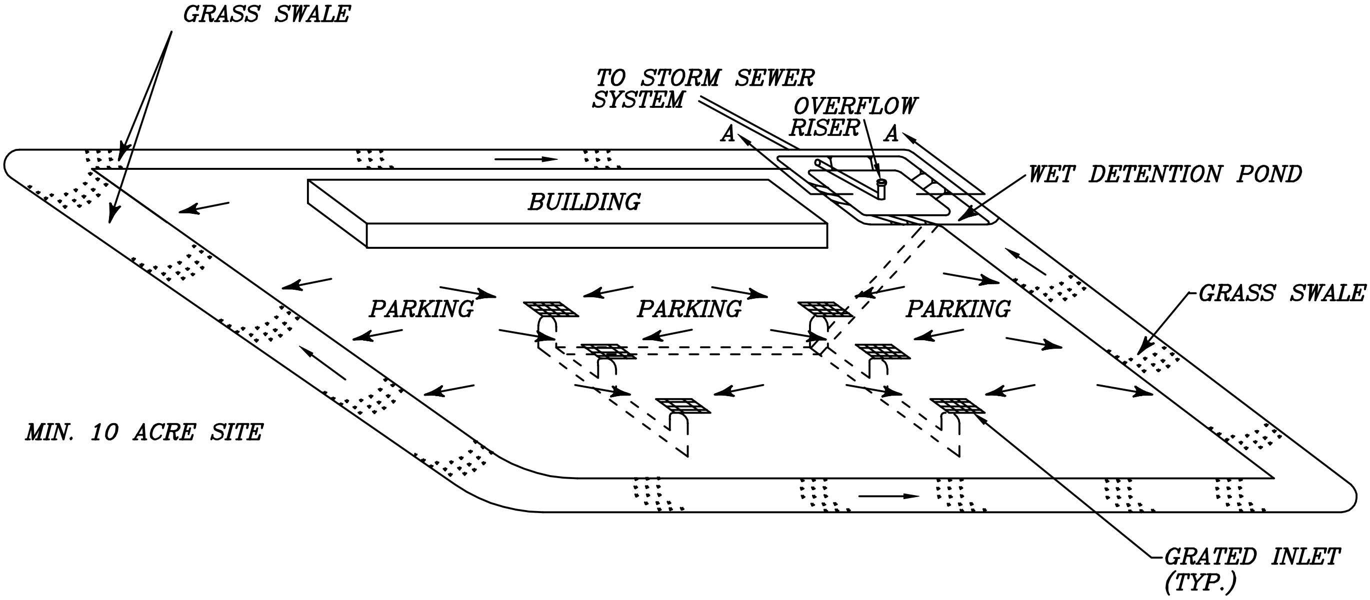
5. SIDE SLOPES – 3:1 OR FLATTER.

6. SPLASH AREAS SHOULD BE PROTECTED AGAINST SCOURING WITH RIP RAP, CONCRETE OR OTHER ACCEPTABLE MATERIAL.

7. PONDING OF RUNOFF IN WATER QUALITY BASIN ACCOMPLISHED BY EMBANKMENT AND/OR EXCAVATION DEPENDING ON TERRAIN. REFERENCE CONSTRUCTION DRAWING FOR BASIN TYPE AND DIMENSIONS.

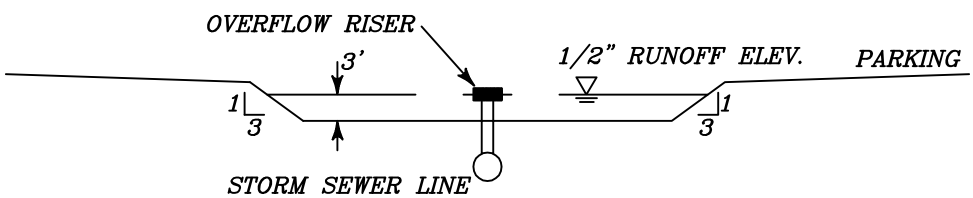
FIGURE 4.15

BMP 4.2.2: POTENTIAL WET POND DESIGN



PLAN

WET POND (PERMANENT POOL) DETAIL



SECTION AA

FIGURE 4.16a

BMP 4.2.2: IN–LINE GRASS SWALES, WET POND: PERMANENT POOL MIN. 10 ACRE SITE

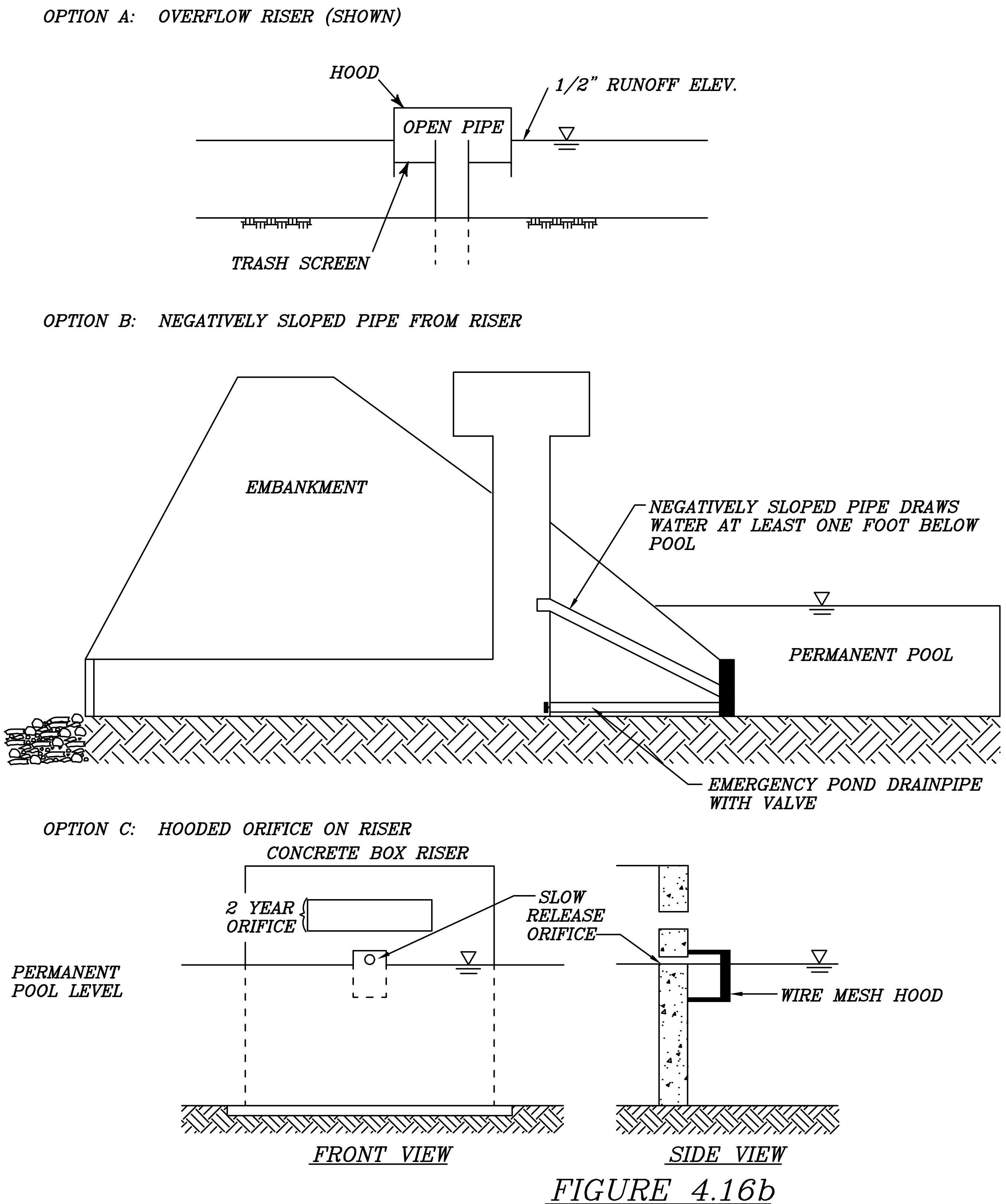


FIGURE 4.16b
BMP 4.2.2: WET POND:
PERMANENT POOL – RISER OPTIONS

GENERAL NOTES:

1. PERMANENT POOL STORAGE VOLUME IS EQUAL TO 1800 CUBIC FEET PER DRAINED ACRE (1/2 INCH RUNOFF VOLUME). SWALES DRAIN DIRECTLY OR THROUGH PIPES TO PERMANENT POOL.

2. DIMENSIONS – LIMIT OF EXCAVATION, RISER HEIGHT AND PIPE DIAMETER SHOULD BE SPECIFIED ON THE CONSTRUCTION DRAWINGS.

3. RISER PIPE MATERIAL – PVC OR CORRUGATED METAL PIPE. ALL PIPE CONNECTIONS SHALL BE WATERTIGHT.

4. FILL MATERIAL AROUND PIPE SHALL BE COMPACTED TO 95% STANDARD PROCTOR OR CONSIST OF CEMENT STABILIZED SAND. A MINIMUM OF 2 FEET OF COMPACTED BACKFILL SHALL BE PLACED OVER THE PIPE BEFORE CROSSING IT WITH CONSTRUCTION EQUIPMENT.

5. SIDE SLOPES – 3:1 OR FLATTER.

6. SPLASH AREAS SHOULD BE PROTECTED AGAINST SCOURING WITH RIP RAP, CONCRETE OR OTHER ACCEPTABLE MATERIAL.

7. PONDING OF RUNOFF IN WATER QUALITY BASIN ACCOMPLISHED BY EMBANKMENT AND/OR EXCAVATION DEPENDING ON TERRAIN. REFERENCE CONSTRUCTION DRAWING FOR BASIN TYPE AND DIMENSIONS.

8. FENCE OFF WET POND AND POST WARNING SIGNS. PROVIDE RAISED CURB AND/OR RAIL AROUND POND.

FIGURE 4.16c

BMP 4.2.2: IN–LINE GRASS SWALES, WET POND: PERMANENT POOL – NOTES

4.2.3 Dual Use Flood Control/Water Quality Basin

A. Definition

The dual use basin is a flood control structure that also provides water quality enhancement. The basin has three storage stages, a permanent pool, an extended detention, and a flood control volume. The permanent pool and the extended detention areas of the basins serve the primary function of water quality enhancements.

The volume of the permanent pool is referred as *water quality volume or capture volume*. It is the volume of storm water runoff captured during the duration of the storm and treated for water quality enhancement through quiescent settling and biological uptake.

B. Purpose

The dual use basin is intended to provide storm water quality and quantity control functions in a single facility. The dual use approach may apply to a new basin or an existing flood control structure retrofitted for water quality enhancements.

The permanent pool of the basin captures and treats the design runoff. Extended detention storage is provided above the permanent pool. The extended detention enhances settling of total suspended solids and prevents downstream channel erosion by abating downstream channel velocities. This volume is stored and released over a 24 to 48 hour period. The flood control volume protects downstream flooding from higher magnitude events such as the 100-year storm flood.

C. Planning Considerations

This basin may be provided anywhere along the storm sewer or channel system where hydraulics permit. A key advantage to the dual use basin relative to other water quality basins is efficient land use. A possible disadvantage is increased maintenance requirements over the single-use flood control detention basin due to water quality functions. The basin should be designed to facilitate sediment removal. Inspection and maintenance access should be provided.

D. Design Considerations

Figure 4.17 provides basin plan and profile information and general notes for construction. The water quality volume storage is 0.5 inch of runoff from the drainage area. When a storm begins, the first flush of runoff is captured and treated in the permanent pool. The extended storage provides additional water quality benefits and downstream channel protection, and is usually defined as the volume of an additional 0.5 inch of runoff.

Design considerations of the dual use pond include the following:

1. The water quality portion of the basin must be sized to store the first flush (first 0.5 inch of runoff). This is equal to 1800 cubic feet of storage per drained acre. The permanent pool should remain full at all times to provide a source of water for wetland plants and minimize resuspension of sediments.
2. The depth of the permanent pool should not exceed 8 feet to prevent thermal stratification. Pools less than 2 feet without aquatic vegetation are also prone to

resuspension problems. Basins with variable depths that contain both shallow areas of less than 2 feet and deeper areas of greater than 4 feet may be most beneficial to water quality improvements.

3. The shallow areas of the permanent pool promote growth of emergent aquatic vegetation that enhance nutrient uptake. The deeper pool area provides pollutant removal by gravitational settling. An aquatic shelf with depths less than 18 inches should surround the permanent pool.
4. The permanent pool volume cannot be considered for flood control purposes. The overall design should not impact the water surface elevations of upstream drainage systems, or the routing of the design flood hydrograph.
5. The extended storage should be released within 24 to 48 hours. The slow release should be controlled by the riser design as discussed in Section 4.2.1.1 or any other appropriate outlet control structure.
6. The extended storage and the flood storage stages of the basin should be designed to meet the HCFCD drainage criteria for detention basins.
7. Native vegetation capable of thriving under the conditions of the wet pond should be planted. An assortment of vegetation should be planted to survive in the varied depths of the wet pond. For a partial list of vegetation see Appendix E. For the permanent pool, species should be selected from the open water/deep marsh list and the shallow emergent marsh list.

E. Design Examples

Figures 4.17 and 4.18 provide basin plan and profile information, and general notes for construction.

A drainage area of 50-acres and basin effective depth of two feet provided a basin bottom area of almost one acre. The side slopes assumed a 4:1 horizontal to vertical (H:V) ratio.

The volume of the permanent pool sized to capture the first half inch of runoff from the drainage area (50 acres) is 90,000 cubic feet.

The basin design for the extended storage and flood control volume must follow the HCFCD requirements. Hydrologic and hydraulic modeling is required to size the flood control storage volume and the outlet devices. The designer should refer to the HCFCD drainage criteria manual and meet the requirements of HCFCD.

F. Maintenance

1. Maintenance and inspection access to the basins should be provided.
2. Sediment should be removed from pond or reservoir areas when accumulations exceed one-third the design depth of the pond or reservoir.
3. Accumulated paper, trash and debris should be removed every 6 months or as necessary.
4. The vegetation should be mowed at least twice a year to discourage woody growth and control weeds.
5. A visual check inspection should be conducted after each rainfall event of 1 inch or more in 24 hours until the pond and drainage system are stabilized. Thereafter,

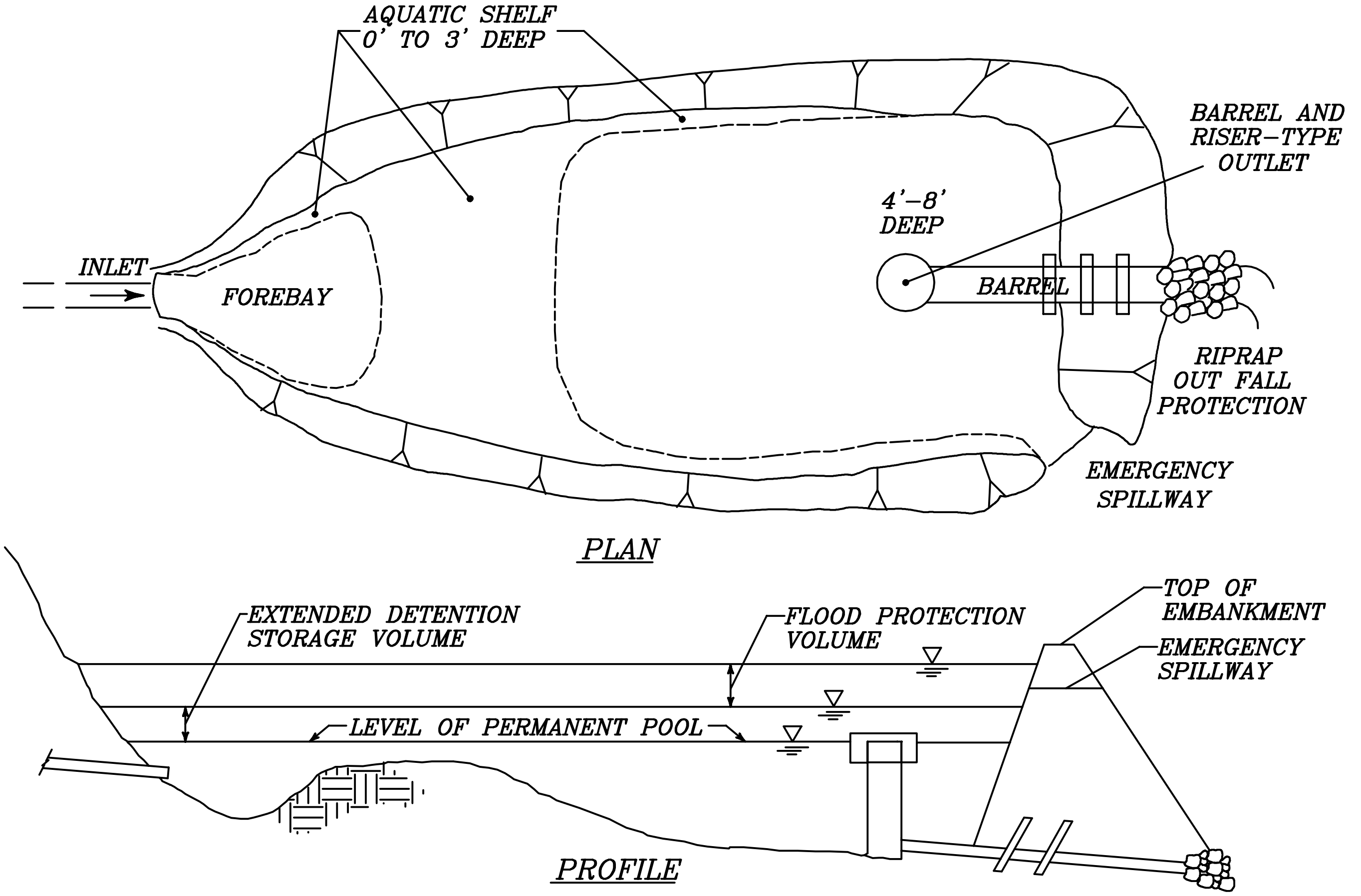
visual checks should be conducted as needed to inspect for damage and any necessary repairs.

6. It is recommended that a complete inspection be conducted at least annually.
7. Standing water above the surface of the permanent pool left after 72 hours indicates clogging of drain pipes or drainageways, and need for inspection and maintenance. Provisions should be made for occasional dewatering as necessary for maintenance work and to control nuisances which may arise.

Sources: Turner Collie & Braden, Lower Colorado River Authority, Metropolitan Washington Council of Governments 1987.

POTENTIAL DUAL USE FLOOD CONTROL/ WATER QUALITY BASIN

(FOR SHALLOW INLET OR OPEN CHANNEL INLET)



GENERAL NOTES:

1. PERMANENT POOL STORAGE VOLUME IS EQUAL TO 1800 CUBIC FEET PER DRAINED ACRE (1/2 INCH RUNOFF VOLUME). THE EXTENDED DETENTION VOLUME DRAINS INTO TOP OF RISER. THE FLOOD PROTECTION VOLUME DRAINS THROUGH SPILLWAY AND TOP OF RISER.

2. DIMENSIONS – LIMIT OF EXCAVATION, RISER HEIGHT AND PIPE DIAMETER SHOULD BE SPECIFIED ON THE CONSTRUCTION DRAWINGS.

3. RISER PIPE MATERIAL – PVC OR CORRUGATED METAL PIPE. ALL PIPE CONNECTIONS SHALL BE WATERTIGHT.

4. RISER OPTIONS – SEE FIGURE 4.18 – WET DETENTION POND RISER OPTIONS

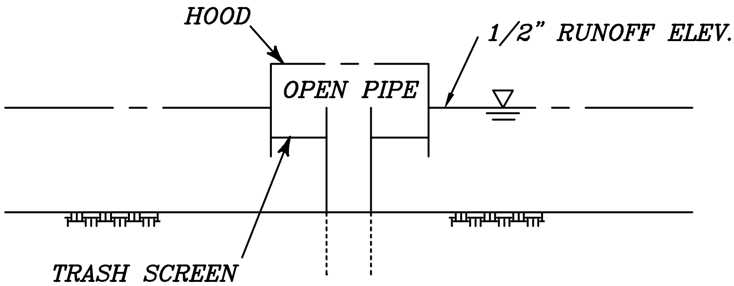
5. SIDE SLOPES – 3:1 OR FLATTER.

