Chapter 6: Performance Criteria

This chapter outlines performance criteria for five groups of structural stormwater management practices (SMPs) to meet water quality treatment goals. These include ponds, wetlands, infiltration practices, filtering systems and open channels. Each set of SMP performance criteria, in turn, is based on six performance goals:

Feasibility

Identify site considerations that may restrict the use of a practice.

Conveyance

Convey runoff to the practice in a manner that is safe, minimizes erosion and disruption to natural channels, and promotes filtering and infiltration.

Pretreatment

Trap coarse elements before they enter the facility, thus reducing the maintenance burden and ensuring a long-lived practice.

Treatment Geometry

Provide water quality treatment, through design elements that provide the maximum pollutant removal as water flows through the practice.

Environmental/Landscaping

Reduce secondary environmental impacts of facilities through features that minimize disturbance of natural stream systems and comply with environmental regulations. Provide landscaping that enhances the pollutant removal and aesthetic value of the practice.

Maintenance

Maintain the long-term performance of the practice through regular maintenance activities, and through design elements that ease the maintenance burden.

Cold climate regions of New York State may present special design considerations. Each section includes a summary of possible design modifications that address the primary concerns associated with the use of that SMP in cold climates. A more detailed discussion of cold climate modifications can be found in the publication *Stormwater BMP Design Supplement for Cold Climates* (Caraco & Claytor, 1997). In addition, Appendix I of this manual provides some sizing examples that incorporate cold climate design.

IMPORTANT NOTES:

ANY PRACTICE THAT CREATES A DAM IS REQUIRED TO FOLLOW THE GUIDANCE PRESENTED IN THE *GUIDELINES FOR DESIGN OF DAMS* (APPENDIX A) AND MAY REQUIRE A PERMIT FROM THE NYSDEC. FOR THE MOST RECENT COPY OF THIS DOCUMENT, CONTACT THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, DAM SAFETY SECTION. AN EVALUATION OF HAZARD CLASSIFICATION MUST BE INCLUDED IN THE DESIGN REPORT FOR STORMWATER PONDS OR WETLANDS CREATED BY A DAM.

THIS CHAPTER FOLLOWING TEXT PRESENTS CRITERIA IN TWO PARTS. DESIGN GUIDELINES ARE FEATURES THAT ENHANCE PRACTICE PERFORMANCE, BUT MAY NOT BE NECESSARY FOR ALL APPLICATIONS. REQUIRED ELEMENTS ARE FEATURES THAT SHOULD BE USED IN ALL APPLICATIONS. A FACT SHEET AT THE BACK OF EACH SECTION HIGHLIGHTS THE REQUIRED ELEMENTS.

APPENDICES F AND G PROVIDE EXAMPLE CHECKLISTS FOR THE CONSTRUCTION AND OPERATION&MAINTENANCE OF EACH OF THE PRACTICE TYPES.

Section 6.1 Stormwater Ponds

Stormwater ponds are practices that have either a permanent pool of water, or a combination of a permanent pool and extended detention, and some elements of a shallow marsh equivalent to the entire WQ_v. Five design variants include:

- P-1 Micropool Extended Detention Pond (Figure 6.1)
- P-2 Wet Pond (Figure 6.2)
- P-3 Wet Extended Detention Pond (Figure 6.3)
- P-4 Multiple Pond System (Figure 6.4)

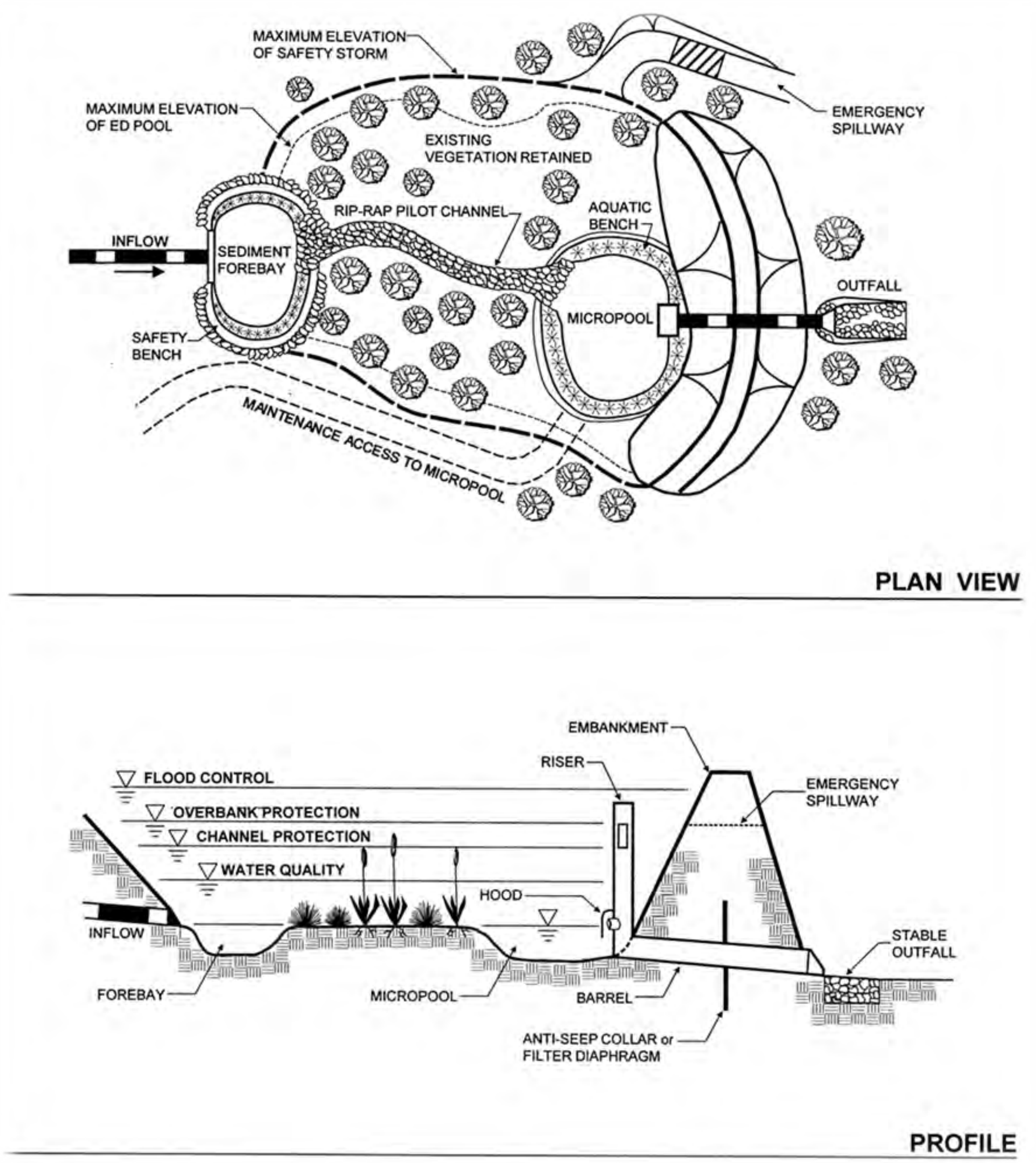
- P-5 Pocket Pond (Figure 6.5)

Treatment Suitability:

Dry extended detention ponds without a permanent pool are not considered an acceptable option for meeting water quality treatment goals. Each of the five stormwater pond designs can be used to provide channel protection volume as well as overbank and extreme flood attenuation. The term "pocket" refers to a pond or wetland that has such a small contributing drainage area that little or no baseflow is available to sustain water elevations during dry weather. Instead, water elevations are heavily influenced, and in some cases maintained, by a locally high water table.

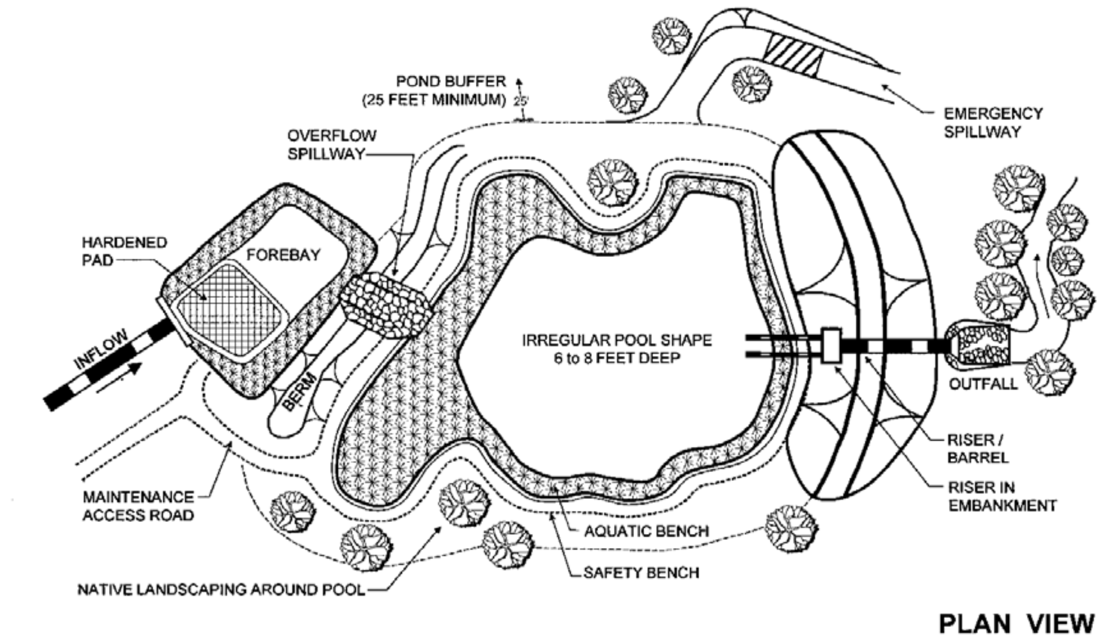
IMPORTANT NOTES
WHILE THE STORMWATER PONDS DESIGNED ACCORDING TO THIS GUIDANCE MAY ACT AS A COMMUNITY AMMENITY, AND MAY PROVIDE SOME HABITAT VALUE, THEY CANNOT BE ANTICIPATED TO FUNCTION AS NATURAL LAKES OR PONDS.

Figure 6.1 Micropool Extended Detention Pond (P-1)



Figure

Figure 6.2 Wet Pond (P-2)



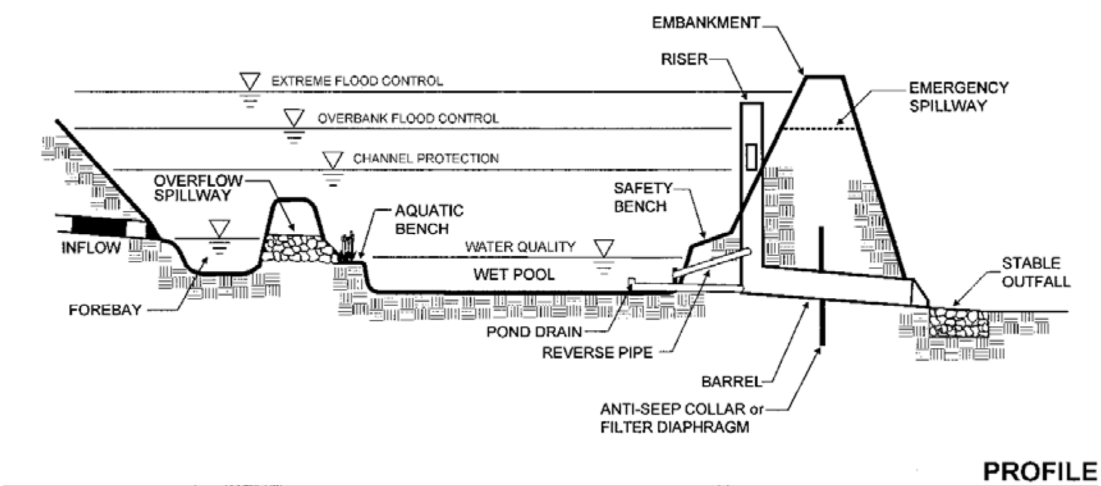
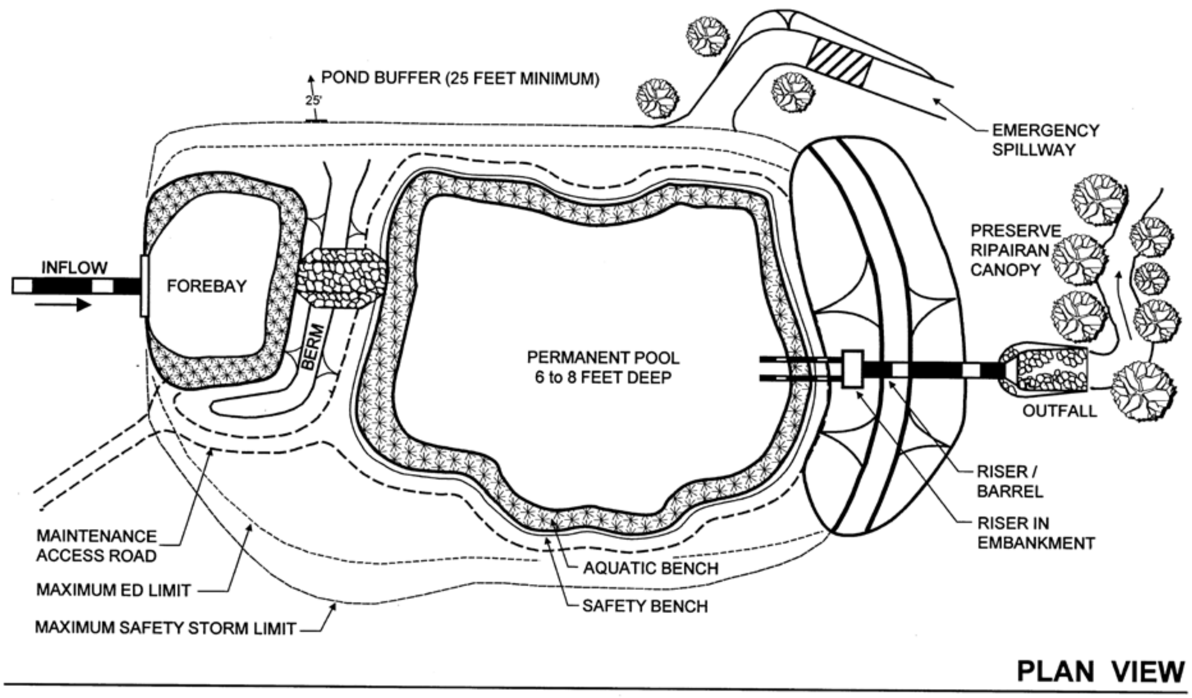