6. SPLASH AREAS SHOULD BE PROTECTED AGAINST SCOURING WITH RIP RAP, CONCRETE OR OTHER ACCEPTABLE MATERIAL.

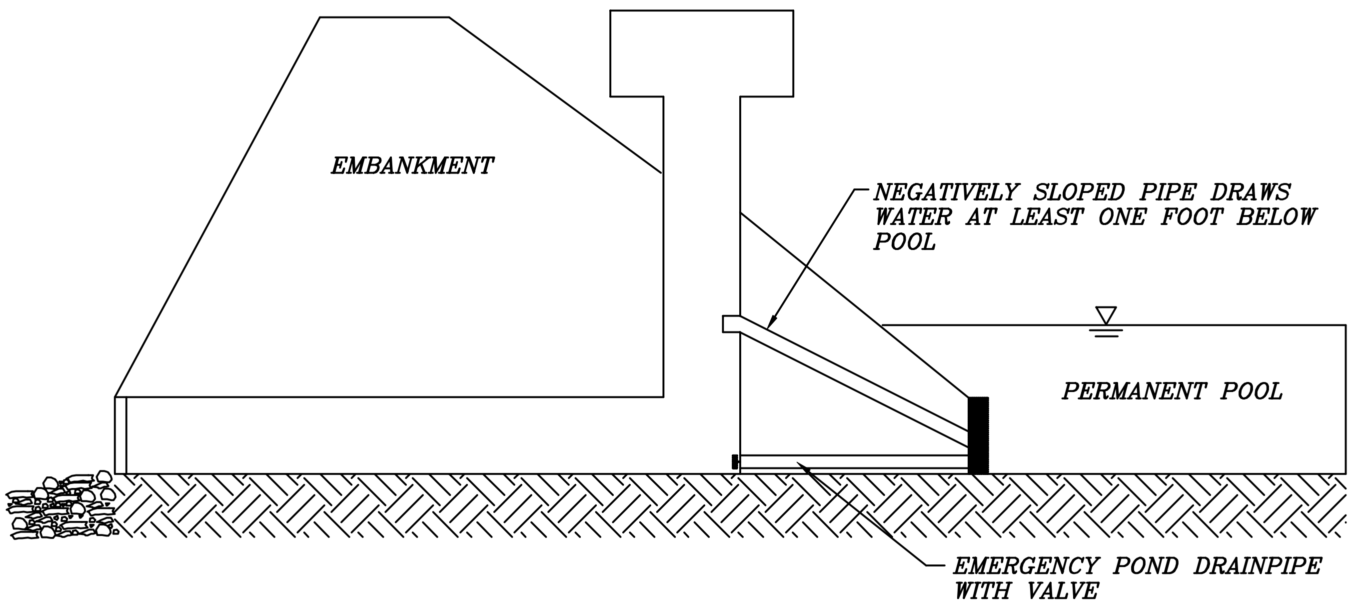
7. PONDING OF RUNOFF IN WATER QUALITY BASIN ACCOMPLISHED BY EMBANKMENT AND/OR EXCAVATION DEPENDING ON TERRAIN. REFERENCE CONSTRUCTION DRAWING FOR BASIN TYPE AND DIMENSIONS.

FIGURE 4.17
BMP 4.2.3: POTENTIAL DUAL USE FLOOD CONTROL/ WATER QUALITY BASIN

OPTION A: OVERFLOW RISER (SHOWN)



OPTION B: NEGATIVELY SLOPED PIPE FROM RISER



OPTION C: HOODED ORIFICE ON RISER

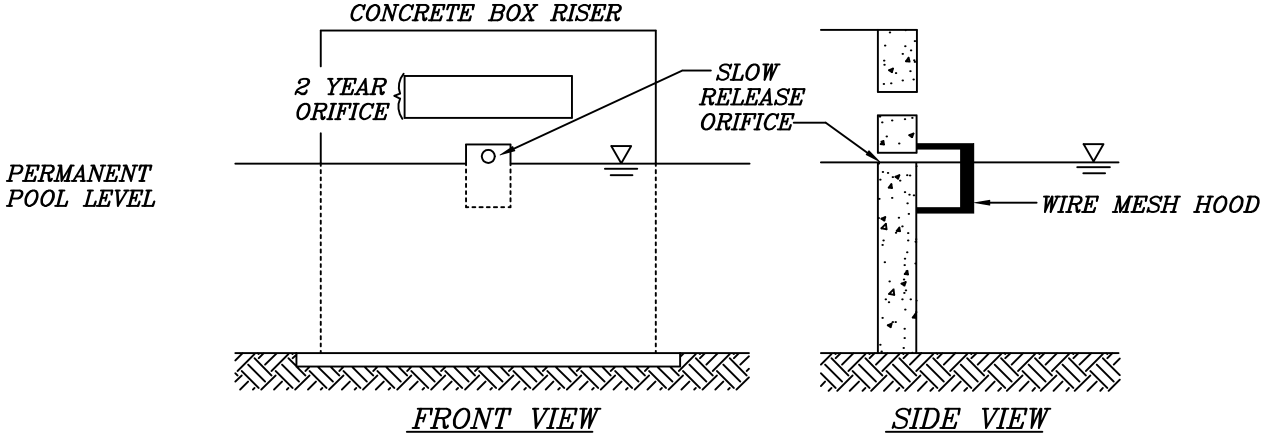


FIGURE 4.18
BMP 4.2.3: WET POND:
RISER OPTIONS

4.2.4 Constructed Wetlands

A. Definition

Storm water wetlands are constructed facilities designed often based on the ecological function of natural wetlands for storm water treatment purposes. Wetland treatment of storm water runoff involves passing runoff through a constructed wetland for providing water quality improvement by removing pollutants.

B. Purpose

Wetland treatment is effective in removing sediment and pollutants that bind to particles, such as heavy metals, nutrients, and hydrocarbons. Wetlands also remove oxygen demanding substances and bacteria. Wetlands can also be effective in removing dissolved nutrients.

Wetlands utilize pollutant removal mechanisms similar to wet ponds, but emphasize the biological processes of wetland habitats. Thus, wetlands are highly effective but sensitive, and can be damaged by pollutant overloads. Features such as sediment forebays can be designed to enhance the pollutant removal capabilities of constructed wetlands. Generally, pollutant removal efficiency increases with a larger ratio of wetland to watershed size. Larger size ratios increase hydraulic residence time and biological processing.

C. Planning Considerations

Because of their shallow depths typically less than 2 feet, wetlands require more land area than other treatment BMPs. Constructed wetlands can be considered for large developments. They can be used in watersheds as small as 5 acres. Constructed wetland basins should be designed to facilitate inspection and maintenance. Maintenance access should be provided.

Wetlands can provide an excellent urban habitat for wildlife and waterfowl, particularly if they are surrounded by a buffer and have some deeper water area. In most cases, storm water detention can be provided in constructed wetlands, allowing dual use of the wetlands.

Requirements for Section 404 permits should be evaluated on a case-by-case basis. Modification of an existing wetland area to serve a storm water quality management function is potentially subject to Section 404 permitting. Newly constructed wetlands, should be evaluated for the exemption listed in 40 CFR 122.2. It provides an exemption to classification as "Waters of the U.S." for waste treatment pond systems or lagoons, designed to meet the requirements of the Clean Water Act. However, if a constructed wetland is exempted by being defined as a treatment facility, it cannot be used for wetlands mitigation for losses due to construction. Modification and ongoing maintenance of an exempt constructed wetland would also be exempt from permitting requirements.

Wetland treatment, however, requires a water budget analysis and careful design. Wetland treatment requires relatively large land area compared with other water quality basins. Careful selection of diversified wetland plant species is one of the most important planning aspects to avoid takeover of the wetlands system by invasive aquatic nuisance plants. There are possible impacts on wetland biota from heavy metal uptake and bacterial contamination from waterfowl.

D. Design Considerations

Figures 4.19a and 4.19b provide basin plan information and general notes for construction.

The following criteria are recommended for constructed wetlands.

1. As a general guideline, no more than 25 percent of the wetland should be open water, with depths between 2-3 feet. The remaining area should be heavily vegetated, with depth less than 1 foot. However, a wetland specialist should be consulted for application to a specific location.
2. The inlet should open onto a forebay for settling larger solids. The forebay should be deep enough for slowing down the flow velocity.
3. An oil/water separator (for example, the SC type separator, discussed in Section 4.4.2) may be needed preceding the inlet to minimize any oil and grease impact on vegetation.
4. The wetland perimeter should have a vegetated buffer 10-20 feet wide that is temporarily flooded in most storm events.
5. Soils in the pool area should be wetland soils, containing a large number of wetland plant propagules. A soil study and geotechnical analysis should be conducted. Soils through the wetland should have a minimum depth of four inches, and an infiltration rate low enough to maintain a permanent pond.
6. The landscaping plan should be carefully designed for wetland habitat, using indigenous species to the maximum extent practicable. See Appendix E for lists of open water/deep marsh vegetation, shallow emergent marsh vegetation, wet/mesic prairie vegetation, dry prairie grasses, wildflowers, trees, and shrubs.
7. A plant management plan needs to be developed by a qualified wetland biologist or professional.

E. Design Example

The example based on Figure 4.19 considers a 100-acre site with a wetland basin. The wetland functions as a shallow permanent pool. Incoming runoff displaces the existing water in the basin. The wetland has an average depth of 1 foot or less, with 25% of the area between 2-3 feet, 25% between 0.5-1 foot and 50% at 0.5 foot depth. The example assumes a shallow inlet with an SC (Spill Control) Oil/Water Separator.

The basin area of 4.5 acres includes the submerged area and the 10 to 20-foot frequently flooded fringe, but does not include maintenance or access.

A riser outlet is shown in Figure 4.19a, but a suitably designed weir or pipe could also be used for the outlet.

F. Maintenance

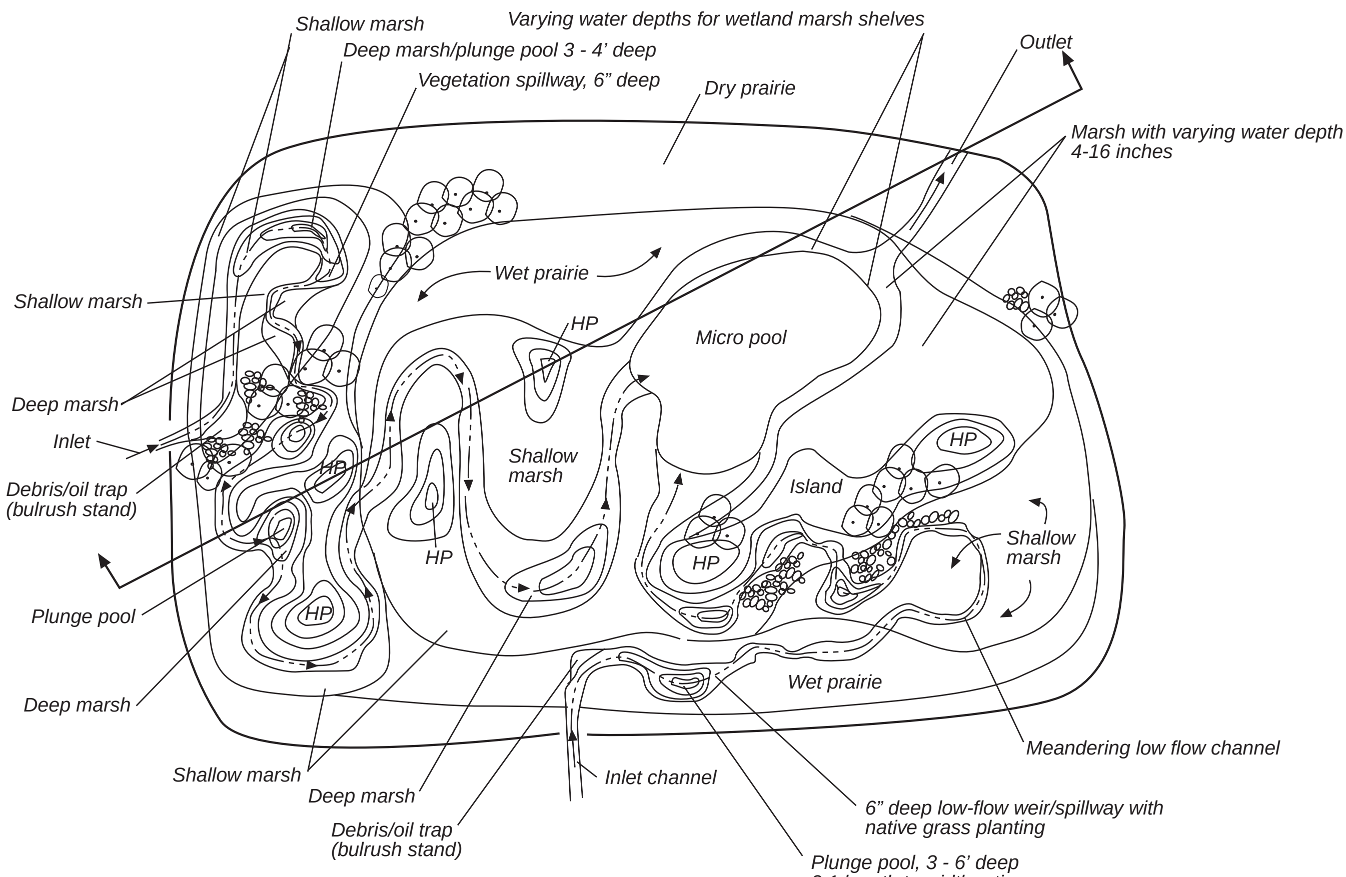
1. Maintenance and inspection access should be provided to the wetland.
2. Oil/water separators preceding the inlet, if required, should be cleaned at least twice a year.
3. If the vegetation will be harvested, design features should be included for

dewatering. The harvesting procedures must be prepared by a qualified professional, and should be reviewed and approved by the agencies with jurisdiction.

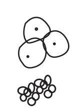
4. A visual check inspection should be conducted after each rainfall event of 1 inch or more in 24 hours until the basin and drainage system are stabilized. Thereafter, visual checks should be conducted as needed to inspect for damage and any necessary repairs.
5. It is recommended that a complete inspection be conducted at least annually.

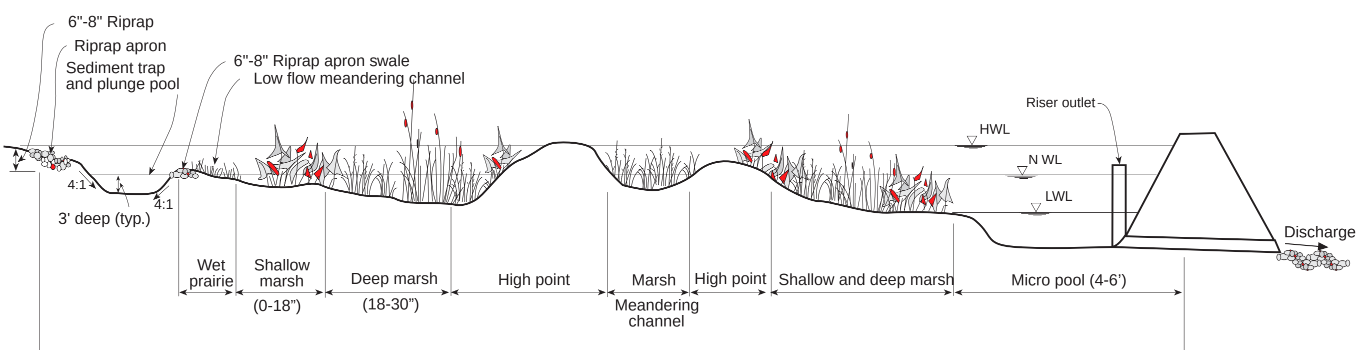
Sources: Metropolitan Washington Council of Governments 1987, Metropolitan Washington Council of Governments 1992, Minnesota Pollution Control Agency, Washington State Department of Ecology.

POTENTIAL WETLAND DESIGN



Utilize cut material from micro pool and channel excavation to create high points.
Maximize the length of low-flow channel to provided maximum treatment.
Maximize ecological benefits through maximized water to vegetation edge and interface.





Schematic Cross-section of Water Quality Treatment Wetland

Not to Scale

NWL: Normal Water Level - Level of Water Quality Volume
HWL: High Water Level - Extended detention Volume

BMP 4.2.4: POTENTIAL WETLAND *FIGURE 4.19a*

GENERAL NOTES:

1. TOTAL PERMANENT STORAGE VOLUME OF WETLAND MUST BE GREATER THAN OR EQUAL TO 1800 CUBIC FEET PER DRAINED ACRE.

2. EFFECTIVE BIOLOGICAL CONTROLS SUCH AS BAT HOUSES FOR BATS AND PERMANENT DEEP WATER FOR FISH WILL BE INCLUDED FOR MOSQUITO CONTROL.

3. WETLAND SURFACE AREA WILL INCLUDE AREAS OF VARYING DEPTH. WETLAND AREA DEPTHS SHOULD BE LESS THAN 6 INCHES FOR 50% OF THE WETLAND AREA, 1/2 TO 1 FOOT FOR 15% OF THE WETLAND AREA, 2 TO 3 FEET FOR 15% OF THE WETLAND AREA, AND 3 TO 6 FEET FOR 20% OF THE WETLAND AREA.

4. LOW AND NORMAL WATER LEVEL FLOW CHANNEL WILL MEANDER ENOUGH TO MAKE IT AT LEAST THREE TIMES THE WIDTH OF THE BASIN.

5. FOREBAY OR PLUNGE POOL WILL BE DESIGNED TO HANDLE THE MAJORITY OF THE SEDIMENT LOAD AND REDUCE STORM WATER INFLOW VELOCITIES. FOREBAY/PLUNGE POOL AT INLETS WILL BE AT LEAST 3 TO 4 FEET DEEP TO PREVENT RESUSPENSION OF SILTS AND POLLUTANTS.

6. AREAS OF WATER CONCENTRATION AND MOVEMENT TO BE HEAVILY VEGETATED WITH NATIVE GRASSES, RUSHES, AND SEDGES UNDERLAIN WITH LOOSE OR GABION BASKET RIPRAP TO PROTECT AGAINST SCOURING.

7. INDIGENOUS PLANT SPECIES WILL BE USED. WETLAND WILL BE PLANTED TO MAXIMIZE SPECIES DIVERSITY. AT LEAST 3 WETLAND PLANT COMMUNITIES TO BE ESTABLISHED: DEEP MARSH, SHALLOW MARSH, AND WET PRAIRIE. PLANT SELECTION FOR EACH OF THESE COMMUNITIES SHOULD INCLUDE AT A MINIMUM 8 DIFFERENT SPECIES OF NATIVE WETLAND VEGETATION. SELECT FROM PLANT SPECIES LISTED IN APPENDIX E.

8. BASIN SIDESLOPES TO BE PLANTED AND MAINTAINED AS NATIVE DRY PRAIRIE. SIDESLOPES 3:1 OR FLATTER.

9. WETLAND PERIMETER WILL INCLUDE A 10 TO 20 FOOT VEGETATED DRY PRAIRIE BUFFER.

10. MICRO POOL OUTLET SHALL BE A RISER. RISER OPTIONS: SEE FIGURE 4.18, WET DETENTION POND: RISER OPTIONS.

11. HIGH POINTS WILL BE INCLUDED TO BALANCE CUT AND FILL ON EARTH MOVING AND PROVIDE WILDLEIFE REFUGE DURING FLOOD EVENTS.

FIGURE 4.19b

POTENTIAL WETLAND DESIGN NOTES

4.3 Infiltration/Filtration Facilities

Infiltration and filtration practices filter storm water through soil, sand or other media which attach to particulates and allow biological processing. Infiltration practices allow storm water to recharge into the soil, and have no underdrain system. Filtration practices use an underdrain system beneath the filter medium to collect and discharge the filtered storm water.

In general, infiltration facilities require permeable soils, and are sensitive to clogging, making them impractical in the Houston/Harris County region, which is typified by soils with fine clays and low permeability. For this reason, infiltration measures such as infiltration basins, infiltration trenches, porous pavement and grid/modular pavement will not be thoroughly discussed in this Manual. Infiltration practices may be useful in the Houston/Harris County region if they are employed as part of Low Impact Development (LID) site design. See Section 4.6 of this Manual for a discussion of LID. The interested reader may refer to the following sources (among others) for more information on infiltration practices:

Washington State Department of Ecology (WSDOE)
Metropolitan Washington Council of Governments (MWCOG)
Florida Department of Environmental Regulation (Florida DER)

Filtration facilities are sensitive to clogging, but not to the extent of infiltration facilities. The sand filter is a popular type of filtration facility, and may be used in conjunction with a water quality dry detention basin for enhanced pollutant removal. (See Section 4.2.1 - Dry Detention Basins). Filtration facilities require some amount of topographic relief to provide adequate hydraulic head for detention and filtration. Therefore, their application to the Houston/Harris County area, which is characterized by generally flat topography, would tend to be limited. For this reason, filtration measures such as full or partial sedimentation-sand filters, will not be thoroughly discussed in this Manual. The interested reader may refer to the following sources (among others) for more information on filtration practices:

Austin Department of Environmental Protection (Austin DEP)
Galli (1990)
Metropolitan Washington Council of Governments
Washington State Department of Ecology (WSDOE)

4.4 Catchment Facilities

Two types of underground storm water treatment devices are discussed in this section: catch basins and oil/grit separators. They are typically designed as inlet devices for storm drains. Catch basins trap coarse sediments and large debris, but are ineffective on oil and grease. Oil and grit separators have several different designs and different removal capabilities.

Catch basin (4.4.1)
Oil/grit separators (4.4.2)

4.4.1 Catch Basin

A. Definition

Catch basins are chambers or sumps installed in a storm sewer, usually at the curb, which allow surface runoff to enter the sewer.

B. Purpose

Many catch basins have a low area for retaining sediment. By trapping coarse sediment, the catch basin prevents trapped solids from clogging the sewer or being washed into receiving waters.

C. Planning Consideration, Design Criteria and Maintenance

Refer to Figure 4.20. Catch basins are typically part of storm sewer design. Inspection and cleaning should be included in the storm sewer life cycle costs. Due to low pollutant removal ability, and possible nuisances (mosquitoes, odors), catch basins should not be considered as stand-alone structural controls, but may be used in conjunction with other controls, including non-structural controls (see Section 4.1).

The grit chambers in most catch basins have a capacity of 0.5 to 1.5 cubic yards. The rate at which catch basins fill is variable, depending on the surrounding land uses and construction activity.

Cleaning should be done on a semi-annual basis and more frequently for areas with active construction.

Source: Pitt, Minnesota Pollution Control Agency.

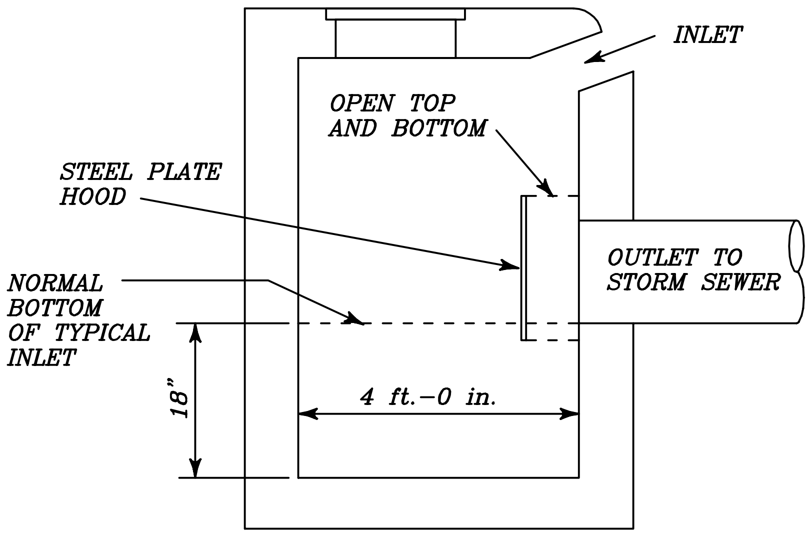


FIGURE 4.20
BMP 4.4.1: CATCH BASIN DESIGN OPTION

4.4.2 Oil/Grit Separators

A. Definition

Oil/grit separators (also called water quality inlets) are inlet devices for separating oil and sediments from water.

B. Purpose

Oil/grit separators have chambers designed to remove sediment and hydrocarbons from urban runoff. They are normally used close to the source before pollutants are conveyed to storm sewers or other BMPs such as infiltration trenches. Oil/grit separators are typically used in areas with heavy traffic or high potential for petroleum spills such as parking lots, gas stations, roads, and loading areas.

There are three general types of separators. The simple spill control (SC) separator (Figure 4.21), typically required with storm water quantity detention facilities, is effective at retaining only small spills. It will not remove diluted oil droplets spread through the storm water from oil contaminated pavement.

More sophisticated designs used for high load situations such as fueling stations, parking lots, and industrial plants include the American Petroleum Institute (API) Figure 4.22, Coalescing Plate Interceptor (CPI) Figure 4.23, and Municipality of Metropolitan Seattle designs. The API design uses a basin with baffles to improve hydraulic conditions for settling solids and floating oil. The CPI design improves coalescing and settling by directing the runoff through closely positioned parallel plates set at an angle. Removal efficiencies of the CPI separator are similar to those of the API separator, but the CPI separator uses 50% to 80% less space. However, both the API and CPI type separators have limited ability to handle storm water flows and hydrocarbon concentration, which are much lower than refinery wastewater. The design used by Municipality of Metropolitan Seattle uses layers of corrugated coalescing plates oriented at 90° to each other.

Performance of oil/grit separators can be enhanced using adsorbent pillows or similar material. Used adsorbent pillows must be properly disposed.

C. Planning Considerations

Oil/grit separators are restricted to small, highly impervious drainage area of two acres or less, and must connect to the storm drainpipe. Suitable locations include gas stations, convenience stores, parking lots, fast food restaurants, industrial loading facilities, and sections of industrial plants.

Separators show some capability to remove coarse sediments (trash, debris and floatables), and oil and grease. However, the overall removal capability is low. Oil/grit separators should only be considered as a primary BMP when properly sized and combined with a program of frequent inspection and maintenance.

While they are highly adaptable, oil/grit separators are relatively expensive to install and potentially expensive to maintain. The greatest concern is the pollutant toxicity of trapped residuals and oily waters, and their disposal. A secondary concern is the possibility of flushing of trapped residuals during longer or larger storms. A well-implemented inspection and maintenance program will ameliorate these potential concerns.

D. Design Criteria

1. In order to provide at least moderate sediment, oil and grease pollutant removal, oil/grit separators should be of the API-type (Figure 4.22) or CPS-type (Figure 4.23) sized to capture 90-micron particles, or an equivalent. Proprietary products are commercially available and may be used if performance is equivalent or better.
2. The oil/grit separator should be an off-line design, capturing only the first flush of runoff. The unit should not interfere with the normal storm sewer function. (In the Municipality of Metropolitan Seattle design, the first flush is based in part on a discharge rate for the design storm of about 1,000 gpm (2.23 cfs) for a 1,500 cf capacity oil/grit separator, giving a hydraulic residence time of 11 minutes.)
3. The API-type separator will typically have three chambers. Runoff enters the first chamber, which contains a permanent pool of water. Coarse sediment is trapped in this chamber by settling. The first chamber can also trap floating trash and debris such as leaves.

   Runoff then passes through an orifice to the second chamber which also contains a permanent pool of water. An inverted pipe elbow which draws water from the lower part of the pool discharges to the third chamber. By drawing water from below the surface, floating oil and grease are trapped until they are adsorbed to sediment particles which then settle out.

   The third chamber discharges water to a storm sewer or other outlet. If the storm drain invert is above the floor of the structure, a permanent pool of water will be formed which will allow some additional settling. If the storm drain invert is at the floor of the oil/grit separator, the third chamber would have no value in pollutant removal.

   In order for the structure to provide even moderate pollutant removal benefits, at least 400 cubic feet of permanent pool storage should be provided per acre of drainage area. Also, the pool should be at least four feet deep.
4. Manholes should be provided to each chamber to provide access for cleaning. Manholes should be accessible to cleaning equipment.

E. Maintenance

1. The facility should be checked weekly by the owner.
2. The facility should be completely inspected and cleaned out at least twice a year to maintain the pollutant removal capabilities.
3. Sediment should be cleaned out with a vacuum truck.
4. Oil adsorbent pads, if used, are to be replaced as needed but should always be replaced after cleaning.
5. The effluent shutoff valve is to be closed during cleaning operations.
6. Waste oil and residuals must be disposed in accordance with current TNRCC and/or Health Department requirements.
7. Any standing water removed during the maintenance operation must be disposed at an approved discharge location.
8. Any standing water removed should be replaced with clean water to prevent oil

carry-over through the outlet weir or orifice.

Sources: Metropolitan Washington Council of Governments 1987, Metropolitan Washington Council of Governments 1992, Minnesota Pollution Control Agency, Washington State Dept. of Ecology, personal communications with Metro staff: B. Burrow, P. Eng, C. Kircher

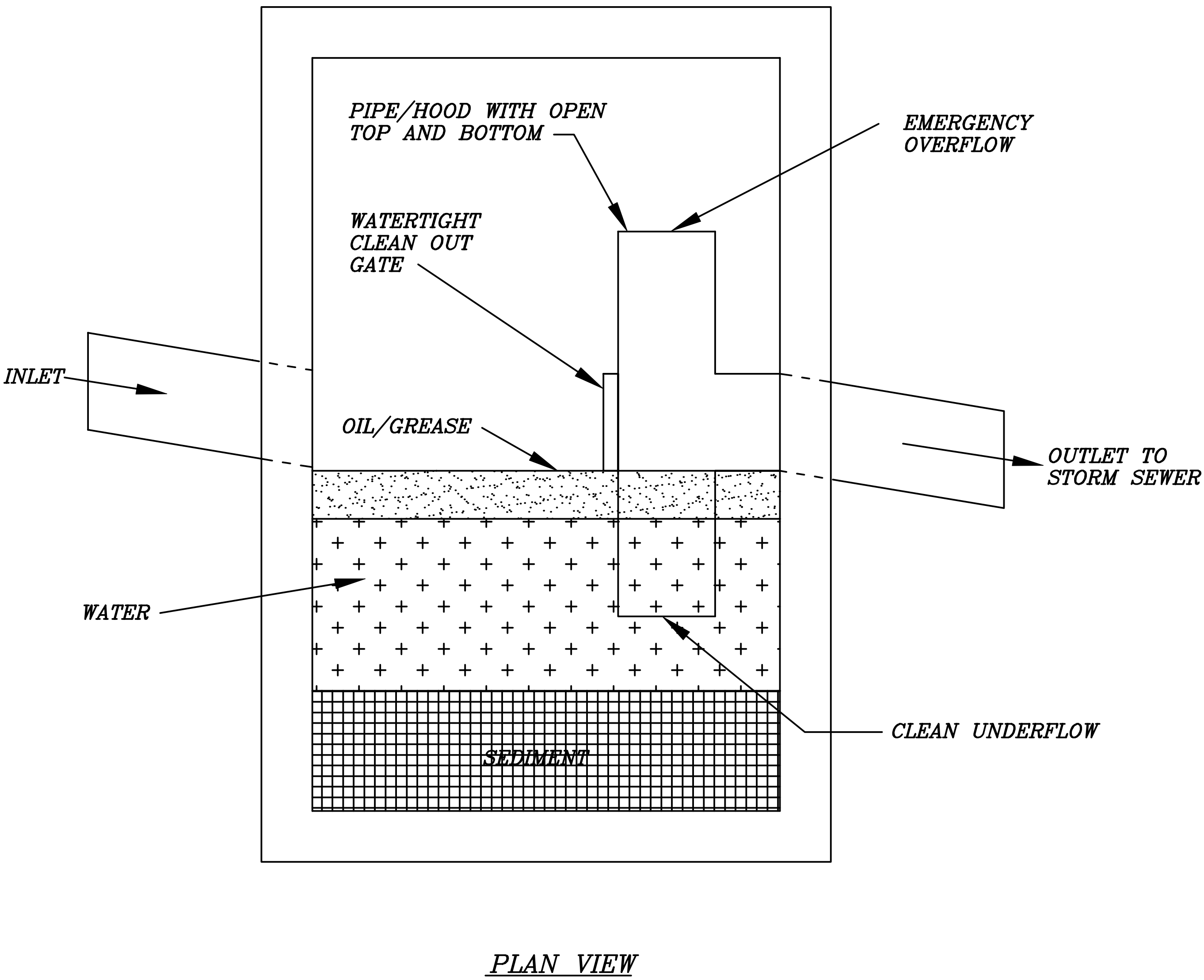
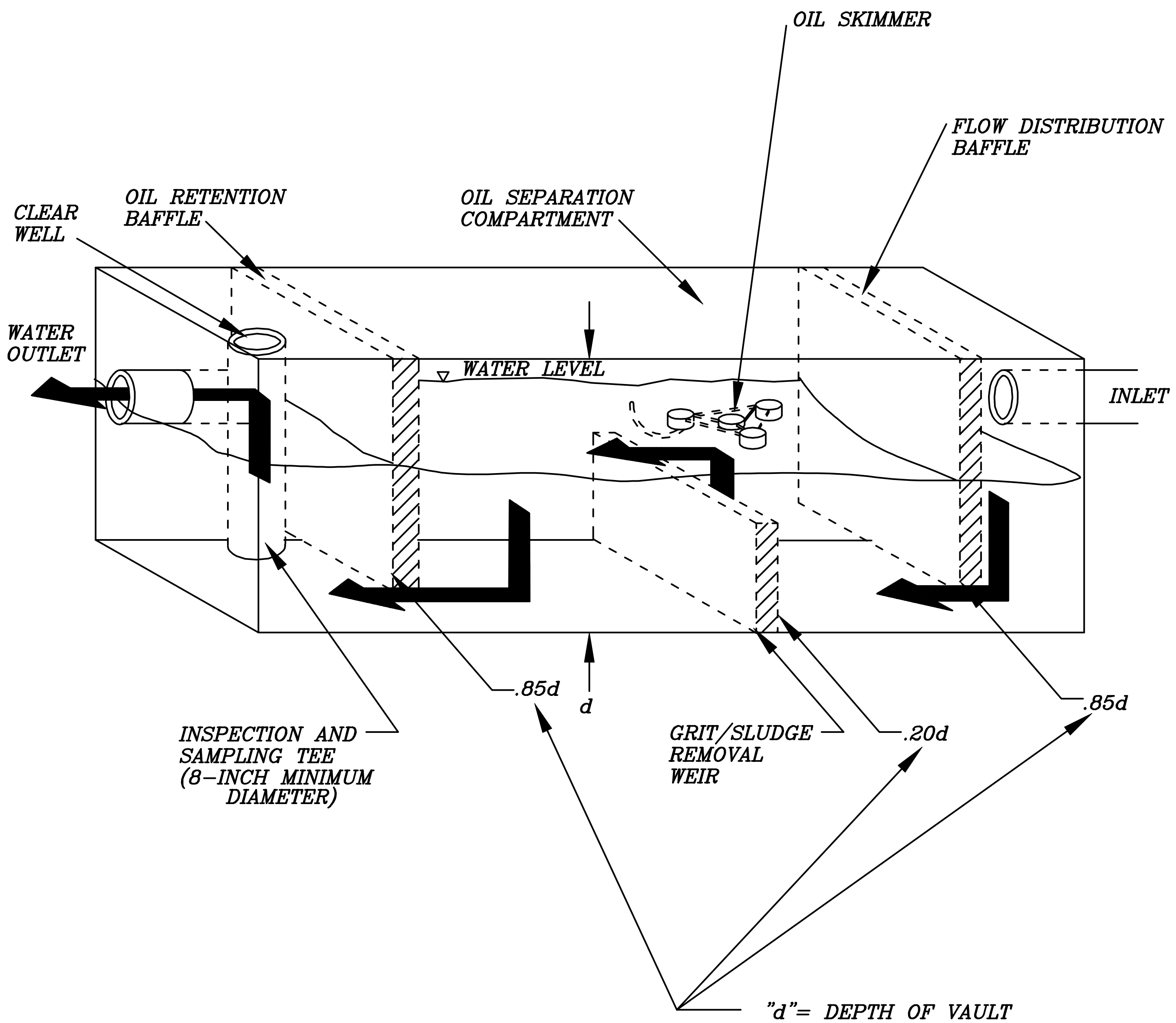


FIGURE 4.21
BMP 4.4.2: OIL/GRIT SEPARATOR:
SC – TYPE SEPARATOR



ADAPTED FROM WSDOE

FIGURE 4.22
BMP 4.4.2: OIL/GRIT SEPARATOR:
API – SEPARATOR

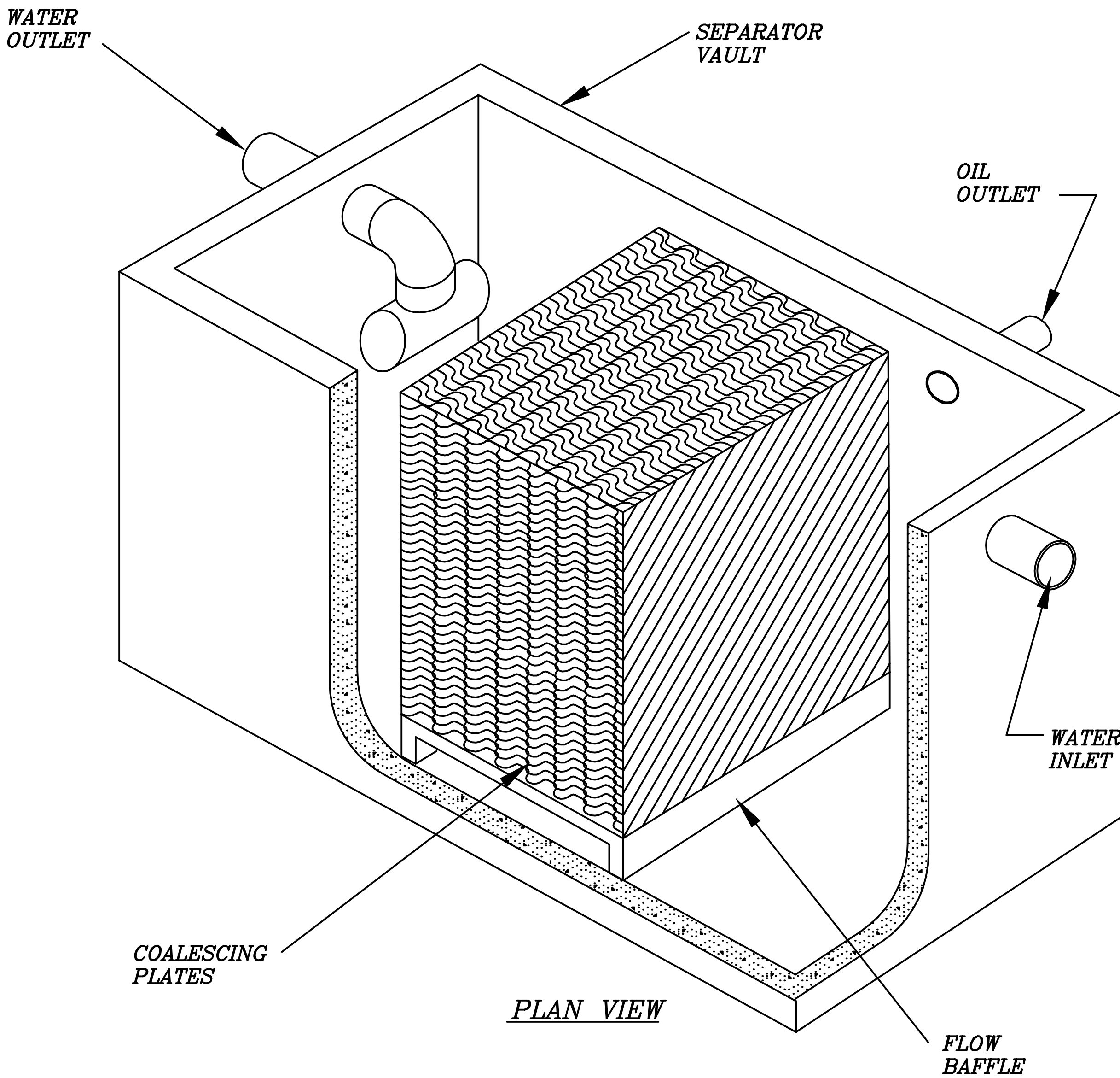


FIGURE 4.23

BMP 4.4.2: OIL/GRIT SEPARATOR:

CPS – SEPARATOR

4.5 Vegetative Practices

This section discusses practices where the primary element is vegetation, for purposes other than erosion and sediment control. Erosion and sediment controls are discussed in a separate manual (*Storm Water Management Handbook for Construction Activities*).

Vegetative practices remove pollutants through infiltration and biological uptake. Absent other BMPs such as ponds or filtration trenches, vegetative practices provide at least a low to moderate amount of pollutant removal, while also enhancing the habitat value and aesthetics of a site.

Vegetative practices include:

4.5.1 Grassed swales (grassed waterways)
4.5.2 Vegetated filter strips

4.5.1 Grassed Swales

A. Definition

A grassed swale is a constructed drainageway with vegetated lining established by sodding or seeding.

B. Purpose

Grassed swales decrease flows and velocity through retardance and infiltration, thus reducing sediment transport.

C. Design Criteria and Requirements

Refer to Figure 4.24.

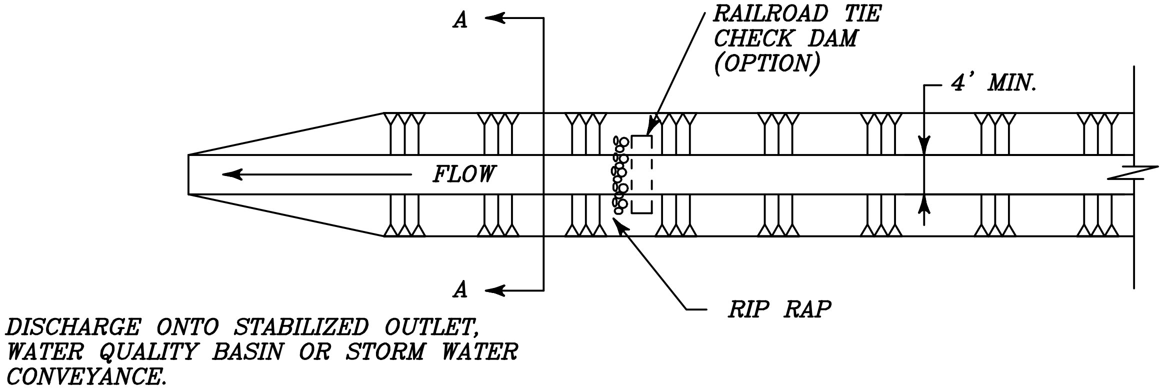
1. Timing: Vegetation and any protective materials should be installed immediately after final channel grading.
2. Capacity: Grass swales for water quality enhancements should be sized to treat the flow generated by 0.27 in/hr rainfall intensity from the drainage area. The maximum water depth should be 3 inches or half the grass height whichever is less.
3. Check Dams:
   Check dams shall be used if site conditions do not allow for achieving a longitudinal slope of 2% or less. They should be reinforced with stone on the downstream side to prevent scouring. Maximum ponding time behind the check dams should not exceed 24 hours.
4. Outlets: All grassed swales should have a stable outlet with adequate capacity, and designed and should be built to prevent erosion of channels and banks.

D. Maintenance

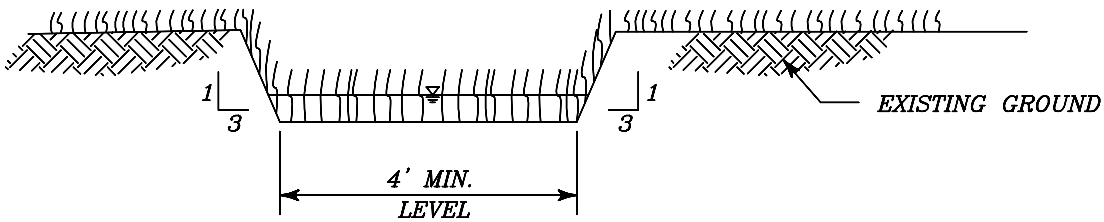
1. Grassed swales should be inspected within 24 hours after each storm of 0.5 inch or greater or daily during periods of prolonged rainfall, until the vegetation is established. During the initial establishment period, repairs and replacements should be made immediately.
2. After the grass has become established, the swale should be checked at least

monthly. All repairs or replacement should be made as soon as possible.