Figure 6.3 Wet Extended Detention Pond (P-3)



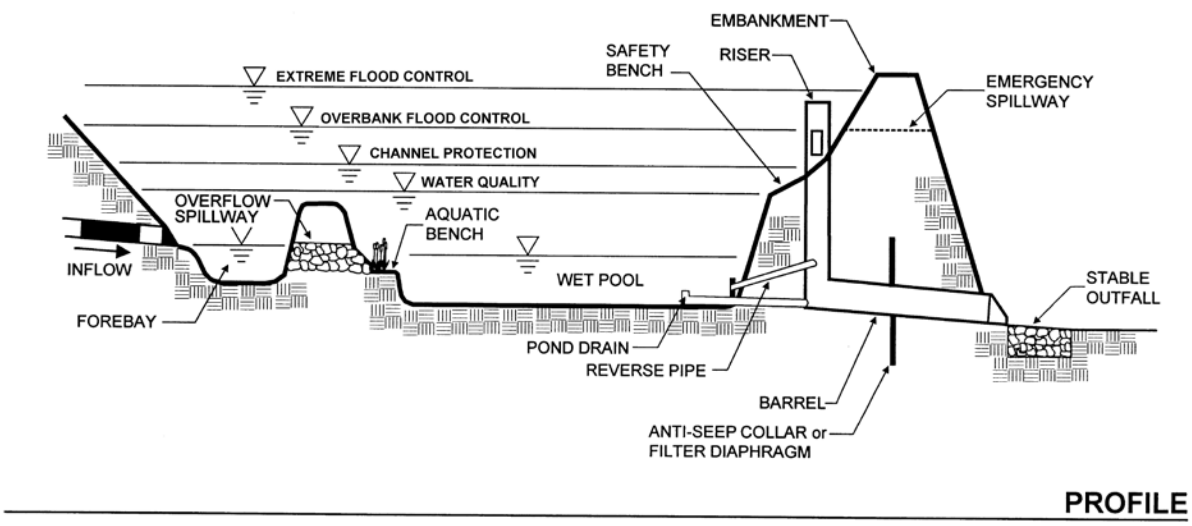


Figure 6.4 Multiple Pond System (P-4)

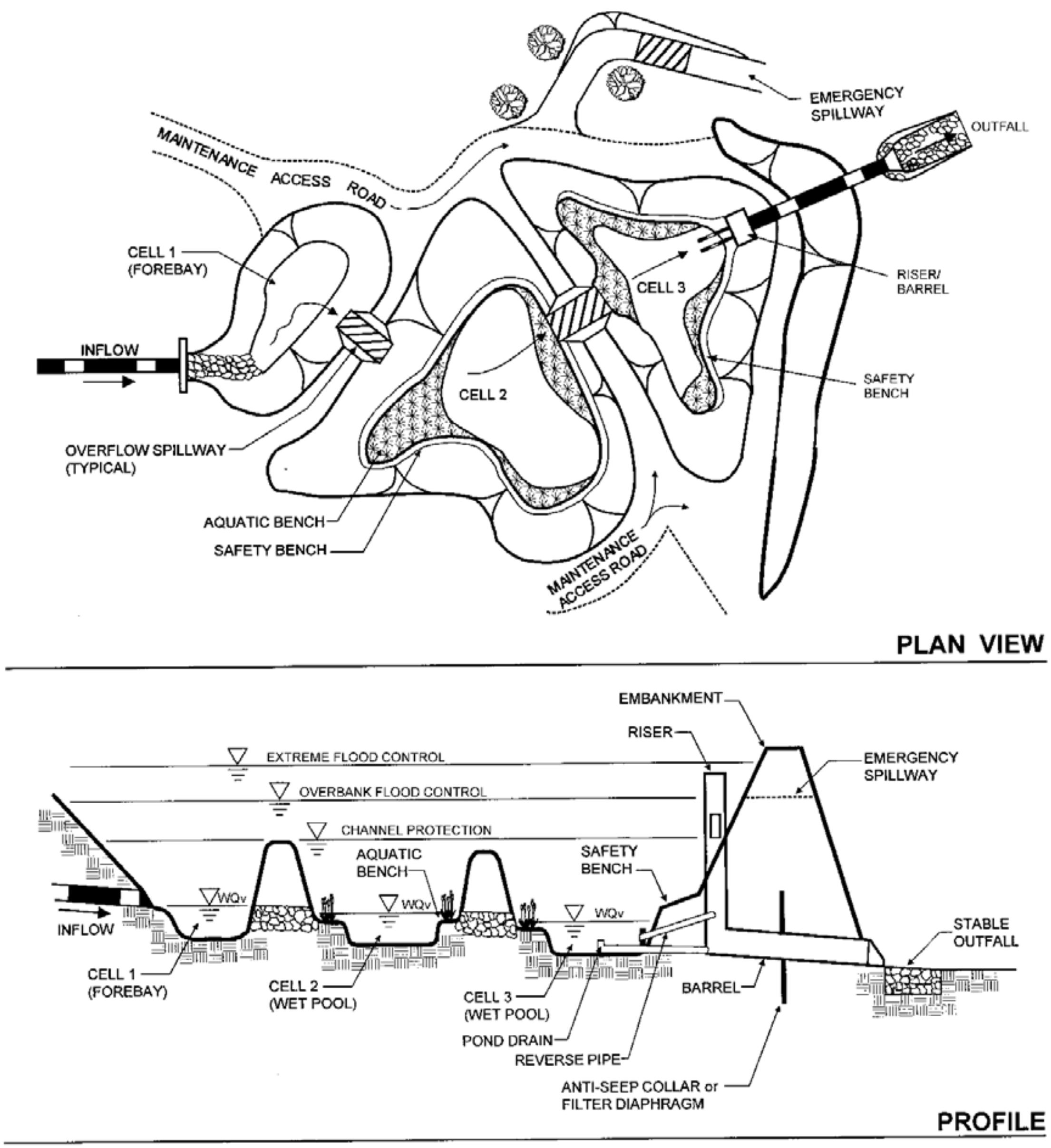
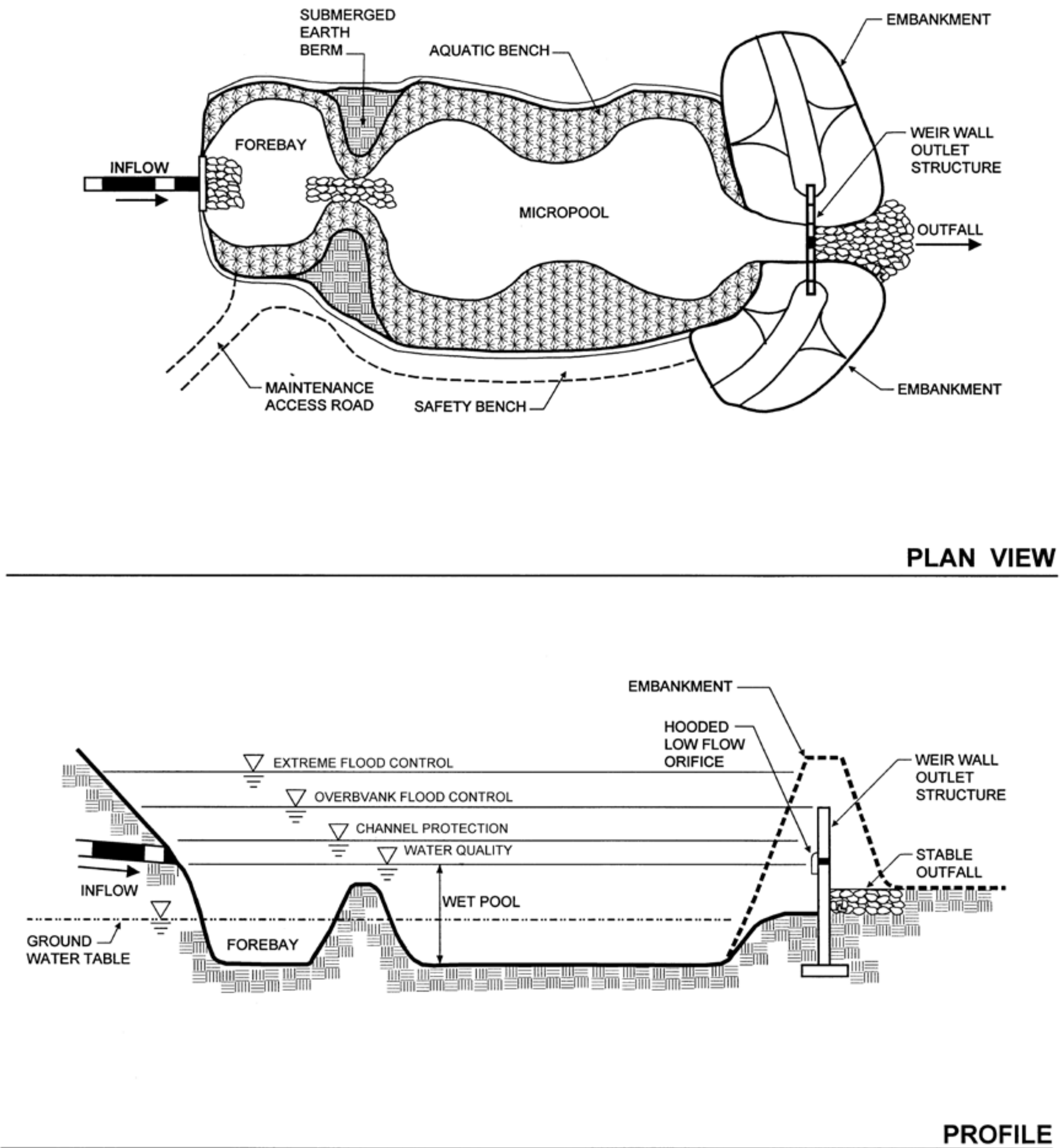


Figure 6.5 Pocket Pond (P-5)



6.1.1 Feasibility

Required Elements

- Stormwater ponds shall not be located within jurisdictional waters, including wetlands.
- Evaluate the site to determine the Hazard Class, and to determine what design elements are required to ensure dam safety (see Guidelines for Design of Dams). For the most recent copy of this document, contact the New York State Department of Environmental Conservation, Dam Safety Division, at: 518-402-8151.
- Avoid direction of hotspot runoff to design P-5.
- Provide a 2' minimum separation between the pond bottom and groundwater in sole source aquifer recharge areas.

Design Guidance

- Designs P-2, P-3, and P-4 should have a minimum contributing drainage area of 25 acres. A 10-acre drainage is suggested for design P-1.
- The use of stormwater ponds (with the exception of design P-1, Micropool Extended Detention Pond) on trout waters is strongly discouraged, as available evidence suggests that these practices can increase stream temperatures.
- Avoid location of pond designs within the stream channel, to prevent habitat degradation caused by these structures.
- A maximum drainage area of five acres is suggested for design P-5.

6.1.2 Conveyance

Inlet Protection

Required Elements

- A forebay shall be provided at each pond inflow point, unless an inflow point provides less than 10% of the total design storm flow to the pond.

Design Guidance

- Inlet areas should be stabilized to ensure that non-erosive conditions exist for at least the 2-year frequency storm event.
- Except in cold regions of the State, the ideal inlet configuration is a partially submerged (i.e., ½ full) pipe.

Adequate Outfall Protection

Required Elements

- The channel immediately below a pond outfall shall be modified to prevent erosion and conform to natural dimensions in the shortest possible distance, typically by use of appropriately-sized riprap placed over filter cloth. Typical examples include submerged earthen berms, concrete weirs, and gabion baskets.
- A stilling basin or outlet protection shall be used to reduce flow velocities from the principal spillway to non-erosive velocities (3.5 to 5.0 fps). (See Appendix L for a table of erosive velocities for grass and soil).

Design Guidance

- Outfalls should be constructed such that they do not increase erosion or have undue influence on the downstream geomorphology of the stream.
- Flared pipe sections that discharge at or near the stream invert or into a step-pool arrangement should be used at the spillway outlet.
- If a pond daylights to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a forested riparian zone in the shortest possible distance. Excessive use of riprap should be avoided to reduce stream warming.

Pond Liners

Design Guidance

- When a pond is located in gravelly sands or fractured bedrock, a liner may be needed to sustain a permanent pool of water. If geotechnical tests confirm the need for a liner, acceptable options include: (a) six to 12 inches of clay soil (minimum 50% passing the #200 sieve and a maximum permeability of 1×10^{-5} cm/sec), (b) a 30 mm poly-liner (c) bentonite, (d) use of chemical additives (*see NRCS Agricultural Handbook No. 386*, dated 1961, or *Engineering Field Manual*) or (e) a design prepared by a Professional Engineer registered in the State of New York.

6.1.3 Pretreatment

Required Elements

- A sediment forebay is important for maintenance and longevity of a stormwater treatment pond. Each pond shall have a sediment forebay or equivalent upstream pretreatment. The forebay shall consist of a separate cell, formed by an acceptable barrier. Typical examples include earthen berms, concrete weirs, and gabion baskets.
- The forebay shall be sized to contain 10% of the water quality volume (WQ_v), and shall be four to six feet deep. The forebay storage volume counts toward the total WQ_v requirement.
- The forebay shall be designed with non-erosive outlet conditions, given design exit velocities.
- Direct access for appropriate maintenance equipment shall be provided to the forebay.

- In sole source aquifers, 100% of the WQ_v for stormwater runoff from designated hotspots shall be provided in pretreatment.

Design Guidance

- A fixed vertical sediment depth marker should be installed in the forebay to measure sediment deposition over time.
- The bottom of the forebay may be hardened to ease sediment removal

6.1.4 Treatment

Minimum Water Quality Volume (WQv)

Required Elements

- Provide water quality treatment storage to capture the computed WQ_v from the contributing drainage area through a combination of permanent pool, extended detention (WQ_v-ED) and marsh. The division of storage into permanent pool and extended detention is outlined in Table 6.1.
- Although both CP_v and WQ_v-ED storage can be provided in the same practice, WQ_v cannot be met by simply providing Cp_v storage for the one-year storm.

Table 6.1 Water Quality Volume Distribution in Pond Designs

Design Variation	%WQv	
	Permanent Pool	Extended Detention
P-1	20% min.	80% max.
P-2	100%	0%
P-3	50% min.	50% max.
P-4	50% min.	50% max.
P-5	50% min.	50% max.

Design Guidance

- It is generally desirable to provide water quality treatment off-line when topography, hydraulic head and space permit (i.e., apart from stormwater quantity storage; see Appendix K for a schematic).
- Water quality storage can be provided in multiple cells. Performance is enhanced when multiple treatment pathways are provided by using multiple cells, longer flowpaths, high surface area to volume ratios, complex microtopography, and/or redundant treatment methods (combinations of pool, ED, and marsh).

Minimum Pond Geometry

Required Elements

- The minimum length to width ratio for the pond is 1.5:1 (i.e., length relative to width).
- Provide a minimum Surface Area:Drainage Area of 1:100.

Design Guidance

- To the greatest extent possible, maintain a long flow path through the system, and design ponds with irregular shapes.

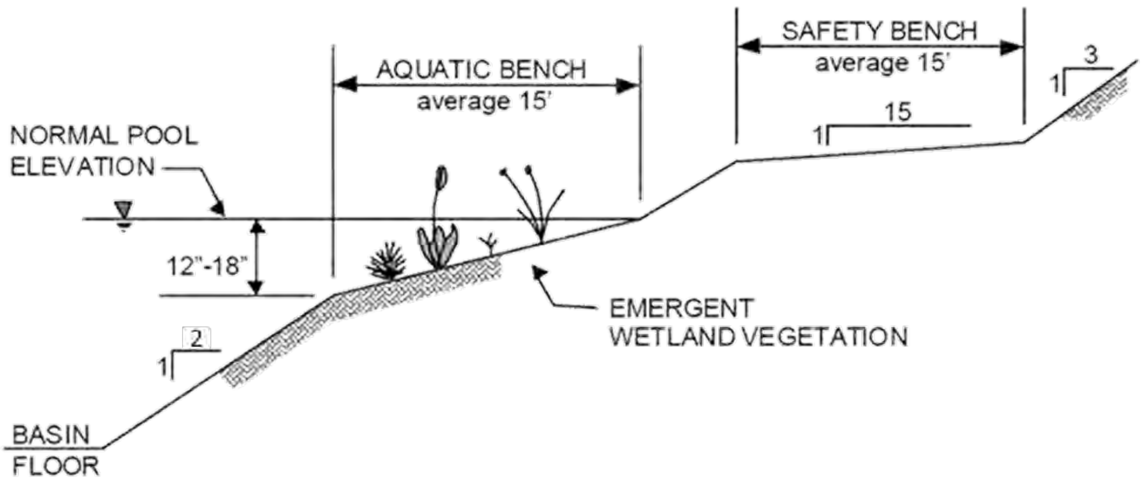
6.1.5 Landscaping

Pond Benches

Required Elements

- The perimeter of all deep pool areas (four feet or greater in depth) shall be surrounded by two benches:
  - Except when pond side slopes are 4:1 (h:v) or flatter, provide a safety bench that generally extends 15 feet outward (10’ to 12’ allowable on sites with extreme space limitations) from the normal water edge to the toe of the pond side slope. The maximum slope of the safety bench shall be 6%.
  - Incorporate an aquatic bench that generally extends up to 15 feet inward from the normal shoreline, has an irregular configuration, and a maximum depth of 18 inches below the normal pool water surface elevation. The slope proceeding from the aquatic bench to the pond basin floor *shall* not exceed 2:1 (h:v).

Figure 6.6 Slope diagram for Pond Benches



Landscaping Plan

<u>Required Elements</u>

- A landscaping plan for a stormwater pond and its buffer shall be prepared to indicate how aquatic and terrestrial areas will be vegetatively stabilized and established.
- Aquatic vegetation must be established in the aquatic and safety benches before the Pond is rendered in-service.

<u>Design Guidance</u>

- Wherever possible, wetland plants should be encouraged in a pond design, either along the aquatic bench (fringe wetlands), the safety bench and side slopes (ED wetlands) or within shallow areas of the pool itself.
- The best elevations for establishing wetland plants, either through transplantation or volunteer colonization, are within six inches (plus or minus) of the normal pool.
- The soils of a pond buffer are often severely compacted during the construction process to ensure stability. The density of these compacted soils is so great that it effectively prevents root penetration, and therefore, may lead to premature mortality or loss of vigor. Consequently, it is advisable to excavate large and deep holes around the proposed planting sites, and backfill these with uncompacted topsoil.
  - As a rule of thumb, planting holes should be three times deeper and wider than the diameter of the rootball (of balled and burlap stock), and five times deeper and wider for container grown stock. This practice should enable the stock to develop unconfined root systems. Avoid species that require full shade, are susceptible to winterkill, or are prone to wind damage. Extra mulching around the

base of the tree or shrub is strongly recommended as a means of conserving moisture and suppressing weeds.

Pond Buffers and Setbacks

Required Elements

- A pond buffer shall be provided that extends 25 feet outward from the maximum water surface elevation of the pond. The pond buffer shall be contiguous with other buffer areas that are required by existing regulations (e.g., stream buffers). An additional setback may be provided to permanent structures.
- Woody vegetation may not be planted or allowed to grow within 15 feet of the toe of the embankment and 25 feet from the principal spillway structure.

Design Guidance

- Existing trees should be preserved in the buffer area during construction. It is desirable to locate forest conservation areas adjacent to ponds. To help discourage resident geese populations, the buffer can be planted with trees, shrubs and native ground covers.
- Annual mowing of the pond buffer is only required along maintenance rights-of-way and the embankment. The remaining buffer can be managed as a meadow (mowing every other year) or forest.

6.1.6 Maintenance

Required Elements

- Maintenance responsibility for a pond and its buffer shall be vested with a responsible authority by means of a legally binding and enforceable maintenance agreement that is executed as a condition of plan approval.
- The principal spillway shall be equipped with a removable trash rack, and generally accessible from dry land.
- Sediment removal in the forebay shall occur every five to six years or after 50% of total forebay capacity has been lost.
- All required safety elements must be inspected and maintained on an annual basis, unless prior inspections indicate more frequent maintenance is required.
- All required maintenance elements must be included in a comprehensive operation and maintenance plan.

Design Guidance

- Sediments excavated from stormwater ponds that do not receive runoff from designated hotspots are generally not considered toxic or hazardous material, and can be safely disposed by either land application or land filling. Sediment testing may be required prior to sediment disposal when a hotspot land use is present (see Section 4.8 for a list of potential hotspots).

- Sediment removed from stormwater ponds should be disposed of according to an approved comprehensive operation and maintenance plan.

Maintenance Access

Required Elements

- A maintenance right of way or easement shall extend to the pond from a public or private road.

Design Guidance

- Maintenance access should be at least 12 feet wide, have a maximum slope of no more than 15%, and be appropriately stabilized to withstand maintenance equipment and vehicles.
- The maintenance access should extend to the forebay, safety bench, riser, and outlet and be designed to allow vehicles to turn around.

Non-clogging Low Flow Orifice

Required Elements

- A low flow orifice shall be provided, with the size for the orifice sufficient to ensure that no clogging shall occur. (See Appendix K for details of a low flow orifice and trash rack options).

Design Guidance

- The low flow orifice should be adequately protected from clogging by either an acceptable external trash rack (recommended minimum orifice of 3") or by internal orifice protection that may allow for smaller diameters (recommended minimum orifice of 1").
- The preferred method is a submerged reverse-slope pipe that extends downward from the riser to an inflow point one foot below the normal pool elevation.
- Alternative methods are to employ a broad crested rectangular, V-notch, or proportional weir, protected by a half-round CMP that extends at least 12 inches below the normal pool.

The use of horizontally extended perforated pipe protected by geotextile fabric and gravel is not recommended. Vertical pipes may be used as an alternative if a permanent pool is present.

Riser in Embankment

Required Elements

- The riser shall be located within the embankment for maintenance access, safety and aesthetics.

Design Guidance

- Access to the riser should be provided by lockable manhole covers, and manhole steps within easy reach of valves and other controls. The principal spillway opening should be "fenced" with pipe or rebar at 8-inch intervals (for safety purposes).

Pond Drain

Required Elements

- Except where local slopes prohibit this design, each pond shall have a drain pipe that can completely or partially drain the pond. The drain pipe shall have an elbow or protected intake within the pond to prevent sediment deposition, and a diameter capable of draining the pond within 24 hours.

Design Guidance

- Care should be exercised during pond drawdowns to prevent rapid drawdown and minimize downstream discharge of sediments or anoxic water. The approving jurisdiction should be notified before draining a pond.

Adjustable Gate Valve

Required Elements

- Both the WQv-ED outlet and the pond drain shall be equipped with an adjustable gate valve (typically a handwheel activated knife gate valve). A gate valve is not required if the WQv is discharged through a weir.
- Valves shall be located inside of the riser at a point where they (a) will not normally be inundated and (b) can be operated in a safe manner.

Design Guidance

- Both the WQv-ED pipe and the pond drain should be sized one pipe size greater than the calculated design diameter.
- To prevent vandalism, the handwheel should be chained to a ringbolt, manhole step or other fixed object.

Safety Features

Required Elements

- Side slopes to the pond shall not exceed 3:1 (h:v), and shall terminate at a safety bench.
- Side slope proceeding from aquatic bench to pond basin floor shall not exceed 2:1 (h:v).
- Both the safety bench and the aquatic bench must be landscaped to prevent access to the deep pool. The vegetation must be established before pond is rendered in-service.

- Warning signs must be posted prohibiting swimming, wading, and skating, warning of possible contamination or pollution of pond water, and indicating maximum depth of pond.
- The principal spillway opening shall not permit access by small children, and endwalls above pipe outfalls greater than 48 inches in diameter shall be fenced to prevent a hazard.
- When the pond slope requirements or any other required safety feature cannot be met perimeter fencing is required at or above the maximum water surface level provided that all required maintenance can still be performed.

6.1.7 Cold Climate Pond Design Considerations

Inlets, outlet structures and outfall protection for pond systems require modifications to function well in cold climates. Among the problems those wishing to use stormwater ponds in cold climates may encounter are:

- Higher runoff volumes and increased pollutant loads during the spring melt
- Pipe freezing and clogging
- Ice formation on the permanent pool
- Road sand build-up

<u>Higher runoff volumes and increased pollutant loads during the spring melt</u>

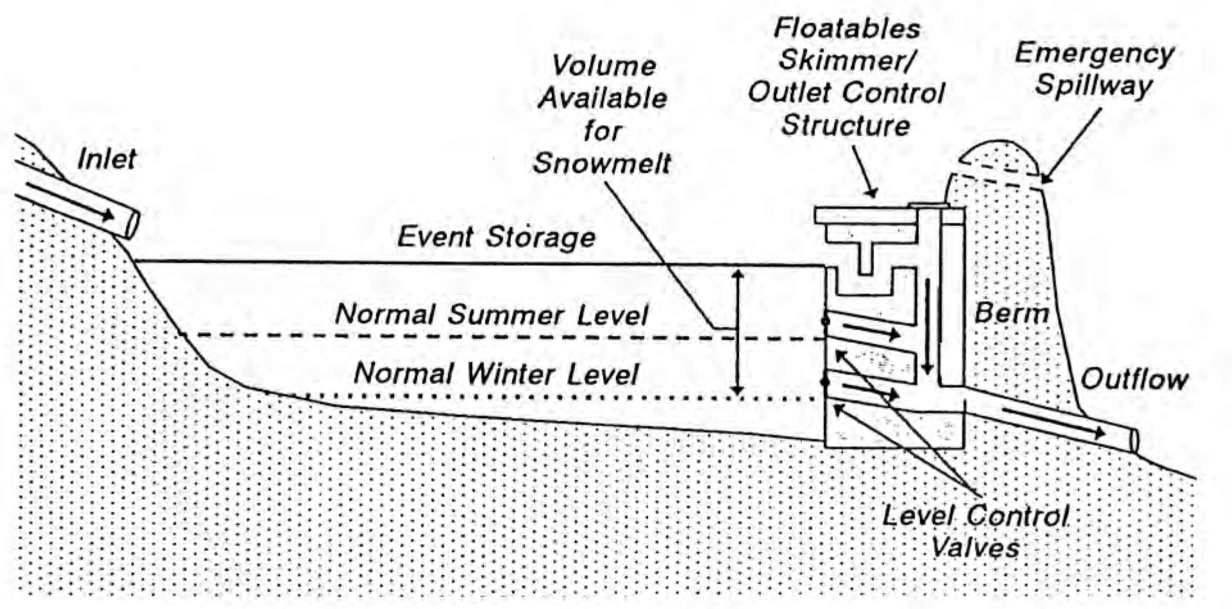
- Operate the pond based on seasonal inputs by adjusting dual water quality outlets to provide additional storage (see Figure 6.6).
- Adapt sizing based on snowmelt characteristics (see Appendix I).
- Do not drain ponds during the spring season. Due to temperature stratification and high chloride concentrations at the bottom, the water may become highly acidic and anoxic and may cause negative downstream effects.

<u>Pipe Freezing and Clogging</u>

- Inlet pipes should not be submerged, since this can result in freezing and upstream damage or flooding.
- Bury all pipes below the frost line to prevent frost heave and pipe freezing. Bury pipes at the point furthest from the pond deeper than the frost line to minimize the length of pipe exposed.
- Increase the slope of inlet pipes to a minimum of 1% to prevent standing water in the pipe, reducing the potential for ice formation. This design may be difficult to achieve at sites with flat local slopes.
- If perforated riser pipes are used, the minimum orifice diameter should be ½". In addition, the pipe should have a minimum 6" diameter.