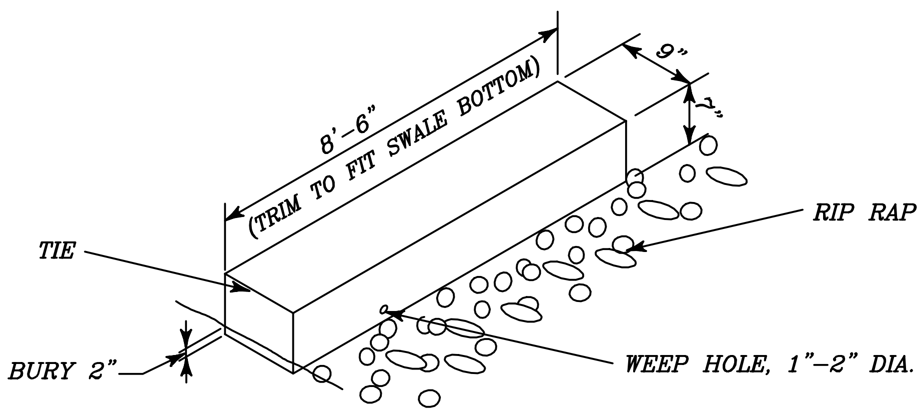
Sources: Metropolitan Washington Council of Governments 1987, Metropolitan Washington Council of Governments 1992, Florida Dept. of Environmental Regulation, Austin Dept. of Environmental Protection, and Harris County, Harris County Flood Control District and City of Houston



PLAN



SECTION A–A



RAILROAD TIE CHECK DAM

GENERAL NOTES

1. BOTTOM WIDTH–4 FEET MINIMUM, CONSTRUCTED LEVEL.
2. DESIGN DEPTH OF WATER – 3 INCHES OR ONE–HALF THE GRASS HEIGHT, WHICHEVER IS LESS.
3. SIDE SLOPE – 3:1 OR FLATTER.
4. MINIMUM CHANNEL SLOPE OF 0.1 PERCENT OR GREATER.
5. IF USING CHECK DAMS ALLOW FOR TAIL WATER IN CALCULATING SWALE DEPTH.
6. TIE IF SPECIFIED SHALL BE NON–LEACHING, NON–TOXIC OR CONCRETE.
7. PLANT SWALE WITH DENSE TURF.

FIGURE 4.24
BMP 4.5.1: GRASS SWALE

4.5.2 Vegetated Filter Strips

A. Definition

Vegetated filter strips are landscaped strips planted with grass, trees or other vegetation.

B. Purpose

Vegetated filter strips treat overland flow through infiltration and biological uptake of sediments and particulate pollutants. There is also some removal of organics and trace metals.

C. Planning Considerations

It is critical that vegetated filter strips be designed and constructed so that runoff flows uniformly across the filter. In order to accomplish this, the filter strip should be constructed along the entire length of a contributory area and receive the runoff as sheet flow. The top edge of the filter should be level. Any depressions will concentrate runoff and short-circuit the filter. In some cases, a shallow stone trench can be used to uniformly distribute runoff at the top of the filter. If a filter has been used to trap sediment during construction, it may be advisable to regrade and reseed the top of the filter. Otherwise, sediment accumulations may cause runoff to concentrate in certain locations.

Refer to Figure 4.25.

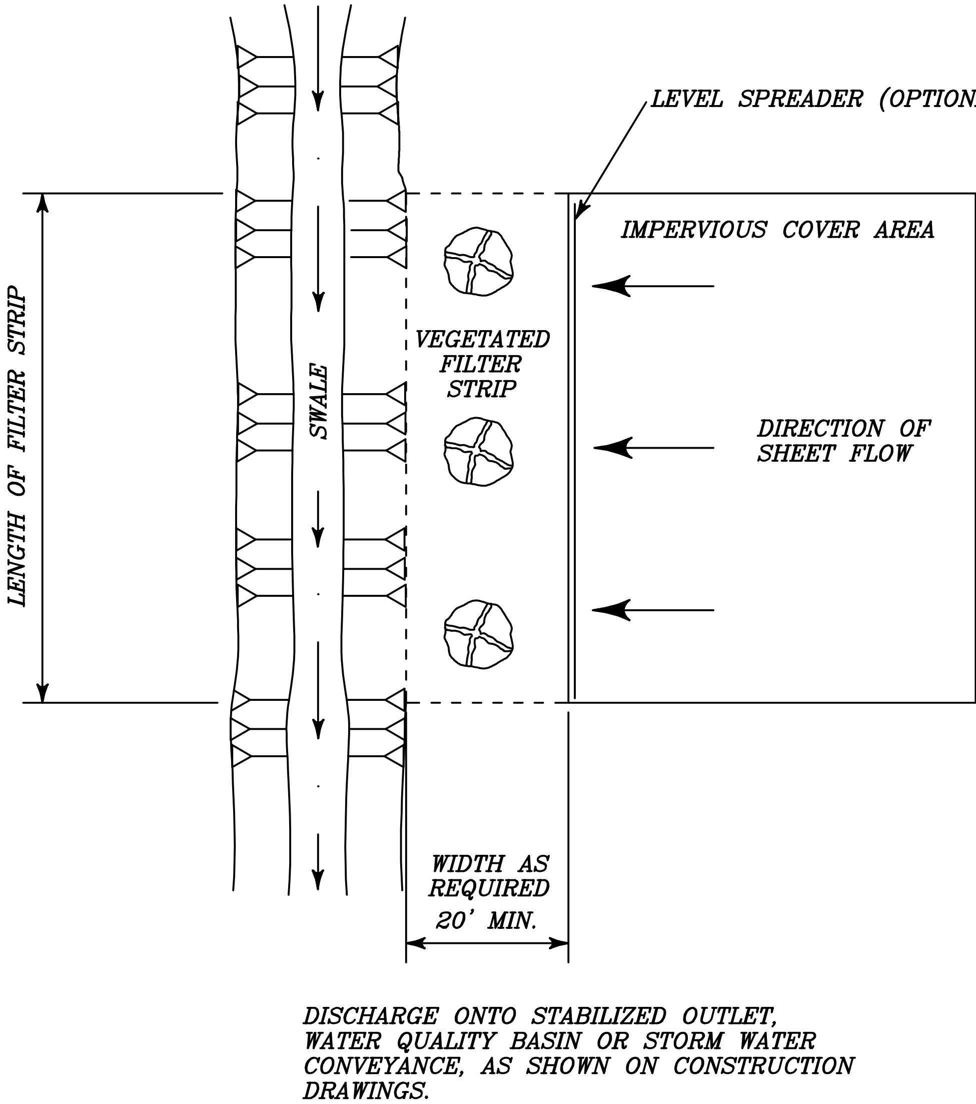
D. Design Criteria

1. Flow velocities over the filter strip should not exceed 1 ft/sec. for the design storm.
2. Slopes should be between 0.1% and 10%.
3. The strip should be constructed along the entire length of the contributing area, and should be a minimum of 20 feet wide.
4. A level spreading device (vegetated berm or rock trench) may be used to facilitate overland sheet flow onto the filter.
5. Close growing vegetation is required. The strip should be protected from erosion until the vegetation is established.

E. Maintenance

1. Maintenance requirements for filter strips can be reduced by managing them as natural areas where vegetation is not mowed. Otherwise, filters should be mowed regularly and fertilized as needed to maintain the vegetation in a healthy condition.
2. Any small rills that form should be repaired promptly to prevent further erosion. This is critical during the initial establishment period for vegetation, but must be checked during later inspections, also.

Sources: Metropolitan Washington Council of Governments 1987, Lower Colorado River Authority, Minnesota Pollution Control Agency, and Harris County, Harris County Flood Control District and City of Houston



GENERAL NOTES

1. MINIMUM FILTER STRIP WIDTH OF 20 FEET.
2. GRADE AS SHOWN ON THE CONSTRUCTION DRAWINGS, SLOPES NOT TO EXCEED 10 PERCENT.

FIGURE 4.25

BMP 4.5.2: VEGETATED FILTER STRIP

4.6 Low Impact Development

A. Definition

Low Impact Development utilizes site design techniques that store, infiltrate, evaporate, and detain runoff on the site to replicate predevelopment runoff characteristics and mimic the natural hydrology of the site.

B. Purpose

Low Impact Development combines site designs with pollution prevention measures to reduce impacts and compensate for development impacts on hydrology and water quality. The purpose of Low Impact Development is to maintain the predevelopment peak storm water runoff and runoff volume, and time of concentration to mimic the predevelopment hydrology. Storm water is managed in small, cost effective landscape features located on each lot rather than being conveyed and managed in large facilities located at the end of the drainage system. Compared with conventional end-of-pipe treatment, it emphasizes management of storm water runoff at the source. The paradigm that currently dominates site planning is that storm water is undesirable and must be removed from the site as quickly as possible to achieve good drainage. The principal goal of low-impact development is to ensure maximum protection of the ecological integrity of the receiving water by maintaining the existing hydrologic regime.

Low Impact Development techniques can be used to provide high quality development. Low Impact Development provides consolidated spaces to support wetland plants and wildlife. As such, it provides natural amenities in terms of plant and animal diversity in close proximity to human habitation.

C. Planning Consideration

Planning consideration includes analysis of predevelopment site hydrology and effective utilization of the existing site features to maintain the predevelopment hydrologic regime. Site hydrology analysis allows full utilization of the property while maintaining the predevelopment hydrologic regime to the greatest extent possible. The planning consideration may require rethinking of the current practice of site development, site grading, and site layout and design. Hydrologic functions of the site should be maintained and managed with the use of reduced impervious surfaces, minimized land clearing and grading.

Low Impact Development techniques alone do not offer flood protection. Additional flood design criteria should be reviewed to ensure flood protection is provided.

Some specific planning considerations include:

1. Minimizing environmental impacts and hydrologic changes.
2. Preserve adequate open space within the development site for bio-retention, and treatment of runoff from rooftops and other impervious surfaces.

Planning considerations for local governments could also include:

3. Providing economic incentives to utilize low impact development strategies.
4. Encouraging public education and support of low impact development.
5. Identifying and eliminate conflicting ordinances, codes, and funding mechanisms

that prevent low impact development.

D. Design Guidelines

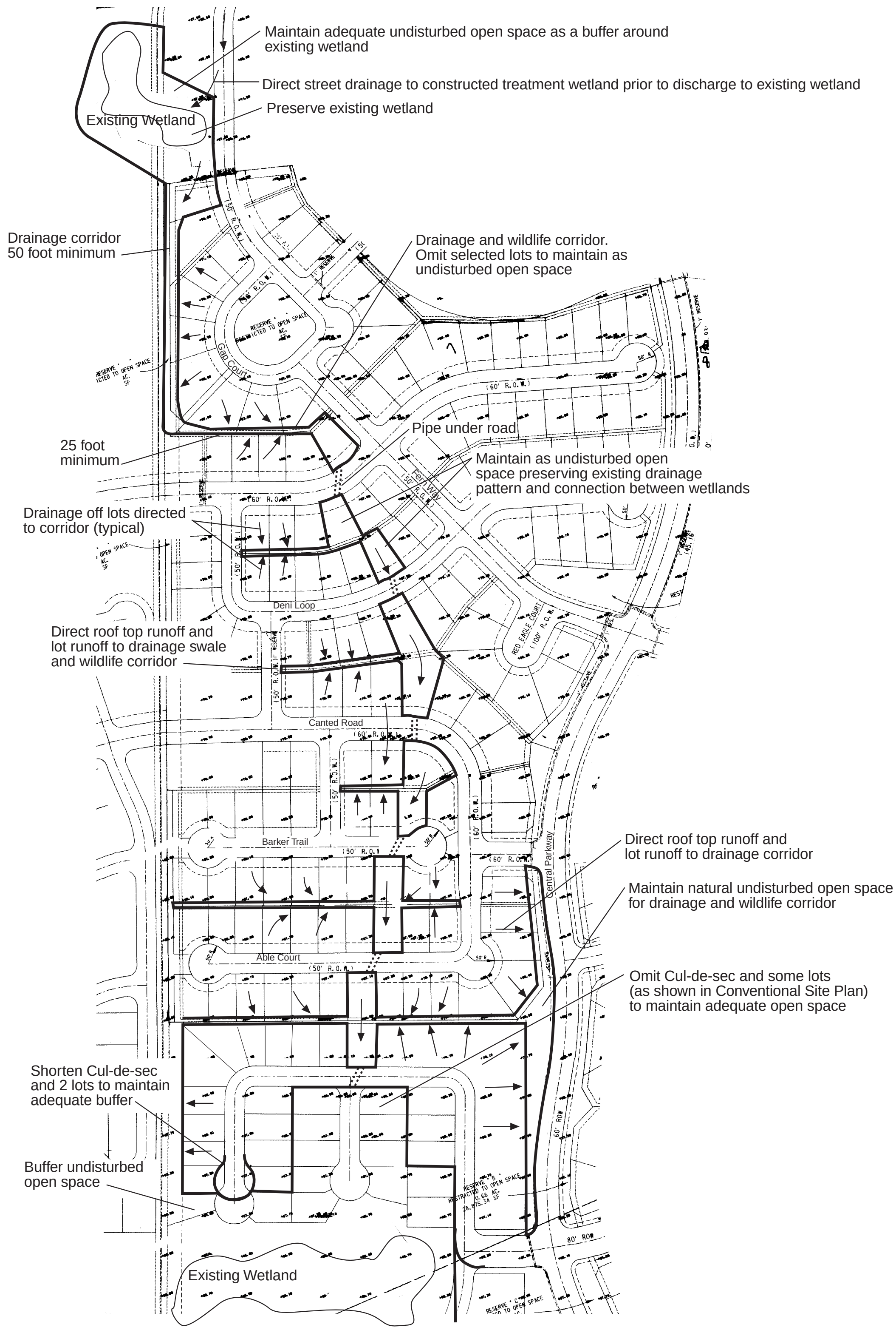
To reduce development impacts and preserve the predevelopment hydrologic conditions the following could be used as general guidelines. Figures 4.26 to 4.30 present sample illustrations of low impact development and conventional site plan layout.

1. Minimize land clearing that requires removal of the native vegetation.
2. Minimize or avoid mass grading and utilize selective clearing.
3. Reduce impervious surface area and minimize connected impervious surfaces.
4. Increase opportunity for on-site retention, detention, and treatment.
5. Maintain predevelopment hydrologic pattern.
6. Utilize native vegetation.
7. Utilize undisturbed existing vegetation buffer strips and areas.
8. Whenever site condition permits, utilize extensive use of swales, grass filter strips, and randomly placed biofilters. Direct roof and landscape open area runoff to vegetated biofilter strips and swales.
9. Preserve soils and areas with high infiltration rate.
10. Provide multi-purpose and multi-benefit storm water detention basin onsite.
11. Grade the site to maximize the overland sheet flow distance.
12. Increase flow-paths or travel distances for surface runoff.
13. Maintain existing time of concentration and minimize impact on the runoff coefficient number.
14. Utilize cisterns, rain barrels, bioretention areas, and created seasonal or permanent wetlands.
15. Provide adequate buffers between development and natural resources, critical areas and drainage ways.
16. Lay out roads, utilities, and pervious surfaces to avoid existing wetlands and drainage paths.
17. Handle road runoff separate from roof top and landscape area runoff.
18. Integrate low-rise and high-rise buildings, town houses, in single-family residential to reduce land consumption.

CONVENTIONAL SITE PLAN

CONVENTIONAL LAND DEVELOPMENT SITE PLAN *FIGURE 4.26 a*

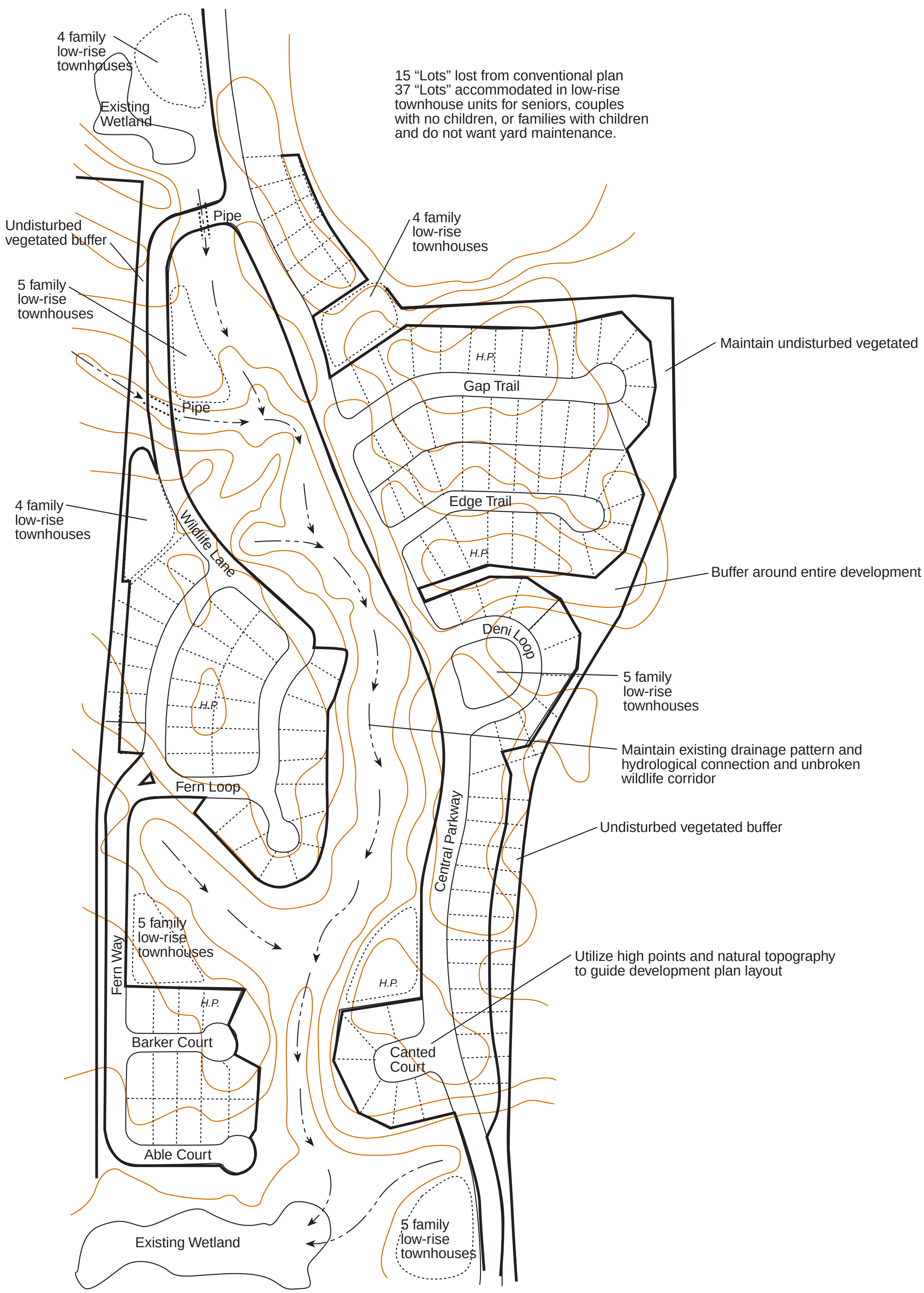
MODIFIED CONVENTIONAL SITE PLAN



MODIFIED CONVENTIONAL LAND DEVELOPMENT SITE PLAN

FIGURE 4.26b

LOW IMPACT DEVELOPMENT SITE PLAN



LOW IMPACT DEVELOPMENT SITE PLAN *FIGURE 4.27a*

GENERAL NOTES:

1. SUBDIVISION GRADING WILL BE DESIGNED TO MINIMIZE LAND CLEARING. MASS GRADING WILL BE AVOIDED AND SELECTIVE CLEARING OF EXISTING VEGETATION, INCLUDING TREES, WILL BE APPLIED.

2. PRE-DEVELOPMENT DRAINAGE PATTERNS WILL BE MAINTAINED TO MAXIMUM EXTENT PRACTICABLE.

3. HIGH GROUND WILL BE DEVELOPED FIRST. WHEN POSSIBLE, NATURAL DRAINAGE PATHS WILL REMAIN UNDEVELOPED AND NOT MASS GRADED.

4. SUBDIVISION LAYOUT WILL BE DESIGNED TO MINIMIZE IMPERVIOUS SURFACES. NATIVE PLANTS WILL BE LEFT UNDISTURBED TO THE GREATEST AERIAL EXTENT POSSIBLE. NATIVE PLANTS WILL BE UTILIZED TO RE-PLANT ANY CLEARED AREAS.

5. LAYOUT OF SUBDIVISION WILL BE DESIGNED TO WORK WITH NATURAL TOPOGRAPHIC AND DRAINAGE PATTERNS. ROADS, UTILITIES, AND IMPERVIOUS SURFACES TO AVOID EXISTING WETLANDS AND DRAINAGE PATHS. INCLUDE AT LEAST 25 FEET OF BUFFER SPACE BETWEEN DEVELOPMENT AND DRAINAGE WAYS, OTHER NATURAL RESOURCES, AND CRITICAL AREAS.