- When a standard weir is used, the minimum slot width should be 3", especially when the slot is tall.
- Baffle weirs can prevent ice formation near the outlet by preventing surface ice from blocking the inlet, encouraging the movement of baseflow through the system (see Appendix K).
- In cold climates, riser hoods and reverse slope pipes should draw from at least 6" below the typical ice layer. This design encourages circulation in the pond, preventing stratification and formation of ice at the outlet.
- Trash racks should be installed at a shallow angle to prevent ice formation (see Appendix K).

Figure 6.6 Seasonal Operation Pond



Ice Formation on the Permanent Pool

- In cold climates, the treatment volume of a pond system should be adjusted to account for ice build-up on the permanent pool by providing one foot of elevation above the WQv. The total depth of the pond, including this additional elevation, should not exceed eight feet.
- Using pumps or bubbling systems can reduce ice build-up and prevent the formation of an anaerobic zone in pond bottoms.
- Provide some storage as extended detention. This recommendation is made for very cold climates to provide detention while the permanent pond is iced over. In effect, it discourages the use of wet ponds (P-2), replacing them with wet extended detention ponds (P-3).
- Multiple pond systems are recommended regardless of climate because they provide redundant treatment options. In cold climates, a berm or simple weir should be used instead of pipes to separate multiple ponds, due to their higher freezing potential.

Road Sand Build-up

- In areas where road sand is used, an inspection of the forebay and pond should be scheduled after the spring melt to determine if dredging is necessary. For forebays, dredging is needed if one half of the capacity of the forebay is full.

Stormwater Ponds

Description: Constructed stormwater retention basin that has a permanent pool (or micropool). Runoff from each rain event is detained and treated in the pool through settling and biological uptake mechanisms.

Design Options: Micropool Extended Detention (P-1), Wet Pond (P-2), Wet Extended Detention (P-3), Multiple Pond (P-4), Pocket Pond (P-5)

KEY CONSIDERATIONS

FEASIBILITY

- Contributing drainage area greater than 10 acres for P-1, 25 acres for P-2 to P-4.
- Follow DEC Guidelines for Design of Dams.
- Provide a minimum 2' separation from the groundwater in sole source aquifers.
- Do not locate ponds in jurisdictional wetlands.
- Avoid directing hotspot runoff to design P-5.

CONVEYANCE

- Forebay at each inlet, unless the inlet contributes less than 10% of the total inflow, 4' to 6' deep.
- Stabilize the channel below the pond to prevent erosion.
- Stilling basin at the outlet to reduce velocities.

PREATREATMENT

- Forebay volume at least 10% of the WQ_v
- Forebay shall be designed with non-erosive outlet conditions.
- Provide direct access to the forebay for maintenance equipment
- In sole source aquifers, provide 100% pretreatment for hotspot runoff.

TREATMENT

- Provide the water quality volume in a combination of permanent pool and extended detention (Table 6.1 in manual provides limitations on storage breakdown)
- Minimum length to width ratio of 1.5:1
- Minimum surface area to drainage area ratio of 1:100

LANDSCAPING

STORMWATER MANAGEMENT SUITABILITY

X	Water Quality
X	Channel Protection
X	Overbank Flood Protection
X	Extreme Flood Protection

Accepts Hotspot Runoff: *Yes*

(2 feet minimum separation distance required to water table)

FEASIBILITY CONSIDERATIONS

L	Cost
L	Maintenance Burden

Key: **L**=Low **M**=Moderate **H**=High

Residential Subdivision Use: Yes

High Density/Ultra-Urban: *No*

Soils: *Hydrologic group 'A' soils may require pond liner*

Hydrologic group 'D' soils may have compaction constraints

Other Considerations:

- *Thermal effects*

• Provide a minimum 10' and preferably 15' safety bench extending from the high water mark, with a maximum slope of 6%. • Provide an aquatic bench extending 15 feet outward from the shoreline, and a maximum depth of 18" below normal water elevation. • Develop a landscaping plan. • Provide a 25'pond buffer. • No woody vegetation within 15 feet of the toe of the embankment, or 25 feet from the principal spillway. **MAINTENANCE REQUIREMENTS** • Legally binding maintenance agreement • Sediment removal from forebay every five to six years or when 50% full. • Provide a maintenance easement and right-of-way. • Removable trash rack on the principal spillway. • Non-clogging low flow orifice • Riser in the embankment. • Pond drain required, capable of drawing down the pond in 24 hours. • Notification required for pond drainage. • Provide an adjustable gate valve on both the WQ_v-ED pipe, and the pond drain. • Side Slopes less than 3:1, and terminate at a safety bench. • Principal spillway shall not permit access by small children, and endwalls above pipes greater than 48" in diameter shall be fenced.	• *Outlet clogging* • *Safety bench* **POLLUTANT REMOVAL** G Phosphorus G Nitrogen G Metals - Cadmium, Copper,Lead, and Zinc removal G Pathogens Coliform, E.Coli, Streptococci removal **Key: G**=Good **F**=Fair **P**=Poor

Section 6.2 Stormwater Wetlands

Stormwater wetlands are practices that create shallow marsh areas to treat urban stormwater and often incorporate small permanent pools and/or extended detention storage to achieve the full WQv. Design variants include:

- W-1 Shallow Wetland (Figure 6.7)
- W-2 ED Shallow Wetland (Figure 6.8)
- W-3 Pond/Wetland System (Figure 6.9)
- W-4 Pocket Wetland (Figure 6.10)

Wetland designs W-1 through W-4 can be used to provide Channel Protection volume as well as Overbank and Extreme Flood attenuation. In these design variations, the permanent pool is stored in a depression excavated into the ground surface. Wetland plants are planted at the wetland bottom, particularly in the shallow regions.

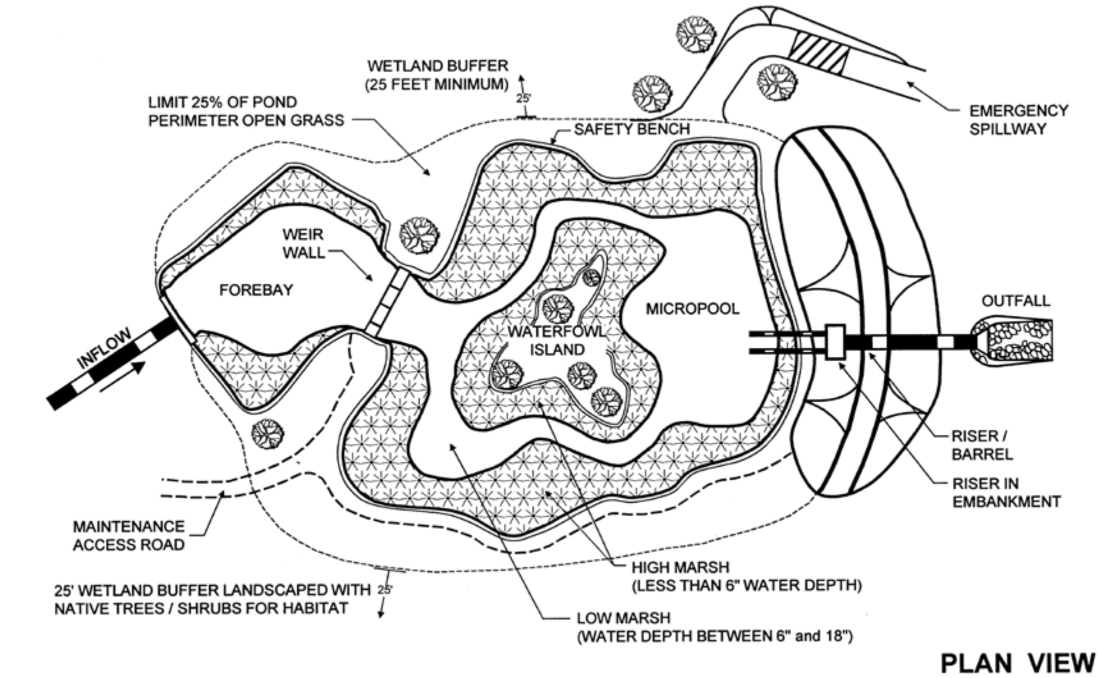
IMPORTANT NOTES

ALL OF THE POND CRITERIA PRESENTED IN PERFORMANCE CRITERIA – PONDS (CHAPTER 6.1) ALSO APPLY TO THE DESIGN OF STORMWATER WETLANDS. ADDITIONAL CRITERIA THAT GOVERN THE GEOMETRY AND ESTABLISHMENT OF CREATED WETLANDS ARE PRESENTED IN THIS SECTION.

ANY PRACTICE THAT CREATES A DAM IS REQUIRED TO FOLLOW THE GUIDANCE PRESENTED IN THE GUIDELINES FOR DESIGN OF DAMS (APPENDIX A) AND MAY REQUIRE A PERMIT FROM THE NYSDEC. FOR THE MOST RECENT COPY OF THIS DOCUMENT, CONTACT THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, DAM SAFETY SECTION. AN EVALUATION OF HAZARD CLASSIFICATION MUST BE INCLUDED IN THE DESIGN REPORT FOR STORMWATER WETLANDS CREATED BY A DAM.

WHILE THE STORMWATER WETLANDS DESIGNED ACCORDING TO THIS GUIDANCE MAY ACT AS A COMMUNITY AMMENITY, AND MAY PROVIDE SOME HABITAT VALUE, THEY CANNOT BE ANTICIPATED TO FUNCTION AS NATURAL WETLANDS

Figure 6.7 Shallow Wetland (W-1)



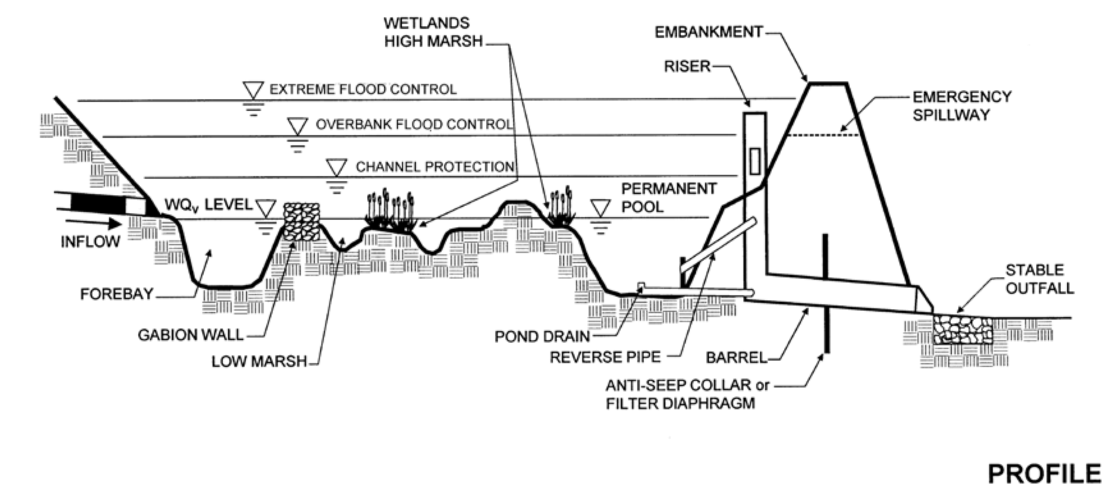


Figure 6.8 Extended Detention Shallow Wetland (W-2)