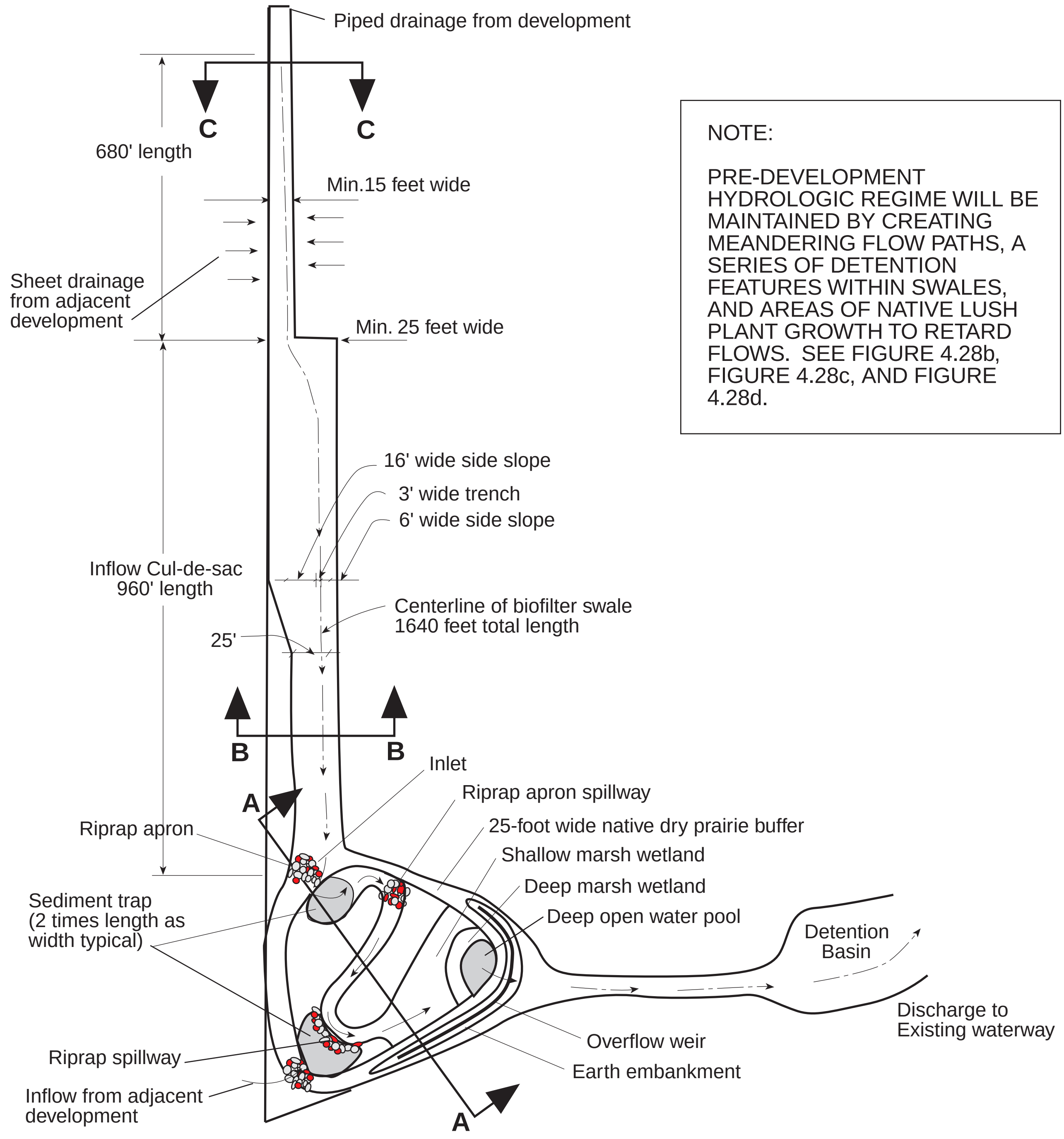
6. NATURAL WETLAND PROCESSES SHOULD BE TAKEN ADVANTAGE OF IN LOW IMPACT PLAN DEVELOPMENT. RUNOFF WILL BE DIRECTED TO CONSTRUCTED WETLANDS AND OTHER STORM WATER CONVEYANCE FEATURES PRIOR TO CONVEYANCE TO NATURAL WETLAND OR RECEIVING WATER. NO DRAINAGE FROM ROADWAYS WILL BE DIVERTED UNTREATED TO A NATURAL WETLAND.

7. PRE-DEVELOPMENT HYDROLOGY OF EXISTING NATURAL WETLANDS WILL BE MAINTAINED.

FIGURE 4.27b

LOW IMPACT DEVELOPMENT SITE PLAN NOTES

TREATMENT PLAN



NOTE:

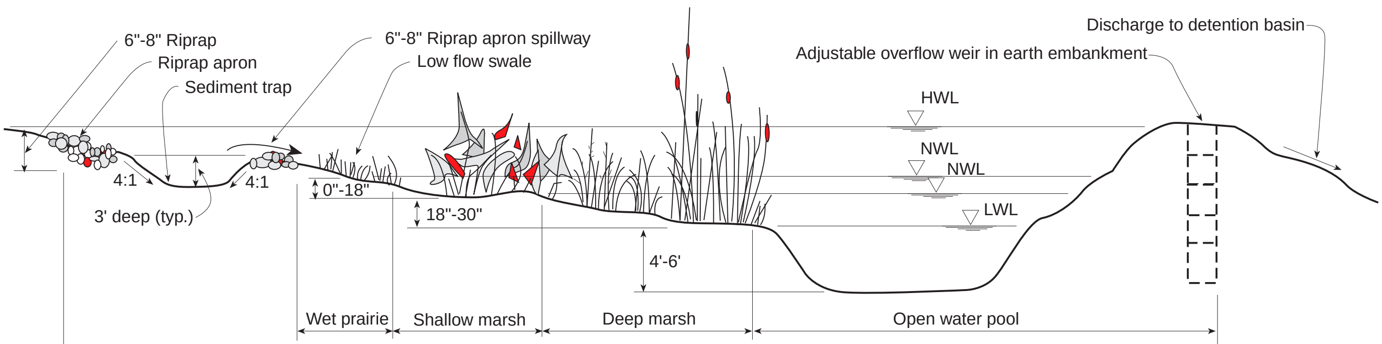
PRE-DEVELOPMENT HYDROLOGIC REGIME WILL BE MAINTAINED BY CREATING MEANDERING FLOW PATHS, A SERIES OF DETENTION FEATURES WITHIN SWALES, AND AREAS OF NATIVE LUSH PLANT GROWTH TO RETARD FLOWS. SEE FIGURE 4.28b, FIGURE 4.28c, AND FIGURE 4.28d.

Schematic Plan: Water Quality Treatment Site

Not to Scale

LOW IMPACT DEVELOPMENT
WATER QUALITY TREATMENT COMPONENTS

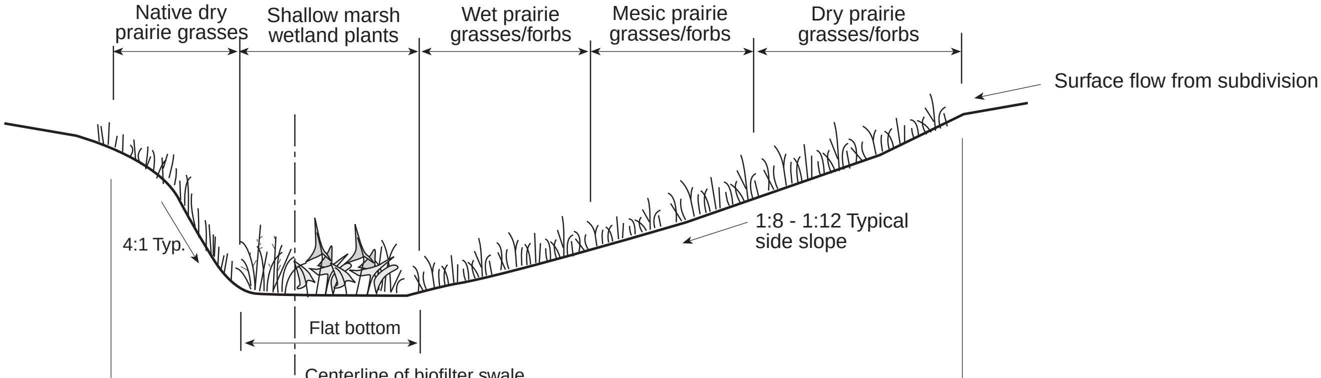
FIGURE 4.28a



Schematic Cross-section A-A Water Quality Treatment Wetland

Not to Scale

FIGURE 4.28b



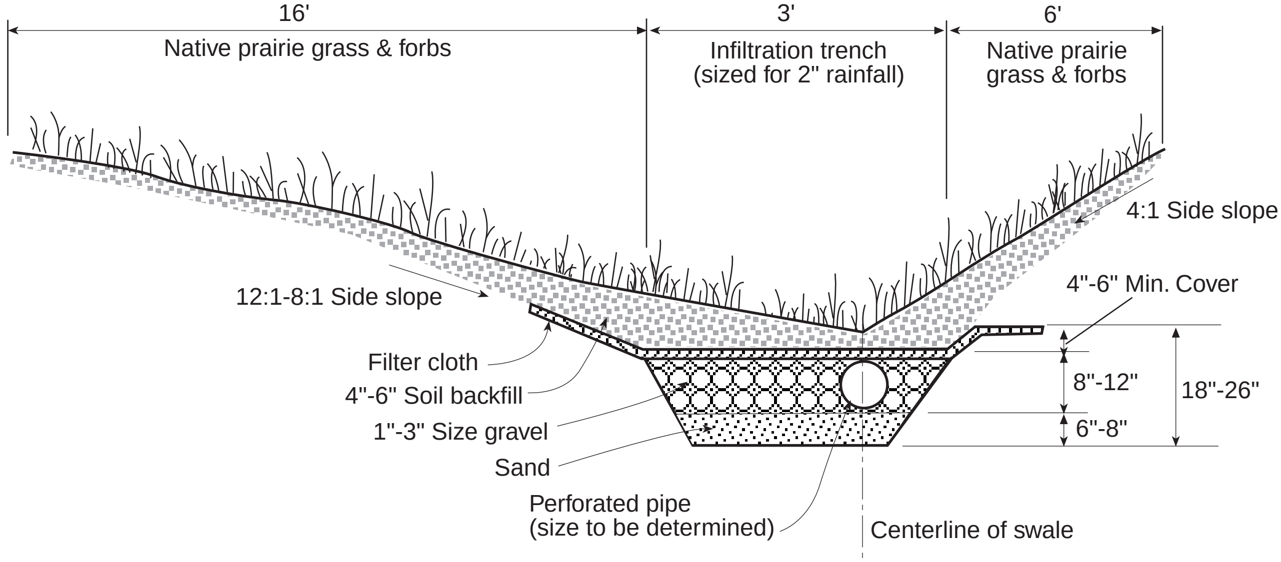
Schematic Cross-section C-C: 15-foot wide Biofilter Swale

Not to Scale

FIGURE 4.28c

LOW IMPACT DEVELOPMENT
WATER QUALITY TREATMENT COMPONENTS

BIO-FILTER

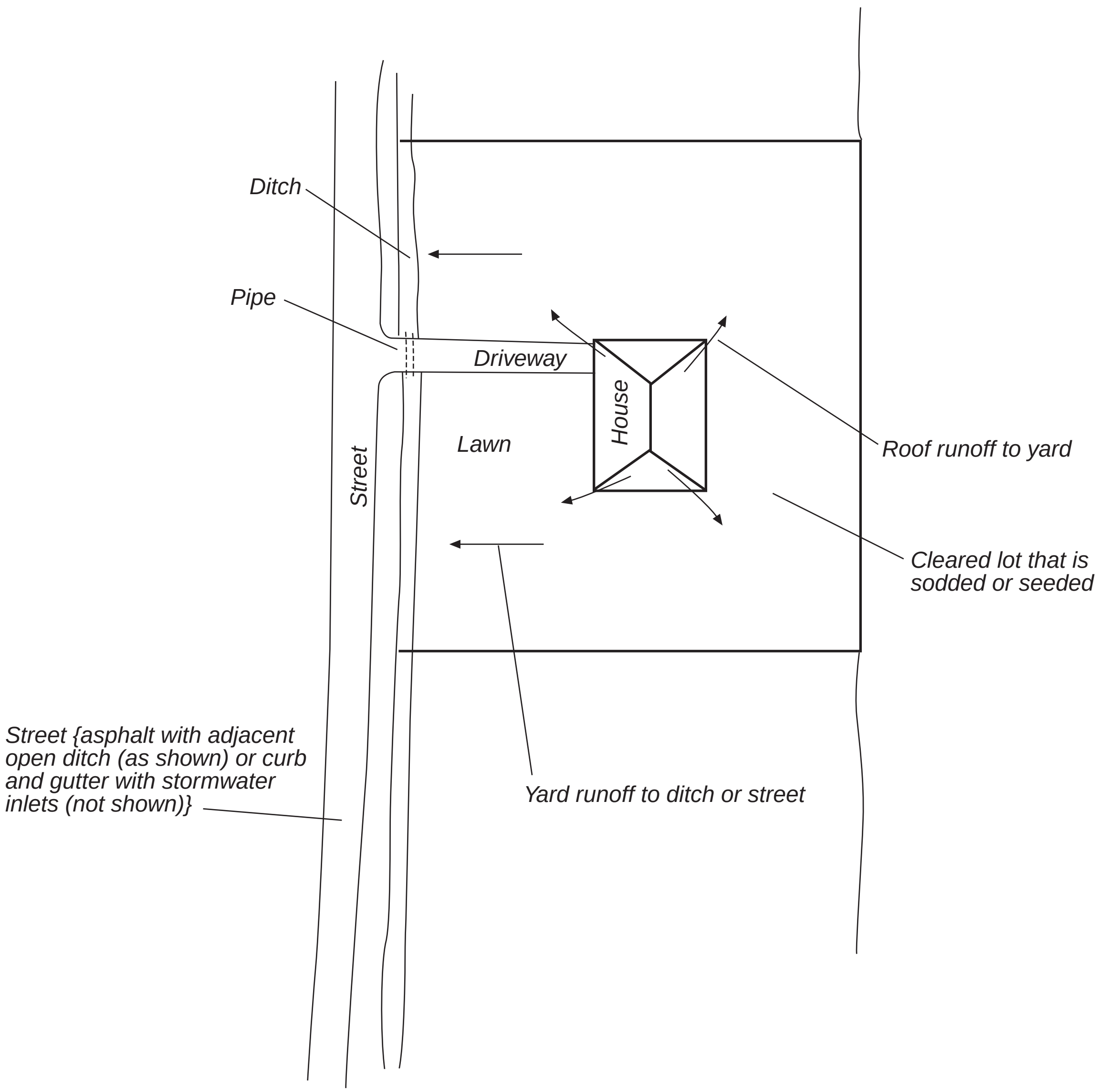


Schematic Cross-section B-B:
25-foot wide Biofilter Swale

Not to Scale

LOW IMPACT DEVELOPMENT - BIO-FILTER *FIGURE 4.28d*

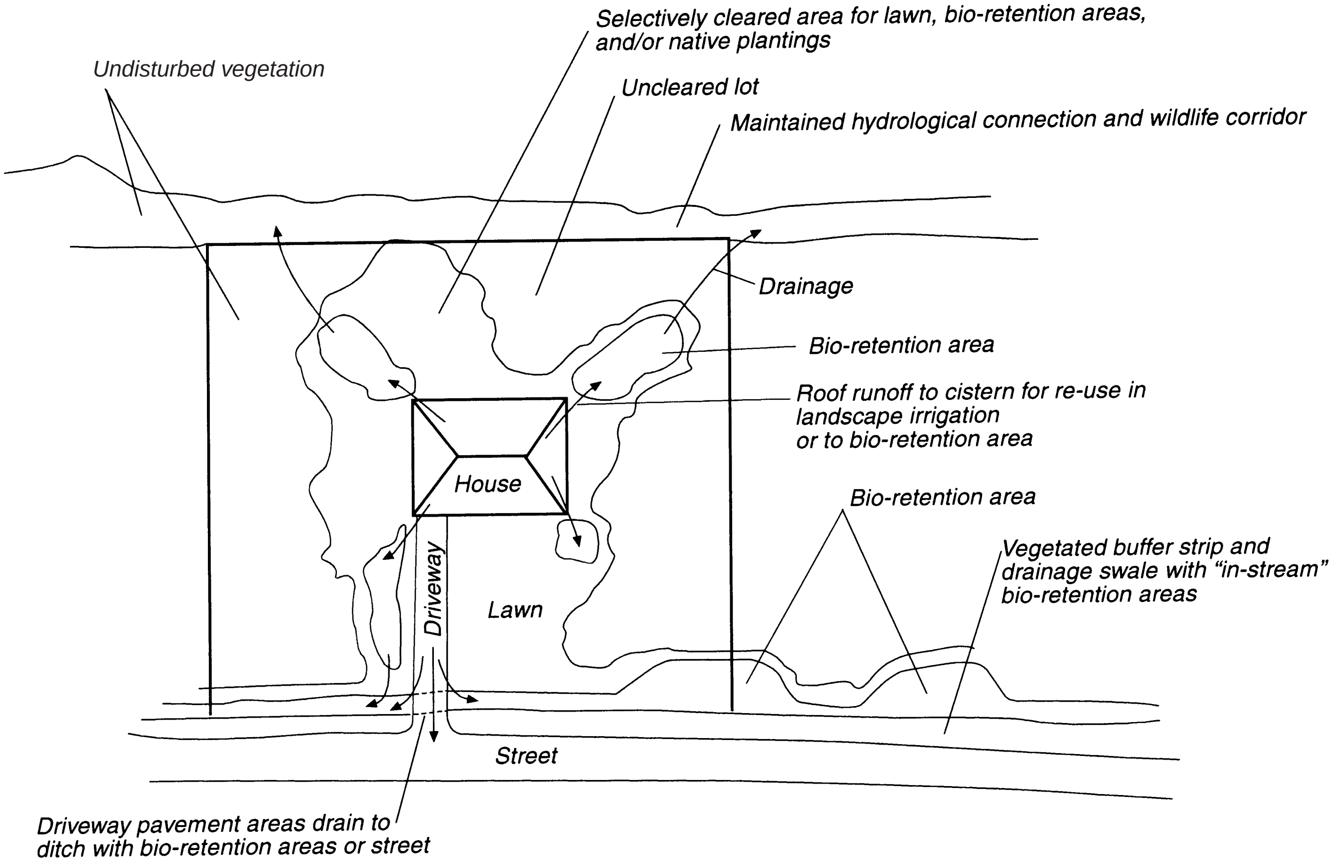
CONVENTIONAL LOT



CONVENTIONAL LOT

FIGURE 4.29a

LOW IMPACT LOT LAYOUT



Bio-retention areas to provide temporary stormwater ponding, water treatment, infiltration, and flow to vegetated buffer strips, bio-swales, and detention basins

GENERAL NOTES:

1. UNCLEARED AREA OF LOT WILL NOT BE MASS GRADED. VEGETATION WILL BE LEFT UNDISTURBED WHEN PRACTICABLE.

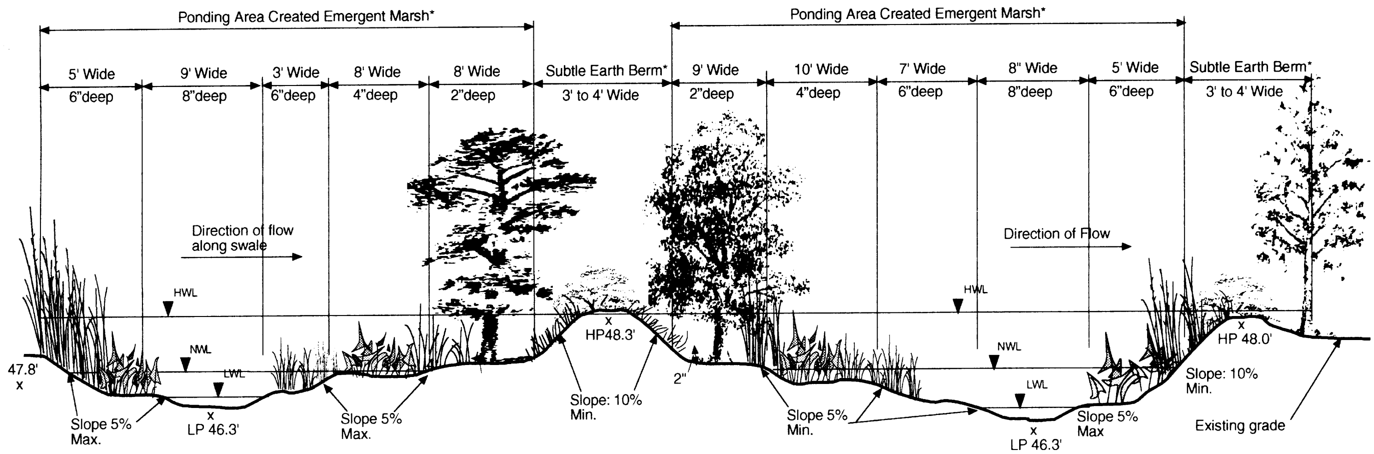
2. ROAD RUNOFF WILL BE HANDLED SEPARATELY FROM ROOFTOPS, UNDISTURBED LANDSCAPE AREAS, AND CLEARED AND REPLANTED OPEN AREAS RUNOFF. ROAD RUNOFF WILL BE TREATED SEPARATELY PRIOR TO DISCHARGE TO STORM SEWERS.

3. ROOFTOP, LANDSCAPE, AND OPEN AREA RUNOFF WILL BE DIRECTED TO VEGETATED BIOFILTER STRIPS AND BIO-RETENTION SWALES (SEE FIGURE 4.30). WHEN POSSIBLE, ROOFTOP, LANDSCAPE, AND OPEN AREA RUNOFF WILL BE RE-USED FOR IRRIGATION IN PARKS AND OTHER AREAS.