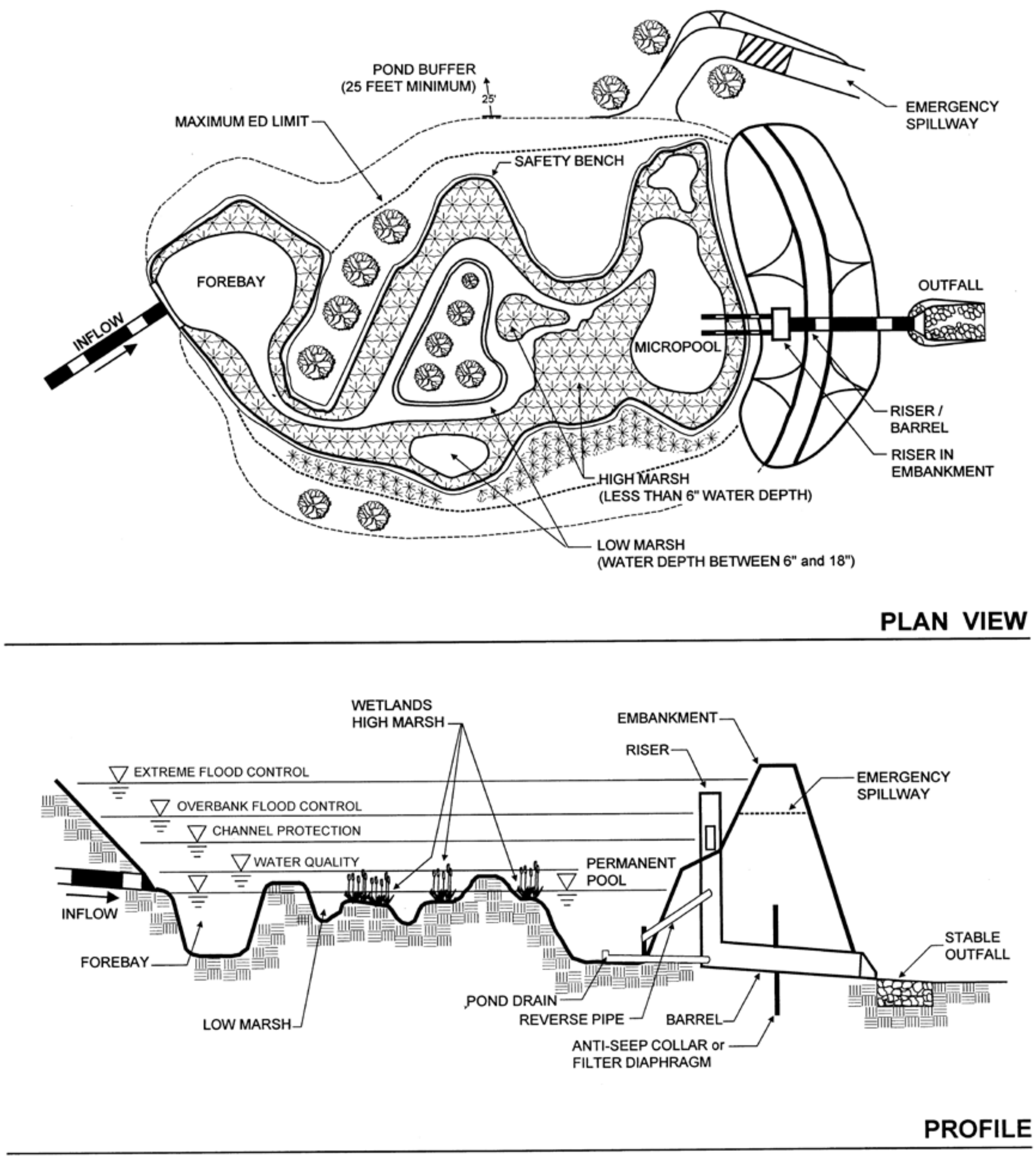
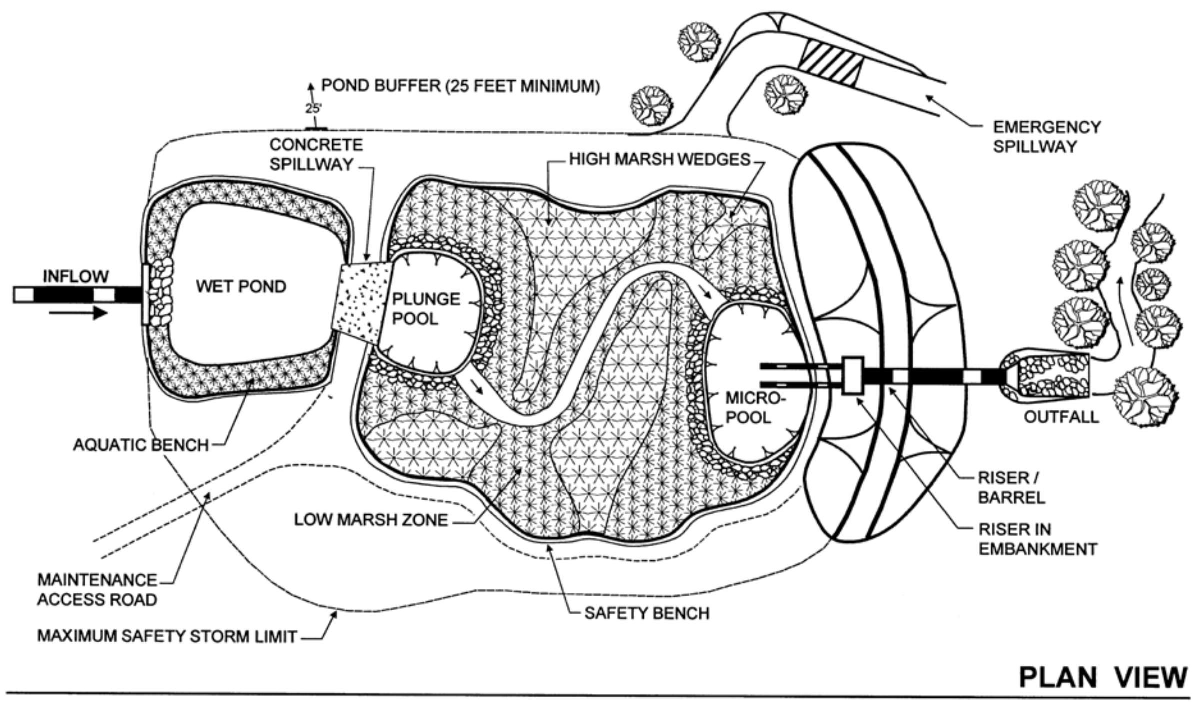


Figure 6.9 Pond/Wetland System (W-3)



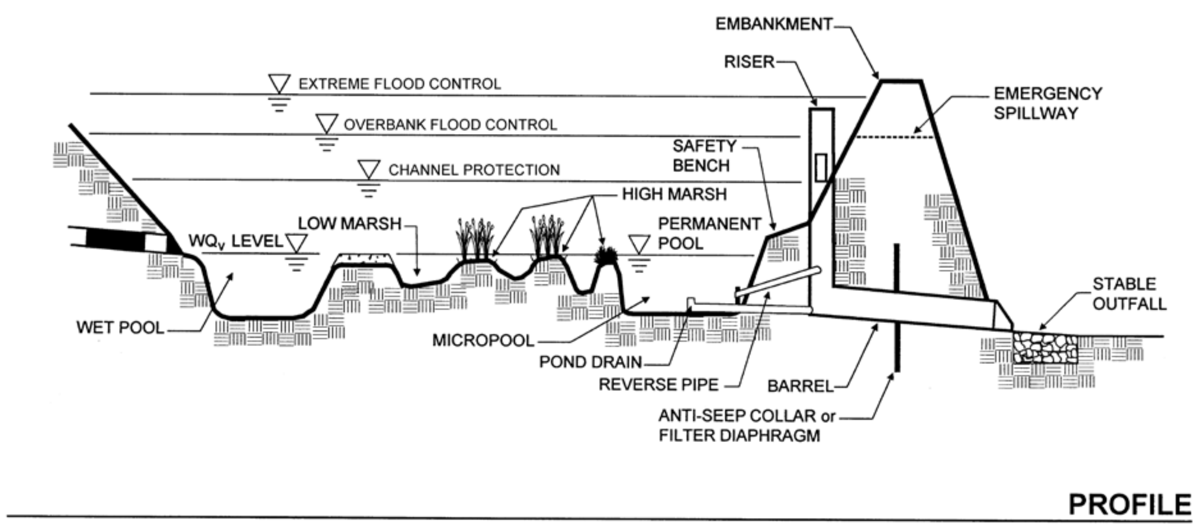
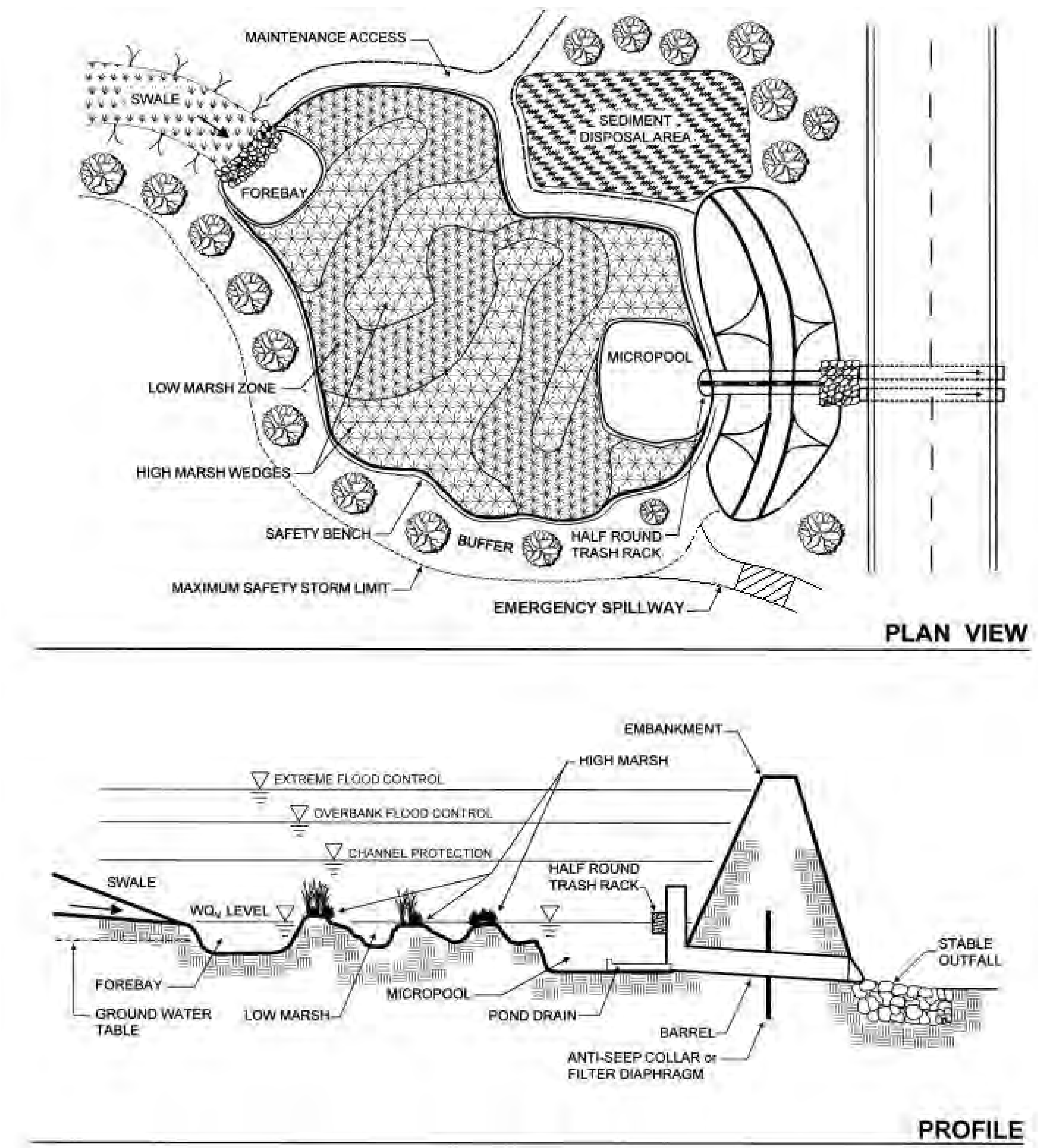


Figure 6.10 Pocket Wetland (W-4)



6.2.1 Feasibility

Design Guidance

- *Stormwater wetlands should not be located within existing jurisdictional wetlands.* In some isolated cases, a permit may be granted to convert an existing degraded wetland in the context of local watershed restoration efforts.
- The use of stormwater wetlands on trout waters is strongly discouraged, as available evidence suggests that these practices can increase stream temperatures.

6.2.2 Conveyance

Required Elements

- Flowpaths from the inflow points to the outflow points of stormwater wetlands shall be maximized.
- A minimum flowpath of 2:1 (length to relative width) shall be provided across the stormwater wetland. This path may be achieved by constructing internal berms (e.g., high marsh wedges or rock filter cells).

Design Guidance

- Microtopography is encouraged to enhance wetland diversity.

6.2.3 Treatment

Required Elements

- The surface area of the entire stormwater wetland shall be at least one percent of the contributing drainage area (1.5% for shallow marsh design).
- A minimum of 35% of the total surface area can have a depth of six inches or less, and at least 65% of the total surface area shall be shallower than 18 inches.
- At least 25% of the WQ_v shall be in deepwater zones with a depth greater than four feet.
- If extended detention is used in a stormwater wetland, provide a minimum of 50% of the WQ_v in permanent pool; the maximum water surface elevation of WQ_v-ED shall not extend more than three feet above the permanent pool.
- A forebay shall be located at the inlet, and a four to six foot deep micropool that stores approximately 10% of the WQ_v shall be located at the outlet to protect the low flow pipe from clogging and prevent sediment resuspension.

Design Guidance

- The bed of stormwater wetlands should be graded to create maximum internal flow path and microtopography.

- To promote greater nitrogen removal, rock beds may be used as a medium for growth of wetland plants. The rock should be one to three inches in diameter, placed up to the normal pool elevation, and open to flow-through from either direction.

6.2.4 Landscaping

Required Elements

- A landscaping plan shall be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of a plan include: delineation of pondscaping zones, selection of corresponding plant species, planting plan, sequence for preparing wetland bed (including soil amendments, if needed) and sources of plant material.
- A wetland plant buffer must extend 25 feet outward from the maximum water surface elevation, with an additional 15-foot setback to structures.
- Donor soils for wetland mulch shall not be removed from natural wetlands.

Design Guidance

- Structures such as fascines, coconut rolls, straw bales, or carefully designed stone weirs can be used to create shallow marsh cells in high-energy areas of the stormwater wetland.
- The landscaping plan should provide elements that promote greater wildlife and waterfowl use within the wetland and buffers.
- Follow wetland establishment guidelines (see Appendix H).

6.2.5 Maintenance

Required Elements

- If a minimum coverage of 50% is not achieved in the planted wetland zones after the second growing season, a reinforcement planting is required.

6.2.6 Cold Climate Design Considerations

Many of the cold climate concerns for wetlands are very similar to the ones for ponds. Two additional concerns with regards to stormwater wetlands focus on cold climate impacts to wetland plants:

- Short Growing Season
- Chlorides

Short Growing Season

- Planting schedule should reflect the short growing season, perhaps incorporating relatively mature plants, or planting rhizomes during the winter.

<u>Chlorides</u>

- Use in combination with a grassed infiltration area prior to the wetland to provide some infiltration of chlorides to dampen the shock to wetland plants
- Emphasize the pond/wetland design option to dilute chlorides prior to the wetland area. If this option is used, the pond should use the modifications described in Section 6.1.7. The pond system dilutes chlorides before they enter the marsh, protecting wetland plants.
- Consider salt-tolerant plants if wetland treats runoff from roads or parking lots where salt is used as a deicer.

Stormwater Wetlands

Description: Stormwater wetlands (a.k.a. constructed wetlands) are structural practices that incorporate wetland plants into the design to both store and treat runoff. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice

Design Options: Shallow wetland (W-1), Extended Detention Wetland (W-2), Pond/Wetland (W-3), Pocket Wetland (W-4)

KEY CONSIDERATIONS

MUST MEET ALL OF THE REQUIREMENTS OF STORMWATER PONDS.

CONVEYANCE

- Minimum flowpath of 2:1 (length to width)
- Flowpath maximized

TREATMENT

- Micropool at outlet, capturing 10% of the WQ_v
- Minimum surface area to drainage area ratio of 1:100
- ED no greater than 50% of entire WQ_v (permanent pool at least 50% of the volume) 25% of the WQ_v in deepwater zones.
- 35% of the total surface area in depths six inches or less, and 65% shallower than 18"

LANDSCAPING

- Landscaping plan that indicates methods to establish and maintain wetland coverage. Minimum elements include: delineation of pondscaping zones, selection of species, planting plan, and sequence for bed preparation.
- Wetland buffer 25 feet from maximum surface elevation, with 15 foot additional setback for structures.
- Donor plant material must not be from natural wetlands

MAINTENANCE REQUIREMENTS

- Reinforcement plantings after second season if 50% coverage not achieved

POLLUTANT REMOVAL

G	Phosphorus
G	Nitrogen
F	Metals - Cadmium, Copper, Lead, and Zinc removal
G	Pathogens - Coliform, Streptococci, E.Coli removal

Key: G=Good **F**=Fair **P**=Poor

STORMWATER MANAGEMENT SUITABILITY

X	Water Quality
X	Channel Protection
X	Overbank Flood Protection
X	Extreme Flood Protection

Accepts Hotspot Runoff: *Yes*

(2 feet minimum separation distance required to water table)

IMPLEMENTATION CONSIDERATIONS

M	Capital Cost

Maintenance Burden:

M	Shallow Wetland
M	ED Shallow Wetland
H	Pocket Wetland
M	Pond/Wetland

Residential Subdivision Use: Yes

High-Density/Ultra-Urban: *No*

Soils: *Hydrologic group 'A' and 'B' soils may require liner*

Key: **L**=Low **M**=Moderate **H**=High

Section 6.3 Stormwater Infiltration

Stormwater infiltration practices capture and temporarily store the WQ_v before allowing it to infiltrate into the soil over a two-day period. Design variants include the following:

- I-1 Infiltration Trench (Figure 6.11)
- I-2 Infiltration Basin (Figure 6.12)
- I-3 Dry Well (Figure 6.13)

Treatment Suitability: Infiltration practices alone typically cannot meet detention (Q_p) and channel protection (Cp_v) requirements, except on sites where the soil infiltration rate is greater than 5.0 in/hr. However, extended detention storage may be provided above an infiltration basin. Extraordinary care should be taken to assure that long-term infiltration rates are achieved through the use of performance bonds, post construction inspection and long-term maintenance.

Figure 6.11 Infiltration Trench (I-1)

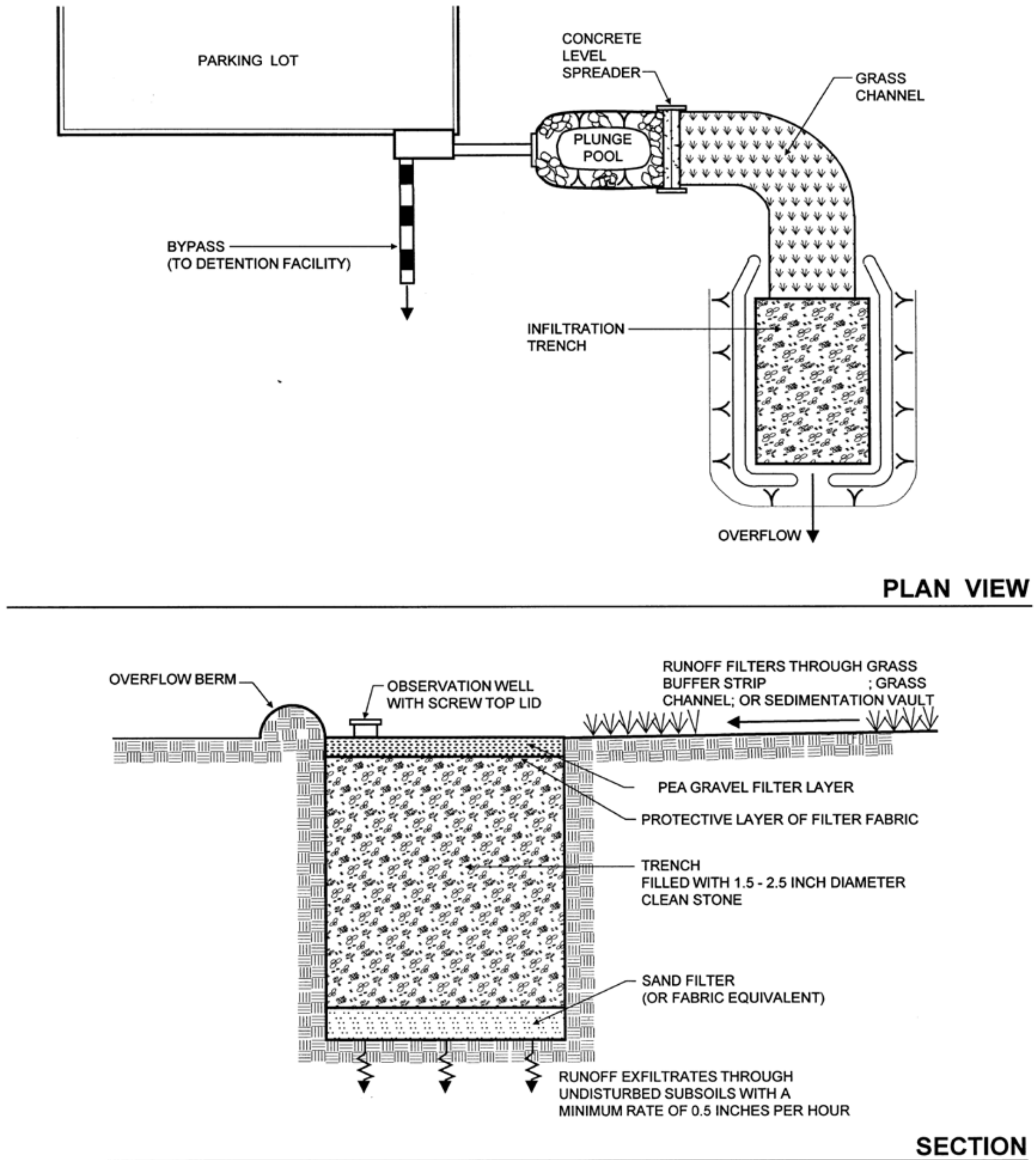
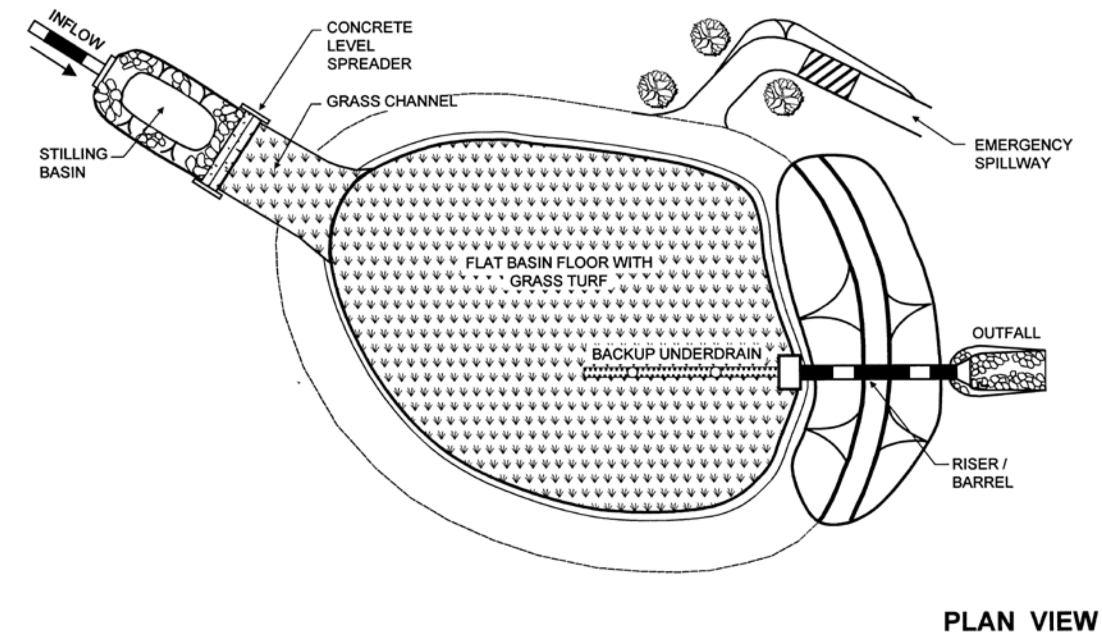


Figure 6.12 Infiltration Basin (I-2)



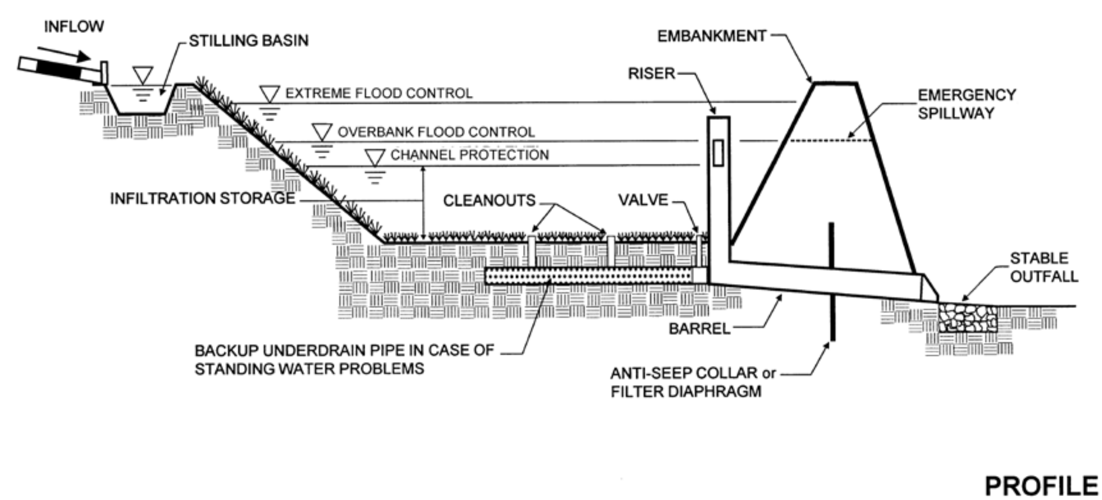
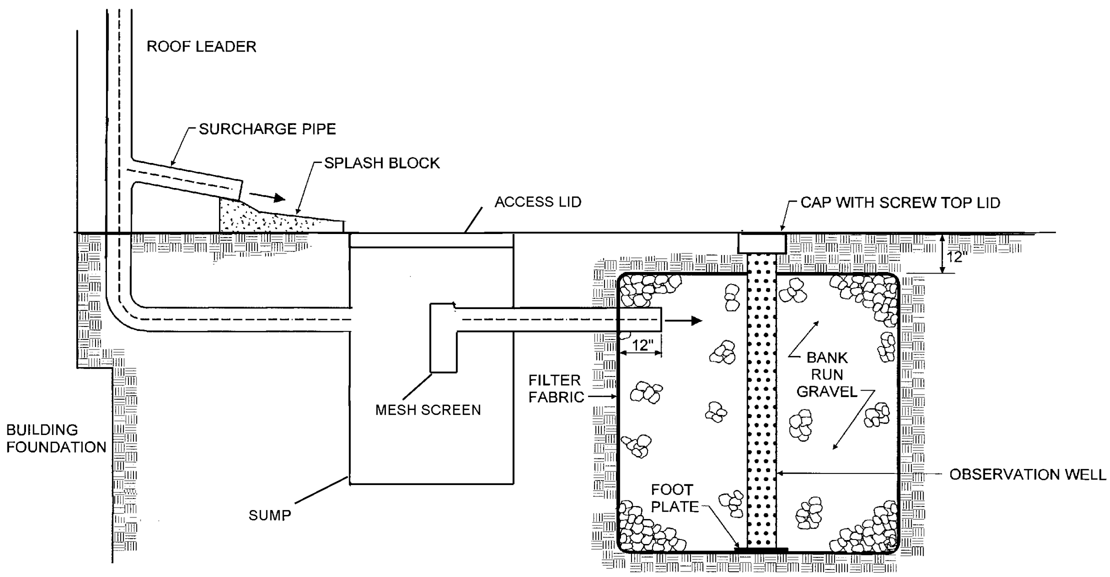


Figure 6.13 Dry Well (I-3)



6.3.1 Feasibility

Required Elements

- To be suitable for infiltration, underlying soils shall have an infiltration rate (fc) of at least 0.5 inches per hour, as initially determined from NRCS soil textural classification, and subsequently confirmed by field geotechnical tests (see Appendix D). The minimum geotechnical testing is one test hole per 5000 sf, with a minimum of two borings per facility (taken within the proposed limits of the facility).

- Soils shall also have a clay content of less than 20% and a silt/clay content of less than 40%.

- Infiltration practices cannot be located on areas with natural slopes greater than 15%.

- Infiltration practices cannot be located in fill soils, except the top quarter of an infiltration trench or dry well.

- To protect groundwater from possible contamination, runoff from designated hotspot land uses or activities must not be directed to a formal infiltration facility. In cases where this goal is impossible (e.g., where the storm drain system leads to a large recharge facility designed for flood control), redundant pretreatment must be provided by applying two of the practices listed in Table 5.1 in series, both of which are sized to treat the entire WQ_v.

- The bottom of the infiltration facility shall be separated by at least three feet vertically from the seasonally high water table or bedrock layer, as documented by on-site soil testing. (Four feet in sole source aquifers).

- Infiltration facilities shall be located at least 100 feet horizontally from any water supply well.
- Infiltration practices cannot be placed in locations that cause water problems to downgradient properties. Infiltration trenches and basins shall be setback 25 feet downgradient from structures and septic systems. Dry wells shall be separated a minimum of 10 feet from structures.

Design Guidance

- The maximum contributing area to infiltration basins or trenches should generally be less than five acres. The infiltration basin can theoretically receive runoff from larger areas, provided that the soil is highly permeable (i.e., greater than 5.0 inches per hour). (See Appendix L for erosive velocities of grass and soil).
- The maximum drainage area to dry wells should generally be smaller than one acre, and should include rooftop runoff only.