LOW IMPACT LOT

FIGURE 4.29b

BI0-RETENTION



Not to Scale

Note: Slopes illustrated are exaggerated.

**Note: Widths will vary upon specific site conditions.*

GENERAL NOTES:

1. TRANSITIONAL SLOPES WILL BE A MINIMUM OF 5%.

2. WHERE PRACTICABLE, EXISTING TREES AND VEGETATION WILL BE LEFT IN PLACE.

3. PONDING AREA CREATED BY EMERGENT MARSH WILL BE PLANTED WITH NATIVE WETLAND VEGETATION IN ALL AREAS BUT THE PERMANENT POOL. A PLANT LIST IS PROVIDED IN APPENDIX E.

LOW IMPACT DEVELOPMENT - BIO-RETENTION *FIGURE 4.30*

5.0

ORDINANCE AND REGULATIONS

5.0 ORDINANCE AND REGULATIONS

The City of Houston Storm Water Discharges Ordinance and the Regulations of Harris County, Texas for Storm Water Quality Management are available on the Storm Water Management Joint Task Force website: http://www.cleanwaterclearchoice.org. The City of Houston ordinance is also available at the City of Houston's Department of Public Works and Engineering's Plan Review Desk, 611 Walker, 2nd Floor, Houston, Texas, and at the City of Houston's Storm Sewer Review Desk, 3300 Main, 2nd Floor, Houston, Texas. The Harris County regulations are also available at the Harris County Public Infrastructure Department – Permit Office, 9900 Northwest Freeway, Suite 103, Houston, Texas.

APPENDIX A

GUIDANCE FOR PLAN SUBMITTAL AND IMPLEMENTATION REVIEW

City of Houston and Harris County procedures for the New Development / Significant Redevelopment Program are available on the Storm Water Management Joint Task Force website: http://www.cleanwaterclearchoice.org.

APPENDIX B

INSPECTION CHECKLISTS FOR NON-STRUCTURAL BEST MANAGEMENT PRACTICES (BMPS)

APPENDIX B

INSPECTION CHECKLISTS
FOR NON-STRUCTURAL (SOURCE CONTROL)
BEST MANAGEMENT PRACTICES (BMPS)

Note:

Sample inspection and maintenance checklists for non-structural best management practices (BMPs) provided in this appendix were derived from various sources. The checklists provide general guidance and may need adaptation for use with a specific practice or site conditions, subject to the review and approval of the local agency with jurisdiction. The completed checklists should be maintained at an accessible location, for examination by the local agency with jurisdiction.

Tables B.1 and B.2 are provided as guidance for multiple checklist application, to use for inspection and monitoring of a program with multiple non-structural controls.

Table B.1 – Applicable Non-Structural Controls			
Potential Pollutant-Causing Activity	**Activity Located on Site (✓)**	**Applicable Non-Structural Control**	**Ref. #**
Uncovered vehicle parking	____	Street Sweeping	4.1.12
Trash disposal	____	Litter Control	4.1.2
Washing of vehicle or equipment	____	Vehicle/Equipment Washing and Steam Cleaning	4.1.6
Vehicle or equipment fueling	____	Fueling Station	4.1.5
Loading or unloading of liquid materials	____	Liquid Materials Loading and Unloading	4.1.7
Storage of raw materials, by-products or products of manufacturing processes	____	Outdoor Storage Outdoor Manufacturing Spill Prevention and Response Plan	4.1.11 4.1.12 4.1.10
Above-ground bulk storage of fuel, petroleum or chemicals	____	Liquids Storage in Aboveground Tanks Liquid Materials Loading and Unloading Spill Prevention and Response Plan	4.1.8 4.1.7 4.1.10
Underground tanks	____	Liquid Materials Loading and Unloading Spill Prevention and Response Plan	4.1.7 4.1.10
Use of pesticides or fertilizers	____	Household Hazardous Materials Storage/Disposal Landscaping Practice Fertilizer and Pesticide Use	4.1.1 4.1.2 4.1.4
Temporary storage of liquid or solid wastes	____	Liquids Storage in Aboveground Tanks	4.1.8
Type of waste:		Container Storage of Liquids	4.1.9
Hazardous Waste	____	Spill Prevention and Response Plan	4.1.10
Food Waste	____	Container Storage of Liquids Spill Prevention and Response Plan	4.1.9 4.1.10
Used Oil/Antifreeze	____	Container Storage of Liquids Spill Prevention and Response Plan	4.1.9 4.1.10
Underground drainage system	____	Household Hazardous Materials Storage/Disposal (recycling oil/antifreeze) Inlet Stenciling	4.1.1 4.1.13
ANY OTHER ACTIVITIES NOT COVERED ABOVE: _______________________			

TABLE B-2: NON-STRUCTURAL CONTROL MATRIX

	Household Hazardous Materials Storage/Disposal (4.1.1)	Litter Control (4.1.2)	Landscaping Practices (4.1.3)	Fertilizer and Pesticide Use (4.1.4)	Fueling Station Practices (4.1.5)	Vehicle/Equipment Washing and Steam Cleaning Practices (4.1.6)	Liquid Materials Loading and Unloading Practices (4.1.7)	Liquids Storage in Above Ground Tanks (4.1.8)	Container Storage of Liquids, Food Wastes, Hazardous Wastes (4.1.9)	Spill Prevention and Response Plan (4.1.10)	Outdoor Storage Practices (4.1.11)	Street Sweeping (4.1.12)	Inlet Stencilling (4.1.13)
LAND USE:													
MANUFACTURING BUSINESSES:													
Cement		●				●	●	●	●	●	●	●	●
Chemicals		●				●	●	●	●	●	●	●	●
Concrete Products		●			●	●	●	●	●	●	●	●	●
Electrical Products		●				●	●	●	●	●	●	●	●
Food Products		●				●	●	●	●	●	●	●	●
Glass Products		●				●	●	●	●	●	●	●	●
Machinery And Equipment		●			●	●	●	●	●	●	●	●	●
Metal Products		●				●	●	●	●	●	●	●	●
Paper And Pulp Mills		●			●	●	●	●	●	●	●	●	●
Paper Products		●				●	●	●	●		●	●	●
Petroleum Products		●			●	●	●	●	●		●	●	●
Printing And Publishing		●				●	●	●	●	●		●	●
Rubber And Plastic Products		●				●	●	●	●	●	●	●	●
Ship And Boat Building/Repair Yards		●				●	●	●	●	●		●	●
Wood Products		●				●	●	●	●	●	●	●	●
Wood Treatment		●		●		●	●	●	●	●	●	●	●
TRANSPORTATION AND COMMUNICATION:													
Airfields/Aircraft Maintenance		●			●	●	●	●	●	●		●	●

TABLE B-2: NON-STRUCTURAL CONTROL MATRIX, continued

	Household Hazardous Materials Storage/Disposal (4.1.1)	Litter Control (4.1.2)	Landscaping Practices (4.1.3)	Fertilizer and Pesticide Use (4.1.4)	Fueling Station Practices (4.1.5)	Vehicle/Equipment Washing and Steam Cleaning Practices (4.1.6)	Liquid Materials Loading and Unloading Practices (4.1.7)	Liquids Storage in Above Ground Tanks (4.1.8)	Container Storage of Liquids, Food Wastes, Hazardous Wastes (4.1.9)	Spill Prevention and Response Plan (4.1.10)	Outdoor Storage Practices (4.1.11)	Street Sweeping (4.1.12)	Inlet Stencilling (4.1.13)
Fleet Vehicle Yards		●			●	●	●	●	●	●		●	●
Railroads		●		●	●	●	●	●	●	●	●	●	●
Private Utility Corridors		●	●						●			●	●
Warehouses And Miniwarehouses		●					●		●	●		●	●
WHOLESALE AND RETAIL BUSINESSES:													
Gas Stations		●			●	●	●	●	●	●		●	●
Recyclers And Scrap Yards		●				●	●	●	●	●		●	●
Restaurants/Fast Food		●					●		●	●		●	●
General Merchandise		●			●	●			●	●		●	●
Vehicle And Equipment Dealers		●			●	●	●	●	●	●		●	●
Nurseries And Building Materials		●		●	●	●			●	●	●	●	●
Chemicals And Petroleum		●		●	●	●						●	●
Foods And Beverages		●			●	●	●	●	●	●		●	●
SERVICE BUSINESSES:													
Commercial Car And Truck Washes		●			●	●				●		●	●
Equipment Repair		●			●	●	●		●	●		●	●
Laundries And Cleaning Services		●					●	●	●	●		●	●
Marinas And Boat Clubs		●			●	●	●	●	●	●		●	●
Professional Services		●				●	●	●	●	●		●	●
Vehicle Maintenance/Repair		●			●	●	●	●	●	●		●	●
Construction Businesses		●				●	●	●	●	●		●	●

TABLE B-2: NON-STRUCTURAL CONTROL MATRIX, continued

	Household Hazardous Materials Storage/Disposal (4.1.1)	Litter Control (4.1.2)	Landscaping Practices (4.1.3)	Fertilizer and Pesticide Use (4.1.4)	Fueling Station Practices (4.1.5)	Vehicle/Equipment Washing and Steam Cleaning Practices (4.1.6)	Liquid Materials Loading and Unloading Practices (4.1.7)	Liquids Storage in Above Ground Tanks (4.1.8)	Container Storage of Liquids, Food Wastes, Hazardous Wastes (4.1.9)	Spill Prevention and Response Plan (4.1.10)	Outdoor Storage Practices (4.1.11)	Street Sweeping (4.1.12)	Inlet Stencilling (4.1.13)
SINGLE FAMILY RESIDENCES	●	●	●	●									●
MULTIFAMILY RESIDENCES	●	●	●	●		●			●			●	●
PUBLIC FACILITIES													
Public Buildings And Streets		●			●		●		●	●		●	●
Vehicle And Equipment Maintenance Facilities		●			●	●	●	●	●	●	●	●	●
Maintenance Of Open Space		●	●	●									●
Maintenance Of Public Storm Water Facilities		●										●	●
Maintenance Of Roadside Vegetation/Ditches		●	●	●									
Maintenance Of Public Utilities Corridors		●	●	●					●				
Maintenance Of Water And Sewer Facilities									●				●
Port Districts		●			●	●	●	●	●	●	●	●	●
INSTITUTIONAL													
Schools		●	●	●					●			●	●
Hospitals		●	●				●		●			●	●
Sports Facilities (Stadia)		●	●	●		●			●		●	●	●
OPEN SPACE													
Golf Courses		●	●	●					●		●	●	●
Parks		●	●	●								●	●

Sample Inspection and Maintenance Checklists

4.1 NON-STRUCTURAL CONTROLS

- 4.1.1 Household Hazardous Material Storage / Disposal
- 4.1.2 Litter Control
- 4.1.3 Landscaping Practices
- 4.1.4 Fertilizer and Pesticides
- 4.1.5 Fueling Station Practices
- 4.1.6 Vehicle / Equipment Washing and Steam Cleaning Practices
- 4.1.7 Liquid Materials Loading and Unloading Practices
- 4.1.8 Liquids Storage in Above-ground Tanks Practices
- 4.1.9 Container Storage of Liquids, Food Wastes, Hazardous Wastes
- 4.1.10 Spill Prevention and Response Plan
- 4.1.11 Outdoor Storage Practices
- 4.1.12 Street Sweeping
- 4.1.13 Inlet Stenciling

4.1.1.a HOUSEHOLD HAZARDOUS MATERIALS STORAGE / DISPOSAL

Inspection Date_______________ **By:** ____________________

Time _______________ **Location:** ____________________

Item	Household Hazardous Materials LIST BELOW *(Use less toxic alternatives where feasible)*	Storage Location	Securely stored, safe from children/pets and protected from	Correction Action/By	Corrected Date	Collection Center Location	Date(s)	Recycling Center Location	Date(s)
1	Paints								
2	Cleaning Products								
3	Automotive								
4	Other								
Comments:									

4.1.1.b COMMERCIAL / INDUSTRIAL CHEMICAL / MATERIAL AREAS

Inspection Date______________ **By:** ______________________
Time ______________ **Location:** ______________________

ITEM	Site Specific Checklist For Chemical/Material Storage Areas	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	Hazardous material containers are properly labeled.				
2	MSDS are readily accessible.				
3	Indoor containers/drums are stored on pallets.				
4	Outdoor containers/drums are protected from precipitation.				
5	Spill response container is placed with hazardous materials that are stored covered outdoors.				
6a.	Secondary containment is in use.				
6b.	If yes, describe materials that are provided secondary containment and where are the materials located. ________________________________				
7	Containers/drums are in good condition with no corrosion.				
8	Drain funnels or air pumps are used for fluid transferal?				
9a.	Spill control equipment is nearby and available to use if a spill suddenly occurs. Exclude spill response containers that are discussed in question 5.				
9b.	List available spill equipment: ____________________				
10	Annual inspections and corrective actions for storage areas are documented and kept onsite?				
11	Rags or wipes used with solvents/thinners, or other hazardous cleaning fluids are collected and handled appropriately according to applicable local, state or federal regulations.				
12	Outside dumpsters are covered.				
II.	**Good Housekeeping Checklist For Chemical/Material Storage Areas**				
1	Bags are in good condition with no tears evident.				
2	Dry-bulk material in bags is not exposed to wind or rain.				
3	Paper waste, spent rags/cloths, and other waste products are properly segregated, handled and stored while awaiting disposal.				
4	Visual inspections or leak tests been performed for overhead piping conveying Section 313 chemicals w/o sec. containment.				
5a.	Owner/Operator has a spill response plan.				
5b.	If yes, a copy should be kept onsite and additional copy should be provided to the PPP during annual inspection.				
Comments:					

4.1.2 LITTER CONTROL

Inspection Date______________ **By:** ______________________

Time ______________ **Location:** ______________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**HOUSEHOLD WASTE**				
1.1	Routine waste is securely contained (garbage containers, dumpsters, etc.)				
1.2	Use of recycling program / facilities.				
1.3	Other method practiced. (Describe below)				
2	**COMMERCIAL AND INDUSTRIAL WASTE**				
2.1	Routine waste is securely contained (garbage containers, dumpsters, etc.)				
2.2	Use of recycling program / facilities.				
2.3	Frequent daily inspection of immediate area around storage areas.				
2.4	Litter containers are conveniently placed and disposed frequently.				
3	**HAULING VEHICLES**				
3.1	Cover over loose material.				
3.2	Use of sealed bottoms for equipment.				
4	**LOADING DOCKS**				
4.1	Dock swept regularly.				
5	**CONSTRUCTION SITE (SEE PRACTICES GIVEN IN "STORM WATER MANAGEMENT FOR CONSTRUCTION ACTIVITIES")**				
6	**MOTORISTS AND PEDESTRIANS**				
6.1	Secure vacant lots and vegetated areas.				
6.2	Provide litterbags or baskets.				
7	**OTHER ITEM (DESCRIBE ITEM AND GIVE COMMENTS)**				

4.1.3 LANDSCAPING PRACTICES

Inspection Date______________ **By:** ______________________

Time ______________ **Location:** ______________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**WATERING AND MOWING:** ***(guidelines)***				
1.1	Deep Watering (about 1") no more than every 5 or 6 days.				
1.2	Mulching mower used, kept in good condition.				
1.3	Other method practiced. (Describe below)				
2	**XERISCAPING (USE OF NATIVE PLANTS)**				
2.1	**Locations (List below):**				
3	**OTHER ITEM (DESCRIBE ITEM AND GIVE COMMENTS)**				

4.1.4 FERTILIZER AND PESTICIDE USE

Inspection Date______________ **By:** ______________________

Time ______________ **Location:** ______________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**FERTILIZER USE *(guidelines)***				
1.1	Use of native or low maintenance landscaping as feasible to minimize fertilize use.				
1.2	Soil test conducted (recommended).				
1.3	Fertilize warm season grasses (Bermuda, Bahia, Centipede, St. Augustine) in the spring or summer.				
1.4	Fertilize cool season grasses (Ryegrass) in the fall or early winter.				
1.5	Apply fertilizer when soil moisture is adequate, and little likelihood of heavy rain.				
1.6	Sprinkle lawn after application.				
1.7	Prevent spill on impervious areas.				
1.8	Other method practiced. (Describe below)				
2	**PESTICIDES AND HERBICIDES USE**				
2.1	Use of pest resistant vegetation and proper care to minimize pesticide use.				
2.2	Label all products used.				
2.3	Non-toxic alternatives or least toxic chemicals used. (List below)				
2.4	Apply on affected areas and under windless conditions.				
2.5	Proper storage and disposal.				
2.6	Certification or licensing for commercial or institutional applicators.				
2.7	Use of Integrated Pest Management program if practicable.				
2.8	Other method currently practiced. (Describe below)				
3	**OTHER ITEM (DESCRIBE ITEM AND GIVE COMMENTS)**				

4.1.5 FUELING STATION PRACTICES

Inspection Date______________ **By:** ______________________

Time ______________ **Location:** ______________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**FACILITIES AND EQUIPMENT**				
1.1	Canopy over fuel island.				
1.2	Condition of Drain on "downhill" side of island is satisfactory.				
	(Should be connected to sump, process treatment, or where permitted, to the sanitary sewer.)				
1.3	Condition of positive control valve for drain is satisfactory.				
1.4	Condition of sump, if used, is satisfactory.				
	(Oily residuals indicate need for cleanup.)				
1.5	Condition of oil/water separator, if used, is satisfactory.				
	(Complete Oil/Grit Separator inspection checklist. Oily residuals indicate need for cleanup.)				
1.6	Other:				
2	**REQUIRED MAINTENANCE AND/OR REPAIRS:**				

4.1.6 VEHICLE / EQUIPMENT WASHING AND STEAM CLEANING PRACTICES

Inspection Date______________ **By:** ______________________
Time ______________ **Location:** ______________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**FACILITIES AND EQUIPMENT *(guidelines)***				
1.1	Wash water contained and treated by a closed-loop recycling system, or discharge in process treatment.				
1.2	Uncovered wash areas are paved, protected from storm water flow from adjacent areas.				
1.3	Condition of catch basin, if used, is satisfactory.				
	(Oily residuals indicates need for cleanup. Complete Catch Basin Inspection checklist.)				
1.5	Condition of oil/water separator, if used, is satisfactory.				
	(Complete Oil/Grit Separator inspection checklist. Oily residuals indicate need for cleanup.)				
1.7	Signing forbidding oil changing near wash facility.				
1.8	Soap, if used, is low phosphate type (for residential car washing only.)				
1.9	Other method currently practiced. Describe below.				
2	**REQUIRED MAINTENANCE AND/OR REPAIRS:**				

4.1.7 LIQUID MATERIALS LOADING AND UNLOADING PRACTICES

Inspection Date______________ **By:** ________________________
Time ______________ **Location:** ________________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**CONTAINED LIQUIDS AT LOADING AND UNLOADING DOCKS *(guidelines)***				
1.1	Condition of overhangs or door skirts is satisfactory.				
1.2	Spill cleanup materials in readily accessible location, and well maintained.				
1.3	Other method currently practiced. Describe below.				
2	**BULK LOADING /UNLOADING**				
2.1	Written operation plan is current and practiced by employees.				
2.2	Drip pan used where spillage may occur.				
2.3	Spillage of drip pans residuals are cleaned up.				
2.4	Other method currently practiced. Describe below.				
3	**REQUIRED MAINTENANCE AND OR REPAIRS:**				

4.1.8 LIQUIDS STORAGE IN ABOVEGROUND TANK PRACTICES

Inspection Date______________ **By:** ______________________
Time ______________ **Location:** ______________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**PERMANENT TANK STORAGE *(guidelines)***				
1.1	Condition of tank overfill protection system is satisfactory.				
1.2	Condition of containment dike(s) around tank(s) is satisfactory.				
1.3	Condition of impervious surface within dike is satisfactory.				
1.4	Condition of positive control valve on outlet is satisfactory.				
1.5	Condition of small spill sump is satisfactory.				
	(Presence of residuals indicates need for cleanup.)				
1.6	Accumulated storm water released frequently during rainy periods (if not exposed to the stored liquids.)				
1.7	Condition of Oil/Grit Separator (for petroleum tanks or other heavy use area) is satisfactory. Complete Oil/Grit Separator inspection checklist.				
1.8	Other:				
2	**SPILL RESPONSE PLAN:**				
2.1	Spill Response Plan is available in readily accessible location.				
2.2	Date of last update to Spill Response Plan: __________				
3	**REQUIRED MAINTENANCE AND OR REPAIRS:**				

4.1.9 CONTAINER STORAGE OF LIQUIDS, FOOD WASTES, HAZARDOUS WASTES

Inspection Date______________ **By:** ______________________
Time ______________ **Location:** ______________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**FACILITIES AND EQUIPMENT *(guidelines)***				
1.1	Waste containers kept in protective structures (lean-to, service bay, etc.) while awaiting transfer.				
1.2	Condition of impervious surface under containers with liquids is satisfactory.				
1.3	Condition of curb or dike around containers with liquids is satisfactory.				
1.4	Condition of sump collecting drainage from storage area is satisfactory.				
	(Presence of residuals indicates need for cleanup.)				
1.5	Drip pan use under containers fixed with valves or spigots is satisfactory.				
1.6	Employee trained in spill control/cleanup is present during loading/unloading activity.				
1.7	Spill cleanup materials is readily accessible location, and well maintained.				
1.8	Other:				
2	**REQUIRED MAINTENANCE AND OR REPAIRS:**				

4.1.10 SPILL PREVENTION AND RESPONSE PLAN

Inspection Date______________ **By:** ________________________
Time ______________ **Location:** ________________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**Spill Prevention and Response PLAN *(guidelines)***				
1.1	Spill Preventionand Response procedures have been developed for the site.				
1.2	Team is designated with spill response cleanup responsibility.				
1.3	Summary of Spill Preventionand Response plan posted at appropriate locations.				
1.4	Spill cleanup materials in readily accessible location and well maintained.				
1.5	Personnel are trained in spill containment and response procedures.				
1.6	Other:				
	Spill notification list is part of plan.				
	Contingency Plan in case of catastrophic spill.				
2	**REQUIRED MAINTENANCE AND OR REPAIRS:**				

4.1.11 OUTDOOR STORAGE PRACTICES

Inspection Date______________ **By:** ______________________

Time ______________ **Location:** ______________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**RAW MATERIALS, BUILDING MATERIALS, AND CONCRETE AMD METAL PRODUCTS *(guidelines)***				
1.1	Condition of covered area is satisfactory.				
1.2	Condition of paved area on which materials are stored is satisfactory.				
1.3	Plastic sheeting used over material (for raw materials.)				
1.4	Condition of drainage system and structural control is satisfactory. Complete appropriate inspection checklist for structural control.				
1.5	Other:				
2	**OTHER ITEM (DESCRIBE ITEM AND GIVE COMMENTS)**				
3	**REQUIRED MAINTENANCE AND/OR REPAIRS:**				

4.1.12 STREET SWEEPING

Inspection Date______________ **By:** ______________________

Time ______________ **Location:** ______________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**PRACTICES**				
1.1	Vacuum-type or regenerate sweepers used.				
1.2	Sweeping frequency of at least bi-weekly.				
1.3	Operators instructed to exceed 6 mph. Sweeping speed and to make 2 sweeping passes.				
1.4	Sweeping disposed of at an approved landfill site.				
1.5	Other:				
2	**OTHER ITEM (DESCRIBE ITEM AND GIVE COMMENTS)**				
3	**REQUIRED MAINTENANCE AND/OR REPAIRS:**				

4.1.13 STORM DRAIN INLET STENCILING

Inspection Date______________ **By:** ________________________

Time ______________ **Location:** ________________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**PRACTICES**				
1.1	Signs painted on or adjacent to all storm drain inlets noting receiving waters and warning against dumping.				
1.2	Stenciled message on concrete or metal plates on or adjacent to storm drain inlets noting receiving waters and warning against dumping				
1.3	Other:				
2	**REQUIRED MAINTENANCE AND/OR REPAIRS:**				

4.1.14 OUTDOOR MANUFACTURING PRACTICES

Inspection Date______________ **By:** ______________________

Time ______________ **Location:** ______________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**COVERED ACTIVITY (NOT TOTALLY ENCLOSED)**				
1.1	Condition of sump collecting drainage activity area is satisfactory.				
	(Presence of residuals indicates need for cleanup.)				
1.2	Other method currently practiced. Describe below.				
2	**SEGREGATED EXPOSED ACTIVITY**				
2.1	Condition of curbing around activity is satisfactory.				
2.2	Condition of impervious surface on which activity is located is satisfactory.				
2.3	Condition of drainage system and process control is satisfactory. Complete appropriate inspection checklist for structural control.				
2.4	Other method currently practiced. Describe below.				
2	**OTHER ITEM (DESCRIBE ITEM AND GIVE COMMENTS)**				
3.	**REQUIRE MAINTENANCE AND/OR REPAIRS:**				

4.1.15 RECYCLING MOTOR OIL AND ANTIFREEZE

Inspection Date______________ **By:** ______________________

Time ______________ **Location:** ______________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**PRACTICES**				
1.1	Information posted on recycling procedures.				
1.2	Locations of recycling or collection centers posted.				
1.3	Covered protected area provided for temporary storage of materials/fluids for recycling. (complete appropriate inspection checklist for covered area for hazardous materials.)				
1.4	Temporary storage area for recycle materials is kept neat, clean.				
1.5	Other method currently practiced. Describe below.				
2	**OTHER ITEM (DESCRIBE ITEM AND GIVE COMMENTS)**				
3	**REQUIRE MAINTENANCE AND/OR REPAIRS:**				

APPENDIX C

INSPECTION CHECKLISTS FOR STRUCTURAL BEST MANAGEMENT PRACTICES (BMPs)

APPENDIX C

INSPECTION CHECKLISTS
FOR STRUCTURAL
BEST MANAGEMENT PRACTICES (BMPs)

Note:

Sample inspection and maintenance checklists for structural best management practices (BMPs) are provided in this appendix to aid the owner and/or operator of a BMP, in inspecting and maintaining a BMP. The forms were derived from various sources. The sample forms are generalized and may need adaptation for use with a specific practice or site conditions, subject to the review and approval of the local agency with jurisdiction. The completed checklists should be maintained at an accessible location, for examination by the local agency with jurisdiction.

Sample Inspection and Maintenance Checklists

- 4.2 WATER QUALITY BASINS
  - 4.2.1 Dry Basins
  - 4.2.2 Wet Ponds
  - 4.2.4 Wetland Treatment
- 4.4 CATCHMENT FACILITIES
  - 4.4.1 Catch Basins
  - 4.4.2 Oil/Grit Separators
- 4.5 VEGETATIVE PRACTICES
  - 4.5.1 Grassed Swales
  - 4.5.2 Vegetated Filter Strips

4.2.1 DRY BASINS

Inspection Date______________ **By:** ____________________________

Time ______________ **Location:** ____________________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**SEDIMENT REMOVAL**				
1.1	Design depth (feet): ____________				
1.2	Sediment thickness:____________ (Measure sediment thickness directly, or measure current depth and subtract from design depth to arrive at sediment thickness. Remove sediment if thickness exceeds 1/3 of design depth.)				
2	**EMBANKMENT**				
2.1	Evidence of subsidence.				
2.2	Presence of erosion.				
2.3	Presence of crack.				
2.4	Presence of tree growth.				
2.5	Presence burrowing animals.				
2.6	Other. Describe below.				
2.7	Explanation:				
3	**OUTFALL**				
3.1	Emergency spillway.				
3.2	Outlet.				
3.3	Discharge control such as valve, riser/barrel, weir, check dam, and other.				
3.4	Other. Describe below.				
3.5	Explanation:				
4	**DRAW DOWN TIME**				
	Design volume drains less than 24 hours or remains 72 hours or more after a storm. If answer is yes, outfall or outlet control should be checked, cleaned or adjusted as needed.				
5	**CONTRIBUTORY DRAINAGE**				
5.1	Inlet condition is satisfactory.				
5.2	Upstream channel conditions are satisfactory.				
5.3	Upstream erosion controls are satisfactory.				
5.4	Upstream sediment controls are satisfactory.				
5.5	Other. Describe below.				
5.6	Explanation:				

4.2.1 DRY BASINS (Continued)

Inspection Date______________ **By:** ____________________________

Time ______________ **Location:** ____________________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
6	**DEBRIS / LITTER REMOVAL**				
6.1	Date of last litter removal:				
6.2	Removal of litter is required. (Required if last litter removal was 6 months ago or earlier.)				
7	**MOWING**				
7.1	Date of last mowing performed:				
7.2	Mowing required. (Required if last mowing was 6 months ago or earlier or if trees or woody shrubs are present on embankment.)				
8	**NUISANCE CONTROL**				
8.1	Presence of insects.				
8.2	Presence of weeds				
8.3	Presence of odors.				
8.4	Other. Describe below.				
8.5	Explanation:				
9	**STRUCTURAL REPAIRS/REPLACEMENT**				
	Describe any item needing structural repair and replacement below.				
10	**OTHER ITEM.**				
	Describe item and condition. Explain any problem below.				
	REQUIRED MAINTENANCE AND /OR REPAIRS:				

4.2.2 WET PONDS

Inspection Date______________ **By:** ____________________________

Time ______________ **Location:** ____________________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**SEDIMENT REMOVAL**				
1.1	Design depth of forebay (feet): ____________.				
1.2	Sediment thickness of forebay:____________ (Measure sediment thickness directly, or measure current depth and subtract from design depth to arrive at sediment thickness. Remove sediment if thickness exceeds 1/3 of design depth.)				
1.3	Design depth of other location (feet): _____________.				
1.4	Sediment thickness of other location:____________. (Measure sediment thickness directly, or measure current depth and subtract from design depth to arrive at sediment thickness. Remove sediment if thickness exceeds 1/3 of design depth.)				
2	**EMBANKMENT**				
2.1	Evidence of subsidence.				
2.2	Presence of Erosion.				
2.3	Presence of crack.				
2.4	Presence of tree growth.				
2.5	Presence burrowing animals.				
2.6	Other. Describe below.				
2.7	Explanation:				
3	**OUTFALL**				
3.1	Emergency spillway.				
3.2	Other. Describe below.				
	Explanation:				
4	**CONTRIBUTORY DRAINAGE**				
4.1	Inlet				
4.2	Upstream channel conditions.				
4.3	Upstream erosion controls.				
4.4	Upstream sediment controls.				
4.5	Other. Describe below.				
4.6	Explanation:				

4.2.2 WET PONDS (continued)

Inspection Date______________ **By:** ____________________

Time ______________ **Location:** ____________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
5	**DEBRIS / LITTER REMOVAL**				
5.1	Date of last litter removal:____________________				
5.2	Removal of litter is required. (Required if last litter removal was 6 months ago or earlier.)				
6	**MOWING**				
6.1	Date of last mowing performed:_________________________				
6.2	Mowing required. (Required if last mowing was 6 months ago or earlier or if trees or woody shrubs are present on embankment.)				
7	**NUISANCE CONTROL**				
7.1	Presence of insects.				
7.2	Presence of weeds				
7.3	Presence of odors.				
7.4	Other. Describe below.				
7.5	Explanation:				
8	**STRUCTURAL REPAIRS/REPLACEMENT**				
	Describe any item needing structural repair and replacement below.				
9	**OTHER ITEM.**				
	Describe item and condition. Explain any problem below.				
	REQUIRED MAINTENANCE AND /OR REPAIRS:				

4.2.4 WETLAND TREATMENT (CONSTRUCTED WETLAND)

Inspection Date______________ **By:** ____________________________

Time ______________ **Location:** ____________________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**HARVESTING AND SEDIMENT REMOVAL**				
	ALL HARVESTING AND/OR SEDIMENT REMOVAL SHOULD BE DONE ACCORDING TO PROCEDURES DEVELOPED BY A QUALIFIED PROFESSIONAL.				
2	**EMBANKMENT**				
2.1	Evidence of subsidence.				
2.2	Presence of Erosion.				
2.3	Presence of crack.				
2.4	Presence of tree growth.				
2.5	Presence burrowing animals.				
2.6	Other. Describe below.				
2.7	Explanation:				
3	**OUTFALL**				
3.1	Emergency spillway.				
3.2	Other. Describe below.				
3.3	Explanation:				
4	**CONTRIBUTORY DRAINAGE**				
4.1	Inlet				
4.2	Upstream channel conditions.				
4.3	Upstream erosion controls.				
4.4	Upstream sediment controls.				
4.5	Other. Describe below.				
4.6	Explanation:				

4.2.4 WETLAND TREATMENT (CONSTRUCTED WETLAND) (continued)

Inspection Date______________ **By:** ____________________________
Time ______________ **Location:** ____________________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
5	**DEBRIS / LITTER REMOVAL**				
5.1	Date of last litter removal:_____________________				
5.2	Removal of litter is required. (Required if last litter removal was 6 months ago or earlier.)				
6	**EMBANKMENT MOWING**				
6.1	Date of last mowing performed:__________________________				
6.1	Mowing is required. (Required if last mowing was 6 months ago or earlier or if trees or woody shrubs are present on embankment.)				
7	**NUISANCE CONTROL**				
7.1	Presence of insects.				
7.2	Presence of weeds				
7.3	Presence of odor.				
7.4	Other. Describe below.				
7.5	Explanation:				
8	**STRUCTURAL REPAIRS/REPLACEMENT**				
	Describe any item needing structural repair and replacement below.				
9	**OTHER ITEM.**				
	Describe item and condition. Explain any problem below.				
	REQUIRED MAINTENANCE AND /OR REPAIRS:				

4.4.1 CATCH BASINS

Inspection Date______________ **By:** ______________
Time ______________ **Location:** ______________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**CATCH BASINS**				
1.1	Presence of debris accumulation. (Remove any accumulation of debris.)				
1.2	Evidence of sediment accumulation. (Remove any substantial accumulation of sediment. Suggested guidelines removal guideline: 1 inch or more present. Note: lack of sediment after a significant rainfall indicates flushing and need for more frequent inspection and cleaning to avoid loss of sediment during flushing.)				
1.3	Presence of sheen, odor, or visible.				
1.4	Presence of oil in chamber. Clean, if answer yes and if last cleaning date was 6 months ago or earlier.				
1.5	Other. Describe below.				
1.6	Explanation:				
2	**OUTFALL**				
2.1	Outlets.				
2.2	Other. Describe below.				
2.3	Explanation:				
3	**CONTRIBUTORY DRAINAGE**				
3.1	Inlet condition is satisfactory.				
3.2	Upstream channel conditions are satisfactory.				
3.3	Upstream erosion controls are satisfactory.				
3.4	Upstream sediment controls are satisfactory.				
3.5	Other. Describe below.				
3.6	Explanation:				
4	**NUISANCE CONTROL**				
4.1	Presence of insects.				
4.2	Presence of weeds				
4.3	Presence of odors.				
4.4	Other. Describe below.				
4.5	Explanation:				
5	**STRUCTURAL REPAIRS/REPLACEMENT**				
	Describe any item needing structural repair and replacement below.				
6	**OTHER ITEM.**				
	Describe item and condition. Explain any problem below.				
	REQUIRED MAINTENANCE AND /OR REPAIRS:				

4.4.2 OIL GRIT SEPARATORS (Water Quality Inlets)

Inspection Date______________ **By:** ____________________________

Time ______________ **Location:** ____________________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**OIL/GRIT SEPARATOR**				
1.1	Presence of debris accumulation. (Remove any accumulation of debris.)				
1.2	Evidence of sediment accumulation. (Remove any substantial accumulation of sediment. Suggested guidelines removal guideline: 1 inch or more present. Note: lack of sediment after a significant rainfall indicates flushing and need for more frequent inspection.				
1.3	Condition of adsorbent pillows. (Replace with any cleaning, if oily.)				
1.4	Presence of sheen, odor, or visible. (Clean if present or if last cleaning date was 6 months ago or earlier)				
1.5	Condition of coalescing plates. (Indicate any damage, clogging, oily condition, etc. Clean if last cleaning was 6 months a go or earlier.)				
1.6	Other. Describe below.				
1.7	Explanation:				
2	**OUTFALL**				
2.1	Outlets.				
2.2	Discharge control such as orifice and other type.				
2.3	Other. Describe below.				
2.4	Explanation:				
3	**CONTRIBUTORY DRAINAGE**				
3.1	Inlet condition is satisfactory.				
3.2	Upstream channel conditions are satisfactory.				
3.3	Upstream erosion controls are satisfactory.				
3.4	Upstream sediment controls are satisfactory.				
3.5	Other. Describe below.				
3.6	Explanation:				
4	**NUISANCE CONTROL**				
4.1	Presence of insects.				
4.2	Presence of weeds				
4.3	Presence of odors.				
4.4	Other. Describe below.				
4.5	Explanation:				
5	**STRUCTURAL REPAIRS/REPLACEMENT**				
	Describe any item needing structural repair and replacement below.				
6	**OTHER ITEM.**				
	Describe item and condition. Explain any problem below.				
	REQUIRED MAINTENANCE AND /OR REPAIRS:				

4.5.1 GRASSED SWALES

Inspection Date______________ **By:** ______________

Time ______________ **Location:** ______________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**CHANNEL CONDITION**				
1.1	Presence of spot or area erosion.				
1.2	Presence of bare spots.				
1.3	Presence of weeds.				
1.4	Presence of standing water.				
1.5	Presence of sediment deposits.				
1.6	Other. Describe below.				
1.7	Explanation:				
2	**DEBRIS / LITTER REMOVAL**				
2.1	Date of last litter removal:______________				
2.2	Removal of litter is required. (Required if last litter removal was 6 months ago or earlier.)				
3	**MOWING**				
3.1	Date of last mowing performed:_____________				
3.2	Mowing required. (Required if last mowing was 6 months ago or earlier or if trees or woody shrubs are present on embankment.)				
4	**STRUCTURAL REPAIRS/REPLACEMENT**				
	Describe any item needing structural repair and replacement below.				
5	**OTHER ITEM.**				
	Describe item and condition. Explain any problem below.				
	REQUIRED MAINTENANCE AND /OR REPAIRS:				

4.5.2 VEGETATED FILTER STRIPS

Inspection Date______________ **By:** ____________________________

Time ______________ **Location:** ____________________________

ITEM	DESCRIPTION	Yes/No/NA	Correction Action/By	Corrected Date	Notes
1	**NATURAL FILTER STRIPS**				
1.1	Presence of spot or area erosion.				
1.2	Presence of bare spots.				
1.3	Presence of standing water.				
1.4	Presence of short-circuiting (channel / rills / gullies).				
1.5	Presence of debris / litter.				
1.6	Other. Describe below.				
1.7	Explanation:				
2	**LAWN OR MEADOW FILTER STRIPS**				
2.1	Presence of spot or area erosion.				
2.2	Presence of bare spots.				
2.3	Presence of weeds.				
2.4	Presence of standing water.				
2.5	Presence of short-circuiting (channel / rills / gullies).				
2.6	Presence of sediment deposits.				
2.7	Other. Describe below.				
2.8	Explanation:				
3	**MOWING (LAWN OR MEADOW FILTER STRIPS)**				
3.1	Date of last mowing performed:____________				
3.2	Mowing required. (Required if last mowing was 6 months ago or earlier or if trees or woody shrubs are present on embankment.)				
4	**STRUCTURAL REPAIRS/REPLACEMENT**				
	Describe any item needing structural repair and replacement below.				
5	**OTHER ITEM.**				
	Describe item and condition. Explain any problem below.				
	REQUIRED MAINTENANCE AND /OR REPAIRS:				

APPENDIX D

PROPOSED COMPREHENSIVE MASTER PLANS FOR NEW DEVELOPMENT AND SIGNIFICANT REDEVELOPMENT

CITY OF HOUSTON

PROPOSED COMPREHENSIVE MASTER PLAN FOR NEW DEVELOPMENT AND SIGNIFICANT REDEVELOPMENT

HARRIS COUNTY

PROPOSED COMPREHENSIVE MASTER PLAN FOR
NEW DEVELOPMENT AND SIGNIFICANT REDEVELOPMENT

APPENDIX E

RECOMMENDED PLANT LIST

Recommended Plant List

Storm Water Management Wetlands/Detention Basins
Houston-Galveston Gulf Coast Area
Source: Collins, 1993

(Note: Specific site conditions, regarding soils, hydrology, salinities, and loading rates will influence final plant selection per project.)

Open Water/Deep Marsh

Scientific Name	Common Name	Water Depth	Condition/ Remarks
Cabomba caroliniana	Fanwort	1' - 4'	bushel
Ceratophyllum demersum	Hornwort coontail	1' - 4'	(polishing)
Ceratophyllum muricatum	Coontail	1' - 4'	
Lemna aequinotialis	Duckweed	1' - 4'	
Lemna gibba	Swollen duckweed	1' - 4'	
Lemna minor	Small duckweed	1' - 4'	
Najas guadalupensis	Water-naiad	1' - 4'	rhizome/plug
Nelumbo lutea	American waterlotus	2' - 3'	seed
Nuphar elegans	Spatterdock	2' - 3'	rhizome
Nuphar luteum	Yellow cow-lily (Spatterdock)	2' - 3'	bushel
Nymphaea odorata	Waterlily	6" - 2'	rhizome
Potamogeton pectinatus	Sago pondweed (Fennel-Leaf)	8" - 3'	plugs
Spirodella punctata	Duckweed	1' - 4'	
Wolffia braziliensis	Dotted wolffia	1' - 4'	
Wolffia columbiana	Columbia wolffia	1' - 4'	

Shallow Emergent Marsh

Scientific Name	Common Name	Water Depth	Condition/ Remarks
Acorus calamus	Sweetflag	0 - 2'	rhizome
Agrostis alba	Red top	0 - 4"	seed
Agrostis semiverticillata	Water bent grass	0 - 4"	seed
Alisma subcordatum	Water plantain	0 - 2'	rhizome
Alopercurus aequalis	Short-awn foxtail	0 - 4"	seed
Alopercurus geniculatus	Meadow foxtail	0 - 4"	seed
Alternanthera philoxeroides	Alligator weed	0 - 2'	bushel
Asclepias incarnata	Swamp milkweed	0 - 4"	seed
Bidens cernua	Nodding beggar-ticks	0 - 4"	seed
Calopogon tuberosus	Tuberous grass-pink	0 - 4"	rhizome/plug
Cardamine bulbosa	Bulbous bitter-cress	0 - 1'	plug
Carex (sp.)	Sedge	0 - 1'	rhizome/plug
Carex blanda	Woodland sedge	0 - 1'	
Carex cherokeensis	Cherokee sedge	0 - 4"	plug
Carex Frankii	Frank's sedge	0 - 4"	plug
Carex granularis	Meadow sedge	0 - 4"	plug
Carex hirsutella	Sedge	0 - 4"	
Carex joorii	Hummock sedge	0 - 4"	
Carex longii	Longs sedge	0 - 4"	
Carex lupulina	Hop sedge	0 - 4"	
Carex meadii	Mead's sedge	0 - 4"	

Shallow Emergent Marsh cont'd.