6.3.2 Conveyance

Required Elements

- The overland flow path of surface runoff exceeding the capacity of the infiltration system shall be evaluated to preclude erosive concentrated flow during the overbank events. If computed flow velocities exceed erosive velocities (3.5 to 5.0 fps), an overflow channel shall be provided to a stabilized watercourse. (See Appendix L for erosive velocities of grass and soil).
- All infiltration systems shall be designed to fully de-water the entire WQ_v within 48 hours after the storm event.
- If runoff is delivered by a storm drain pipe or along the main conveyance system, the infiltration practice must be designed as an off-line practice (see Appendix K for a detail), except when used as a regional flood control practice.

Design Guidance

- For infiltration basins and trenches, adequate stormwater outfalls should be provided for the overflow associated with the 10-year design storm event (non-erosive velocities on the down-slope
- For dry wells, all flows that exceed the capacity of the dry well should be passed through the surcharge pipe.

6.3.3 Pretreatment

Required Elements

- A minimum pretreatment volume of 25% of the WQ_v must be provided prior to entry to an infiltration facility, and can be provided in the form of a sedimentation basin, sump pit, grass channel, plunge pool or other measure.
- If the f_c for the underlying soils is greater than 2.00 inches per hour, a minimum pretreatment volume of 50% of the WQ_v must be provided.

- If the f_c for the underlying soils is greater than 5.00 inches per hour, 100% of the WQ_v shall be pre-treated prior to entry into an infiltration facility.

- Exit velocities from pretreatment chambers shall be non-erosive (3.5 to 5.0 fps) during the two-year design storm). (See Appendix L for erosive velocities of grass and soil).

Pretreatment Techniques to Prevent Clogging

Infiltration basins or trenches can have redundant methods to ensure the long-term integrity of the infiltration rate. The following techniques are pretreatment options for infiltration practices:

- Grass channel (Maximum velocity of 1 fps for water quality flow. See the Fact Sheet on page 5-10 for more detailed design information.)

- Grass filter strip (minimum 20 feet and only if sheet flow is established and maintained)

- Bottom sand layer (for I-1)

- Upper sand layer (for I-1; 6" minimum with filter fabric at sand/gravel interface)

- Use of washed bank run gravel as aggregate

- Alternatively, a pre-treatment settling chamber may be provided and sized to capture the pretreatment volume. Use the method prescribed in section 6.4.3 (i.e., the Camp-Hazen equation) to size the chamber.

- Plunge Pool

- An underground trap with a permanent pool between the downspout and the dry well (I-3)

<u>Design Guidance</u>

- The sides of infiltration trenches and dry wells should be lined with an acceptable filter fabric that prevents soil piping.

- In infiltration trench designs, incorporate a fine gravel or sand layer above the coarse gravel treatment reservoir to serve as a filter layer.

6.3.4 Treatment

<u>Required Elements</u>

- Infiltration practices shall be designed to exfiltrate the entire WQ_v through the floor of each practice (sides are not considered in sizing).

- The construction sequence and specifications for each infiltration practice shall be precisely followed. Experience has shown that the longevity of infiltration practices is strongly influenced by the care taken during construction

- Calculate the surface area of infiltration trenches as:

$$A_p = V_w / (nd_t)$$

Where:

A_p	=	surface area (sf)
V_w	=	design volume (e.g., WQ_v) (ft^3)
n	=	porosity (assume 0.4)
d_t	=	trench depth (maximum of four feet, and separated at least three feet from seasonally high groundwater) (ft)

- Calculate the approximate bottom area of infiltration basins using the following equation:

$$A = V_w/d_b$$

Where:

A	=	surface area of the basin (ft2)
db	=	depth of the basin (ft)

NOTE THAT IN TRAPEZOIDAL BASINS, THIS AREA SHOULD FIRST BE USED TO APPROXIMATE THE AREA AT THE BOTTOM OF THE BASIN, BUT CAN LATER BE MODIFIED TO ACCOUNT FOR ADDITIONAL STORAGE PROVIDED ABOVE SIDE SLOPES.

<u>Design Guidance</u>

- Infiltration practices are best used in conjunction with other practices, and downstream detention is often needed to meet the Cp_v and Q_p sizing criteria.
- A porosity value (V_v/V_t) of 0.4 can be used to design stone reservoirs for infiltration practices.

The bottom of the stone reservoir should be completely flat so that infiltrated runoff will be able to infiltrate through the entire surface.

6.3.5 Landscaping

<u>Required Elements</u>

- Upstream construction shall be completed and stabilized before connection to a downstream infiltration facility. A dense and vigorous vegetative cover shall be established over the contributing pervious drainage areas before runoff can be accepted into the facility.
- Infiltration trenches shall not be constructed until all of the contributing drainage area has been completely stabilized.

<u>Design Guidance</u>

- Mow upland and adjacent areas, and seed bare areas.

6.3.6 Maintenance

Required Elements

- Infiltration practices shall never serve as a sediment control device during site construction phase. In addition, the Erosion and Sediment Control plan for the site shall clearly indicate how sediment will be prevented from entering an infiltration facility. Normally, the use of diversion berms around the perimeter of the infiltration practice, along with immediate vegetative stabilization and/or mulching can achieve this goal.

- An observation well shall be installed in every infiltration trench and dry well, consisting of an anchored six- inch diameter perforated PVC pipe with a lockable cap installed flush with the ground surface.

- Direct access shall be provided to infiltration practices for maintenance and rehabilitation. If a stone reservoir or perforated pipe is used to temporarily store runoff prior to infiltration, the practice shall not be covered by an impermeable surface.

Design Guidance

- OSHA trench safety standards should be consulted if the infiltration trench will be excavated more than five feet.

- Infiltration designs should include dewatering methods in the event of failure. Dewatering can be accomplished with underdrain pipe systems that accommodate drawdown.

6.3.7 Cold Climate Design Considerations

Because of additional challenges in cold climates, infiltration SMPs need design modifications to function properly. These modifications address the following problems:

- Reduced infiltration into frozen soils

- Chlorides

Reduced Infiltration

- Draining the ground beneath an infiltration system with an underdrain can increase cold weather soil infiltration.

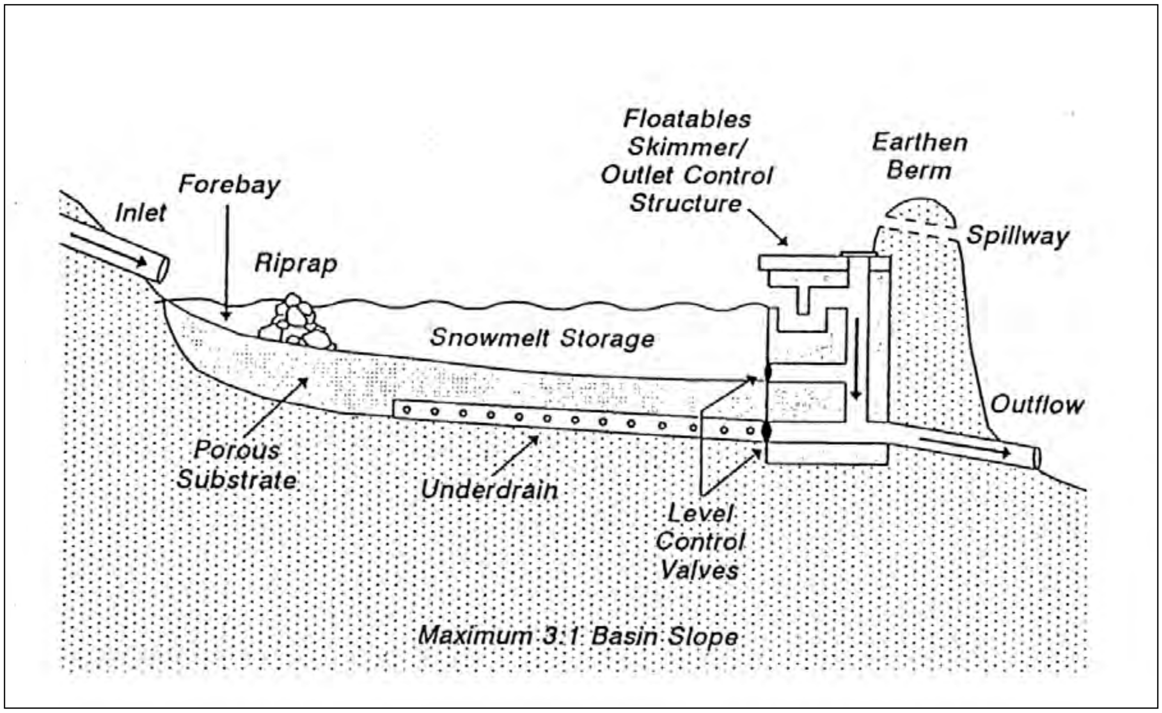
- Another alternative is to divide the treatment volume between an infiltration SMP and another SMP to provide some treatment during the winter months.

- A seasonally operated infiltration/detention facility combines several techniques to improve the performance of infiltration SMPs in cold climates. Two features, the underdrain system and level control valves, are useful in cold climates. The level control and valves are opened at the beginning of the winter season and the soil is allowed to drain. As the snow begins to melt in the spring, the valves are closed, and the snowmelt is infiltrated until the capacity of the soil is reached. After this point, the facility acts as a detention facility, providing storage for particles to settle (Figure 6.14)

Chlorides

- Consider diverting snowmelt runoff past infiltration devices, especially in regions where chloride concentration in groundwater is a concern.
- Incorporate mulch into infiltration basin soil to mitigate problems with soil fertility.
- The selection of upland landscaping materials should include salt-tolerant grasses where appropriate.

Figure 6.14 Seasonal Operation Infiltration Facility



Infiltration Practices

Description: Excavated trench or basin used to capture and allow infiltration of stormwater runoff into the surrounding soils from the bottom and sides of the basin or trench.

Design Options: Infiltration Trench (I-1), Shallow Infiltration Basin (I-2), Dry Well (I-3)

KEY CONSIDERATIONS	STORMWATER MANAGEMENT SUITABILITY
FEASIBILITY • Minimum soil infiltration rate of 0.5 inches per hour • Soils less than 20% clay, and 40% silt/clay, and no fill soils. • Natural slope less than 15% • Cannot accept hotspot runoff, except under the conditions outlined in Section 6.3.1. • Separation from groundwater table of at least three feet (four feet in sole source aquifers). • 25’ separation from structures for I-1 and I-2; 10’ for I-3. CONVEYANCE • Flows exiting the practice must be non-erosive (3.5 to 5.0 fps) • Maximum dewatering time of 48 hours. • Design off-line if stormwater is conveyed to the practice by a storm drain pipe. PRETREATMENT • Pretreatment of 25% of the WQv at all sites. • 50% pretreatment if fc >2.0 inches/hour. • 100% pretreatment in areas with fc >5.0 inches/hour. • Exit velocities from pretreatment must be non-erosive for the 2-year storm. TREATMENT • Water quality volume designed to exfiltrate through the floor of the practice. • Construction sequence to maximize practice life.	X Water Quality X Channel Protection ☐ Overbank Flood Protection ☐ Extreme Flood Protection **Accepts Hotspot Runoff:** *No* **IMPLEMENTATION CONSIDERATIONS** H Capital Cost H Maintenance Burden ***Residential Subdivision Use:*** Yes **High Density/Ultra-Urban:** *Yes* **Drainage Area:** *10 acres max.* **Soils**: *Pervious soils required (0.5 in/hr or greater)* **Other Considerations**: • *Must not be placed under pavement or concrete*

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- Trench depth shall be less than four feet (I-2 and I-3).
- Follow the methodologies in Chapter 6 to size practices.

LANDSCAPING

- Upstream area shall be completely stabilized before flow is directed to the practice.

MAINTENANCE REQUIREMENTS

- Never serves as a sediment control device
- Observation well shall be installed in every trench, (6" PVC pipe, with a lockable cap)
- Provide direct maintenance access.

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Key: **L**=Low **M**=Moderate **H**=High

POLLUTANT REMOVAL

G Phosphorus

G Nitrogen

G Metals - Cadmium, Copper, Lead, and Zinc removal

G Pathogens - Coliform, Streptococci, E.Coli removal

Key: G=Good **F**=Fair **P**=Poor

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Section 6.4 Stormwater Filtering Systems

Stormwater filtering systems capture and temporarily store the WQ_v and pass it through a filter bed of sand, organic matter, or soil. Filtered runoff may be collected and returned to the conveyance system, or allowed to partially exfiltrate into the soil. Design variants include:

- F-1 Surface Sand Filter (Figure 6.15)
- F-2 Underground Sand Filter (Figure 6.16)
- F-3 Perimeter Sand Filter (Figure 6.17)
- F-4 Organic Filter (Figure 6.18)
- F-5 Bioretention (Figure 6.19)

Treatment Suitability: Filtering systems should not be designed to provide stormwater detention (Q_p) or channel protection (Cp_v) except under extremely unusual conditions. Filtering practices shall generally be combined with a separate facility to provide those controls.