Scientific Name	Common Name	Water Depth	Condition/ Remarks
Carex muhlenbergii var. muhlengergii	Muhlenberg sedge	0 - 4"	
Carex rosea	Stellate sedge	0 - 4"	
Carex stripata	Awe-fruited sedge	0 - 4"	
Carex vulpinoides	Fox sedge	0 - 4"	plug
Cyperus (sp.)	Flatsedge	2" - 6"	rhizome/plug
Cyperus articulatus	Jointed flatsedge	2" - 6"	
Cyperus brevifolius	Shortleaf flatsedge	2" - 6"	
Cyperus compressus	Poorland flatsedge	2" - 6"	
Cyperus giganteus	Giant flatsedge	2" - 6"	
Cyperus odoratus	Fragrant flatsedge	2" - 6"	
Dichanthelium scabriusculum	Wooly panic grass	0 - 4"	seed
Dichromena colorata	White-topped sedge	2" - 6"	rhizome/plug
Dichromena latifolia	White-top sedge	2" - 6"	rhizome/plug
Dryopteris ludoviciana	Southern shield-fern	0 - 4"	plug
Echinodorus parvulus	Leaf burhead	0 - 4"	OBL
Echinodorus rostratus	Burhead	3" - 1'	rhizome/plug
Eleocharis acicularis	Reverchon spikerush	3" - 1'	OBL
Eleocharis albida	White spikerush	3" - 1'	OBL
Eleocharis macrostachys	Spikerush	0 - 6"	rhizome/plug
Eleocharis montevidensis	Sand spikerush	0 - 6"	rhizome/plug
Eleocharis obtusa	Blunt spikerush	0 - 6"	OBL
Eleocharis palustris	Creeping spikerush	0 - 6"	OBL
Eleocharis parvula	Small spikerush	0 - 6"	OBL
Eleocharis quadrangulata	Four-square spikerush	3" - 1'	rhizome/plug
Eleocharis rostellata	Beaked spikerush	0 - 6"	OBL
Elodea canadensis	Broad water-weed	0 - 2"	OBL
Elodea nuttalli	Nuttall's water weed (I)	0 - 3"	OBL
Elymus canadensis	Nodding wild-rye	0 - 4"	seed
Elymus virginicus	Virginia wild-rye	0 - 4"	seed
Equisetum laevigatum	Smooth scouring rush	0 - 2'	plug
Equisetum hyemale	Scouring rush		
Eragrostis (sp.)	Lovegrass	0 - 4"	seed
Fimbristylis (sp.)	Fimbry	0 - 4"	plug
Galium (sp.)	Bedstraw	0 - 4"	plug
Glyceria striata	Fowl manna grass	0 - 4"	seed
Hibiscus laevis	Halbred-leaf rosemallow	0 - 6"	container
Hymenocallis (sp.)	Spider-lily	0 - 4"	tuber
Iris pseudacorus	Yellow flag iris	1' - 2'	rhizome/plug
Isoetes melanopoda	Blackfoot quillwort	0 - 18"	
Juncus effusus	Soft rush	6" - 1'	rhizome/plug
Juncus nodatus	Stout rush	0 - 1'	rhizome/plug
Juncus interior	Inland rush	0 - 4"	plug
Juncus torreyi	Torrey's rush	0 - 1'	plug
Justicia americana	Water - willow	2" - 6"	rhizome/plug
Leevsia oryzoides	Rice cutgrass	0 - 2'	seed

Shallow Emergent Marsh cont'd.

Scientific Name	Common Name	Water Depth	Condition/Remarks
Lemna minor	Lesser duckweed	0 - 2'	bushel
Lobelia berlandieri	Berland-Erier	0 - 8"	
Lobelia cardinalis	Cardinal flower	0 - 8"	
Ludwigia palutric	Marsh seedbox	0 - 4"	plug
Marsilea macropoda	Large foot water fern	2" - 6"	rhizome/plug / OBL
Marsilea uncinata	Southern water fern	2" - 6"	OBL
Marsilea vestita	Hairy water fern	2" - 6"	
Mimubus ringins	Allegany monkey-flower	0 - 4"	plug
Muhlenbergia linderheimeri	Lindeimer's muhly	0 - 4"	container
Muhlenbergia mexicana	Mexican muhly	0 - 4"	container
Muhlenbergia racemosa	Green muhly	0 - 4"	container
Najas guadalupensis	Water-naiad	1' - 4'	rhizome/plug
Oenothera texensis	Texas evening primrose	0 - 6"	seed
Osmunda regalis	Royal fern	0 - 6"	Container / OBL
Panicum hemitomon	Maiden-cane	0 - 6"	rhizome
Panicum longifolium	Panic grass	0 - 4"	seed
Panicum virgatum	Switch grass	0 - 4"	seed
Paspalum lividum	Longtom	0 - 4"	seed
Peltandra virginica	Arrow arum	0 - 1'	rhizome
Polygonum (sp.)	Knotweed/ Smartweed	0 - 2'	bushel
Polystichum acrostichoides	Christmas fern	0 - 1"	FACU
Pontederia cordata	Pickerelweed	2" - 1'	rhizome/plug
Potamogeton (sp.)	Pondweed	0 - 2'	bushel
Potamogeton diversifolius	Water thread	0 - 2'	
Potamogeton illinoensis	Shining pondweed	0 - 2'	
Potomogeton nodosus	Long-leaf pondweed	0 - 2'	
Ranunculus flabellaris	Yellow water butter-cup	0 - 1'	plug
Rhynochospora (sp.)	Beakrush	0 - 6"	plugs
Rhynochospora corniculata	Horned Rush	2" - 6"	rhizome/plug
Saggitaria brevirostra	Arrowhead	2" - 6"	
Saggitaria falcata	Arrowhead	2" - 6"	
Saggitaria graminea	Grassy arrowhead	2" - 6"	
Saggitaria lancifolia	Scythe fruit arrowhead	2" - 6"	
Saggitaria longiloba	Longtube arrowhead	2" - 6"	
Saggitaria latifolia	Arrowhead	2" - 1'	rhizome/plug
Saggitaria papillosa	Nipplebract arrowhead	2" - 1'	
Saggitaria platyphylla	Delta arrowhead	2" - 1'	
Scirpus americanus	Three-square (Olney's) bulrush	2" - 6"	rhizome/plug
Scirpus californicus	Giant bulrush	2" - 2'	
Scirpus cyperinus	Woolgrass	0 - 6"	rhizome
Scirpus hallii	Bulrush	2" - 2'	
Scirpus pungens	American bulrush	0 - 18"	
Scirpus validus	Softstem bulrush	1' - 3'	rhizome/plug
Sisyrinchium (sp.)	Blue-eye grass	0 - 6"	seed
Sparganium androcladum	Branching burreed		
Sparganium eupycarpum	Giant burreed	0 - 8"	plugs/container

Shallow Emergent Marsh cont'd.

Scientific Name	Common Name	Water Depth	Condition/Remarks
Thelypteris palustris var. pubescens	Southern marsh fern	0 - 2"	
Typha domingensis	Narrowleaf cattail	0 - 3"	
Xyris difformis	Common yellow-eyed grass	0 - 4"	container
Xyris iridifolia	Iris-leaf yellow-eyed grass	0 - 4"	container

Wet/Mesic Prairie

Scientific Name	Common Name	Water Depth	Condition
Alopecurus caroliniancy	Carolina foxtail	0 (moist soil, poor drainage)	
Andropogon glomeratus	Bushy bluestem	0 (moist soil, poor drainage)	seed
Andropogon gyrans	Elliott beardgrass	0 (moist soil, poor drainage)	
Andropogon ternarius	Silvery beardgrass	0 (moist soil, poor drainage)	
Andropogon virginicus	Broomsedge	0 (moist soil, poor drainage)	
Aristida desmantha	Curly threeawn	0 (moist soil, poor drainage)	
Aristida lanosa	Woolly sheath threeawn	0 (moist soil, poor drainage)	
Aristida purpurea var. purpurea	Purple threeawn	0 (moist soil, poor drainage)	
Aristida purpurescens	Arrow feather threeawn	0 (moist soil, poor drainage)	
Arundinaria gigantea	Giant (southern) cane	0 (moist soil, poor drainage)	FACW
Arundo donax	Giant reed (I)	0 (moist soil, poor drainage)	FAC+
Athyrium filix-femina var. asplenioides	Southern lowland lady fern	0 (moist soil, poor drainage)	FAC+
Carex blanda	Sedge	0 (moist soil, poor drainage)	4" pot
Carex cherokeensis	Cherokee sedge	0 (moist soil, poor drainage)	4" pot/seed
Chasmanthium latifolium	Inland sea oats	0 (moist soil, poor drainage)	seed
Chloris inflata	Swollen windmill grass	0 (moist soil, poor drainage)	FACU
Cooperia drummondii	Rain lily	0 (moist soil, poor drainage)	bulb
Cyperus acuminatus	Short-point flat sedge	0 (moist soil, poor drainage)	seed/plug
Dichanthelium spicata	Coastal saltgrass (saline)	0 (moist soil, poor drainage)	
Dichanthelium oligosanthes var. scribnerianum	Scribners Rosette grass	0 (moist soil, poor drainage)	
Dichanthelium stricata	Inland saltgrass (saline)	0 (moist soil, poor drainage)	
Elymus canadensis	Canada wildrye	0 (moist soil, poor drainage)	seed
Elymus virginicus	Virginia wildrye	0 (moist soil, poor drainage)	seed
Eragrostis capillaris	Lace grass	0 (moist soil, poor drainage)	
Eriochloa sericea	Texas cupgrass	0 (moist soil, poor drainage)	
Erioneuron pilosum	Hairy woolgrass	0 (moist soil, poor drainage)	
Eupatorium greggi	Gregg's mist flower	0 (moist soil, poor drainage)	4" pot
Eupatorium perfoliatum	Common boneset	0 (moist soil, poor drainage)	seed
Glyceria septentrionalis	Eastern mannagrass	0 (moist soil, poor drainage)	
Helianthus angustifolius	Swamp sunflower	0 (moist soil, poor drainage)	seed
Leersia hexandra	Clubhead cutgrass	0 (moist soil, poor drainage)	
Leersia lenticularis	Catchfly grass	0 (moist soil, poor drainage)	
Leersia monandra	Bunchgrass	0 (moist soil, poor drainage)	
Leersia oryzoides	Rice cutgrass (endangered)	0 (moist soil, poor drainage)	
Leersia virginica	White grass	0 (moist soil, poor drainage)	
Leptochloa dubia	Green sprangletop	0 (moist soil, poor drainage)	
Leptochloa fascicularis	Bended sprangletop	0 (moist soil, poor drainage)	

Wet/Mesic Prairie cont'd.

Scientific Name	Common Name	Water Depth	Condition
Monanthochloe littoralis	Shoregrass (saltgrass) (saline)	0 (moist soil, poor drainage)	
Muhlenbergia capillaris	Gulf Coast muhly	0 (moist soil, poor drainage)	seed
Muhlenbergia lindhiemeri	Lindhiemer's muhly	0 (moist soil, poor drainage)	4" pot/seed
Neeragrostis reptans	Creeping lovegrass	0 (moist soil, poor drainage)	
Osmunda cinnamomea	Cinnamon fern	0 (moist soil, poor drainage)	FAW
Panicum virgatum	Switchgrass	0 (moist soil, poor drainage)	seed
Paspalum fluitans	Winter paspalum	0 (moist soil, poor drainage)	
Paspalum dissectum	Mudbank paspalum	0 (moist soil, poor drainage)	
Penstemon tenuis	Gulf Coast penstemon	0 (moist soil, poor drainage)	seed
Poa arachnifera	Texas bluegrass	0 (moist soil, poor drainage)	
Polystichum acrostichoides	Christmas fern	0 (moist soil, poor drainage)	FACU
Ruellia brittonia	Mexican petunia	0 (moist soil, poor drainage)	4" pot
Salvia lyrata	Lyre-leaf sage	0 (moist soil, poor drainage)	seed
Salvia uliginosa	Bog sage	0 (moist soil, poor drainage)	4" pot
Schizachyrium scoparium	Little bluestem	0 (moist soil, poor drainage)	seed
Setaria magna	Giant bristlegrass	0 (moist soil, poor drainage)	
Sorghastrum nutan	Indiangrass	0 (moist soil, poor drainage)	Seed / FACW
Sporobolus sp.	Dropseed	0 (moist soil, poor drainage)	FAC/FACW+
Thelypteris kunthii	Southern shield fern	0 - 2"	FAC
Tridens albescens	White tridens	0 (moist soil, poor drainage)	seed
Tridens flavus	Purple top	0 (moist soil, poor drainage)	seed
Tripsacum dactyloides	Eastern gama grass	0 (moist soil, poor drainage)	seed
Trisetum interruptum	Prairie trisetum	0 (moist soil, poor drainage)	
Vallisneria americana	American wild celery	0 (moist soil, poor drainage)	
Woodwardia arevlata	Chain fern	0 - 2"	FACW
Zizamiopsis miliacea	Marsh millet	0 (moist soil, poor drainage)	

Dry Prairie Grass & Wildflower

Scientific Name	Common Name	Water Depth	Quantity/Condition
Andropogon gerardii	Big bluestem	0	seed
Aster subulatus	Annual aster	0	seed
Aster texanus	Texas aster	0	seed
Bifora americana	Prairie bishop's weed	0	seed
Bothriochloa barbinodis var. barbinodis	Cane beardgrass	0	
Bouteloua curtipendula	Sideoats grama	0	seed
Bouteloua curtipendula var. curtipendula	Tall grama	0	
Bouteloua dactyloides	Buffalograss	0	
Bouteloua gracilis	Blue grama	0	seed
Bouteloua hirsuta	Hairy grama	0	
Bouteloua trifida	Red grama	0	
Bouteloua texana	Texas millet	0	
Bouteloua texensis	Texas brome	0	
Buchloe dactyloides	Buffalograss	0	seed
Castilleja indivisa	Texas paintbrush	0	seed
Chasmanthium latifolia	Broadleaf woodoats	0	
Claytonia virginica	Springbeauty	0	seed or corm

Dry Prairie Grass & Wildflower cont'd.

Scientific Name	Common Name	Water Depth	Quantity/ Condition
Coreopsis tinctoria	Plains coreopsis	0	seed
Cyrtomium falcatum	Asian holly fern	0	UPL
Echinacea sanguinea	Purple coneflower	0	seed
Eragrostis (sp.)	Sand lovegrass	0	seed
Euphorbia bicolor	Snow-on-the-prairie	0	seed/packet
Gaillardia pulchella	Indian blanket	0	seed
Hymenoxys scaposa	Plains yellow daisy	0	seed
Liatris mucronata	Narrow-leaf gayfeather	0	seed
Liatris squarrosa	Blazing star	0	seed
Lupinus texensis	Bluebonnet	0	seed
Monarda citriodora	Lemon mint	0	seed
Monarda lindheimeri	Lindheimer Beebalm	0	seed/packet
Oenothera speciosa	Evening primrose	0	seed/packet
Panicum virgatum	Alamo switchgrass	0	seed
Rudbeckia amplexicaulis	Clasping coneflower	0	seed
Rudbeckia hirta	Black-eyed Susan	0	seed
Schizachyrium scoparius	Little bluestem	0	seed
Sisyrinchium pruinosum	Dotted blue-eyed grass	0	seed
Sorghastrum nutans	Indiangrass	0	seed
Thelesperma (sp.)	Greenthread	0	seed
Tripsacum dactyloides	Eastern gama grass	0	seed
Verbena bipinnatifida	Prairie verbena	0	seed

Trees and Shrubs

Scientific Name	Common Name	Water Depth	Condition
Callicarpa americana	American beautyberry	0	1 gal
Carya aquatica	Water hickory	0 - 6"	15 gal
Cephalanthus occidentalis	Common buttonbush	0 - 1'	1 gal
Cornus drummondii	Roughleaf dogwood	0	5 gal
Crataegus marshallii	Parsley hawthorn	0	10 gal
Forestiera acuminata	Swamp privet	0 - 1"	containers
Fraxinus texensis	Texas ash	0	5 gal
Ilex verticillata	Winterberry	0 - 6"	containers
Ilex vomitoria	Yaupon holly	0	5 gal
Liquidambar styraciflua	Sweetgum	0" - 6"	15 gal
Myrica cerifera	Wax myrtle	0" - 6"	1 gal
Prunus mexicana	Mexican plum	0	10 gal
Quercus laurifolia	Laurel oak	0 - 1'	15 gal/ Acorn
Quercus lyrata	Overcup oak	0 - 1'	15 gal
Quercus michauxii	Swamp chestnut oak	0 - 6"	5 gal
Quercus nigra	Water oak	0 - 6"	5 gal
Quercus nuttallii	Nuttall oak	0 - 8"	15 gal
Quercus phellos	Willow oak	0 - 6"	5 gal/Acorn
Salix nigra	Black willow	0 - 6"	B & B
Rhus lanceolata	Flame leaf sumac	0	5 gal
Taxodium distichum	Bald cypress	0 - 6"	5 gal

ABBREVIATION	INDICATOR	DESCRIPTION
OBL	Obligate wetland	Occur almost (est. prob. > 99%) under natural conditions in wetlands.
FACW	Facultative wetland	Usually occur in wetlands (est. prob. 76-99%), but occasionally found in nonwetlands.
FAC	Facultative	Equally likely to occur in wetlands or nonwetlands (est. prob. 34-66%).
FACU	Facultative upland	Usually occur in nonwetlands (est. prob. 67-99%), but occasionally found in wetlands (e.p. 1-33%).
UPL	Obligate upland	Occur in wetlands in another region, but occur almost always (e.p. > 99%) under natural conditions in nonwetlands.

APPENDIX F

ACRONYMS AND TERMS

ACRONYMS AND TERMS

Agencies:

Austin DEP	Austin Department of Environmental Protection
COH	City of Houston
EPA, USEPA	Environmental Protection Agency
Florida DER	Florida Department of Environmental Regulation
GBNEP	Galveston Bay National Estuary Program
HC	Harris County
HCFCD	Harris County Flood Control District
Joint Task Force	Harris County/Harris County Flood Control District and City of Houston Storm Water Management Joint Task Force
LCRA	Lower Colorado River Authority
Minnesota PCA	Minnesota Pollution Control Agency
MWCOG	Metropolitan Washington Council of Governments
TAEX	Texas Agricultural Extension Service
TPDES	Texas Pollutant Discharge Elimination System
TNRCC	Texas Natural Resource Conservation Commission (formerly Texas Water Commission)
TWC	Texas Water Commission
TxDOT	Texas Department of Transportation
Wisconsin DNR	Wisconsin Department of Natural Resources
WSDOE	Washington State Department of Ecology

General Acronyms:

BMP	Best Management Practice
CWA	Clean Water Act
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NOI	Notice of Intent
NOT	Notice of Termination
PPP	Pollution Prevention Plan
SPCC	Spill Prevention Control and Countermeasure (Plan)
SWMP	Storm Water Management Program
SWPPP	Storm Water Pollution Prevention Plan
SWQMP	Storm Water Quality Management Plan
TAC	Technical Advisory Committee to the Joint Task Force

Terms:

backwater	The elevated upstream water surface profile caused by a downstream control structure such as a weir or dam.
capture volume	The storm water volume retained for treatment in a permanent pool.
design runoff	The first 0.5 inch (1/2 inch) of runoff from a drainage area. This is equal to 1,800 cubic feet per drained acre.
developed area	Land improved for urban use.
drainage basin	See drainage area.
drainage area	Area that is tributary to a storm water discharge point.
drained area	See drainage area.
effective depth	The depth of the water pond that is contained in the effective volume of a water quality basin.
effective volume	The volume of a water quality basin that provides actual storage for storm water runoff. The effective volume is usually less than the total volume of a basin. (See "total volume").
impervious cover	Impervious cover includes surfaces such as buildings, pavement, and some natural surfaces of impermeable rocks that prevent infiltration of rainfall into the ground.
first flush	See design runoff.
municipal separate storm sewer system	A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains): (i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the United States; (ii) Designed or used for collecting or conveying storm water; (iii) Which is not a combined sewer; and (iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.

Terms, ***continued*****:**

non-structural control	A design feature or practice which minimizes contact between storm water and pollutants.
oil/grit separator	See "water quality inlet."
practicable	That which can be feasibly done. See also reasonably attainable.
qualified inspector	A person who is qualified by experience or training to inspect and report on a best management practice, and to specify remedial action for maintenance.
reasonably attainable	That which can be achieved; economically attainable. See also practicable.
regulations	Refers to rules and laws of the United States government, the State of Texas, and to rules, laws, and ordinances to be established by the City of Houston and Harris County to implement water quality controls for storm water runoff.
residential area, existing	An existing residential land use.
residential area, new	A proposed conversion of land to residential use.
structural control	A design feature to capture storm water runoff for settling, filtration, infiltration, biological processing, or other treatment before release into the storm water conveyance system.
tail water	See "backwater."
temporary aboveground storage	A portable tank or other non-permanent aboveground storage.
tight-lined	Directly connected by pipe to the storm water conveyance system.
total volume	For water quality basins, the total volume excavated, including the effective volume and overlying soils.
water quality inlet	Catchment facility which processes storm water runoff from a storm sewer inlet, typically involving separation of oil and grit from water. Also known as "oil/grit separator."
watershed	See drainage area.
wetland	An area that is typically inundated with surface or groundwater and that support plants adapted to saturated soil conditions.
wet pond	A wet pond is a storm water control structure providing both retention and treatment of storm water runoff.

APPENDIX G

REFERENCES

REFERENCES

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