Figure 6.15 Surface Sand Filter (F-1)

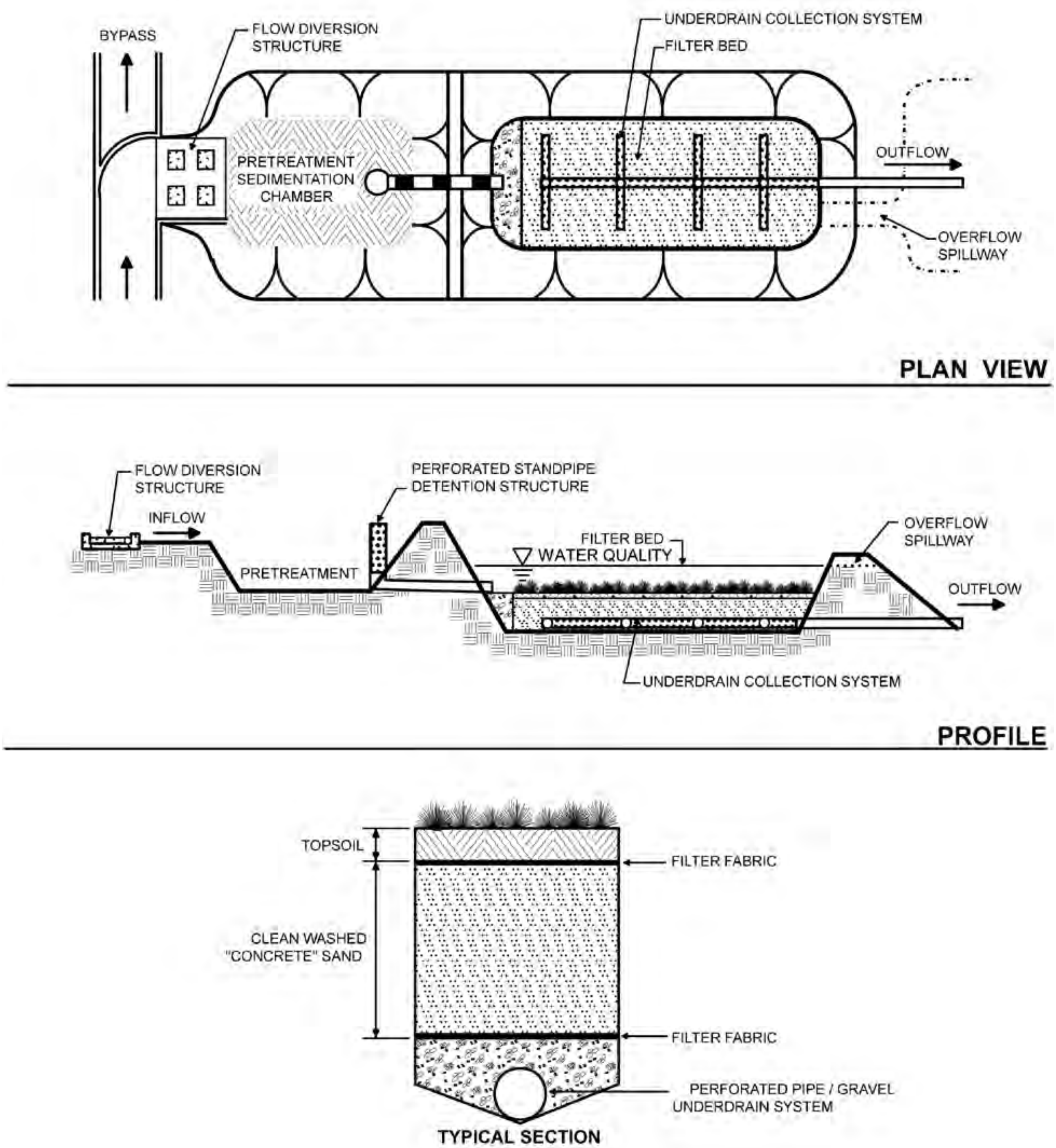


Figure 6.16 Underground Sand Filter (F-2)

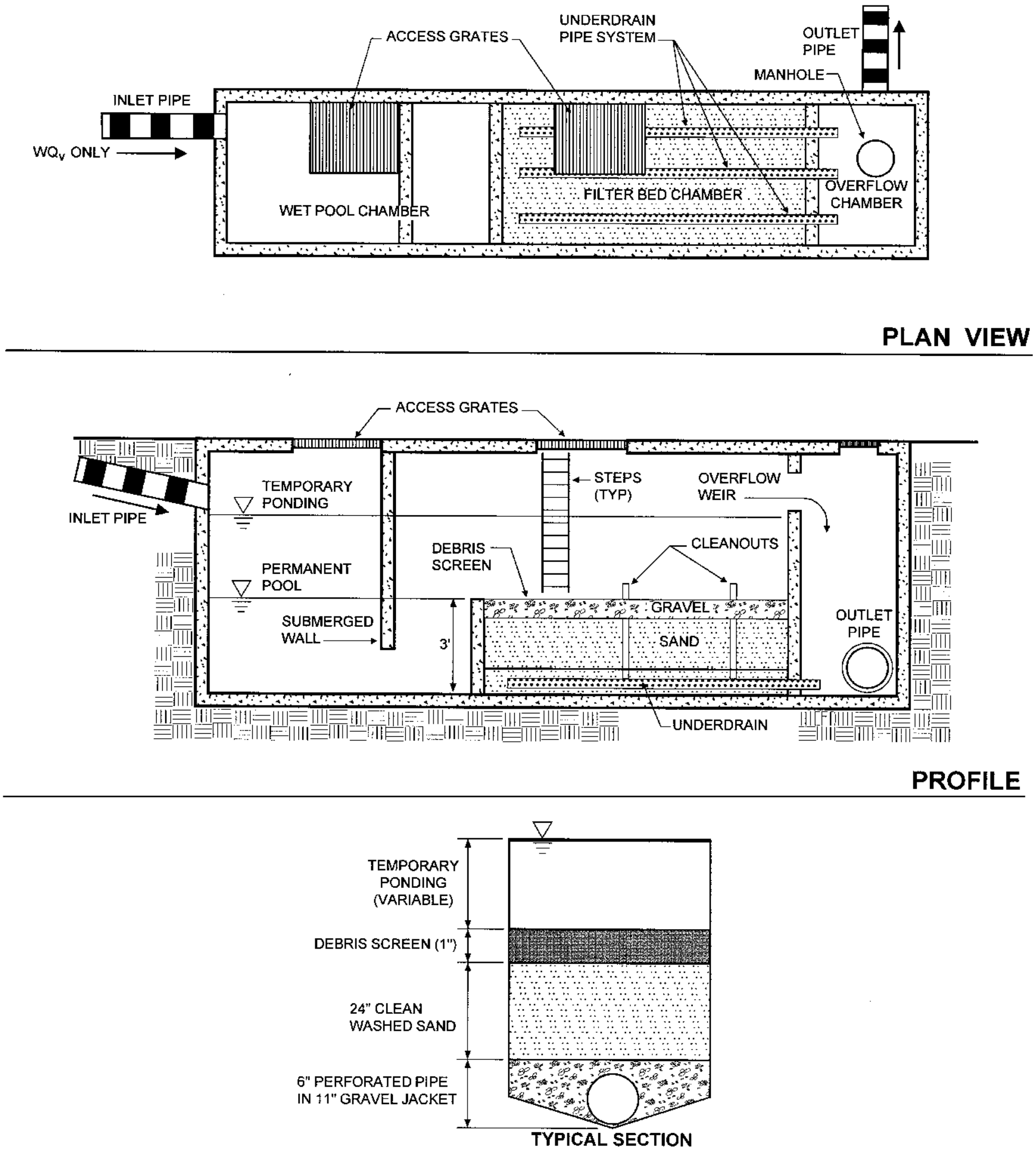


Figure 6.17 Perimeter Sand Filter (F-3)

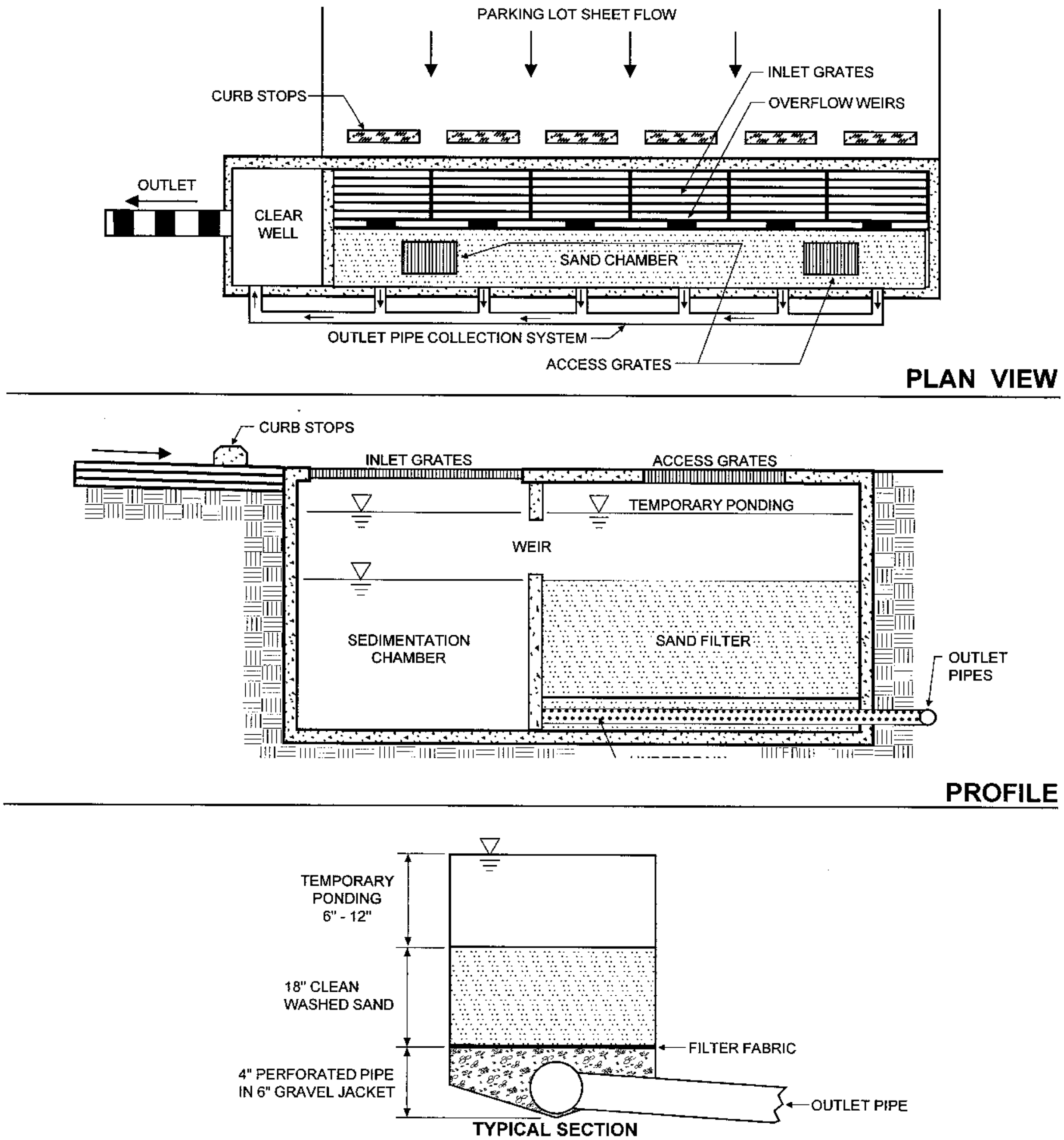


Figure 6.18 Organic Filter (F- 4)

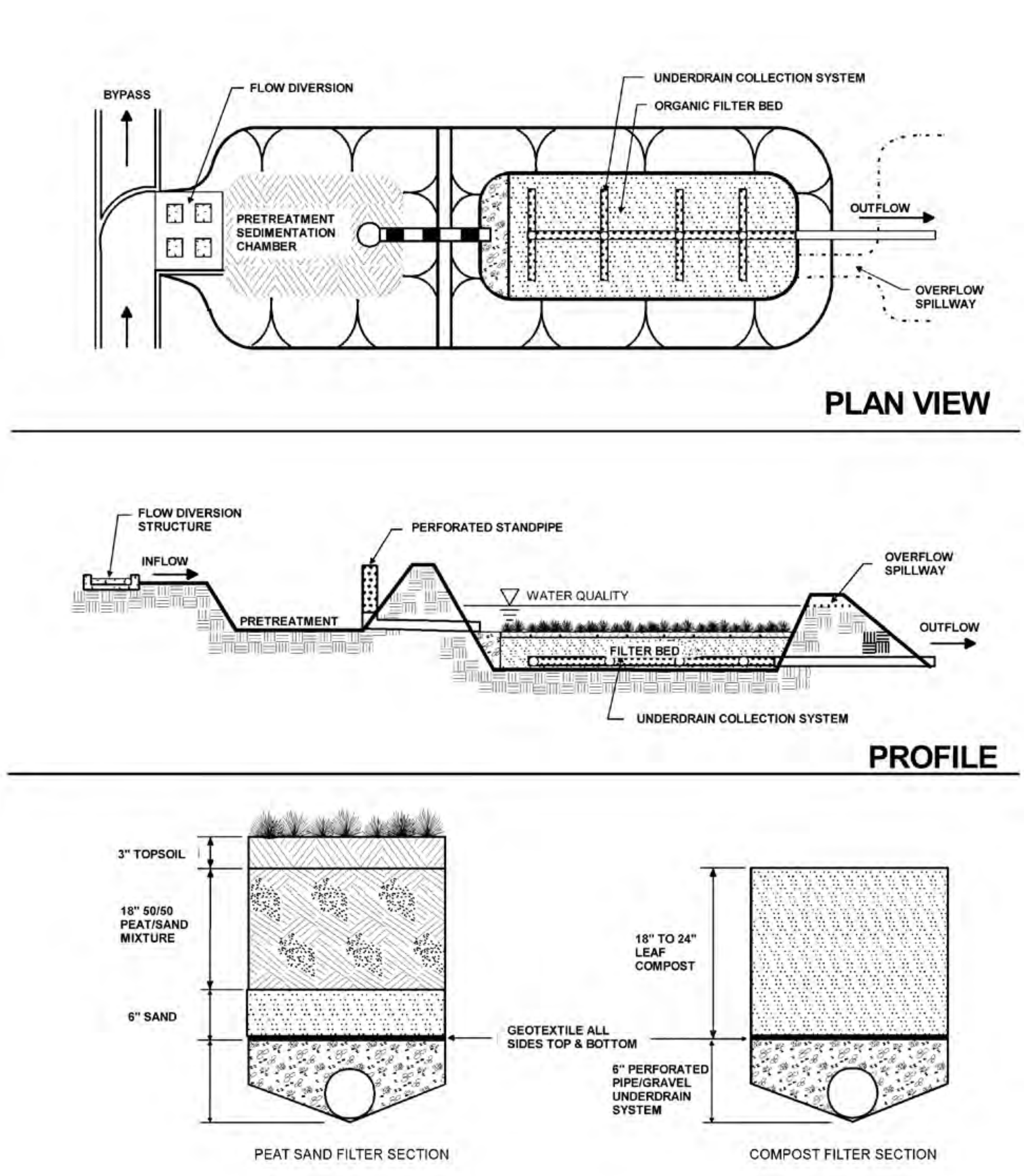
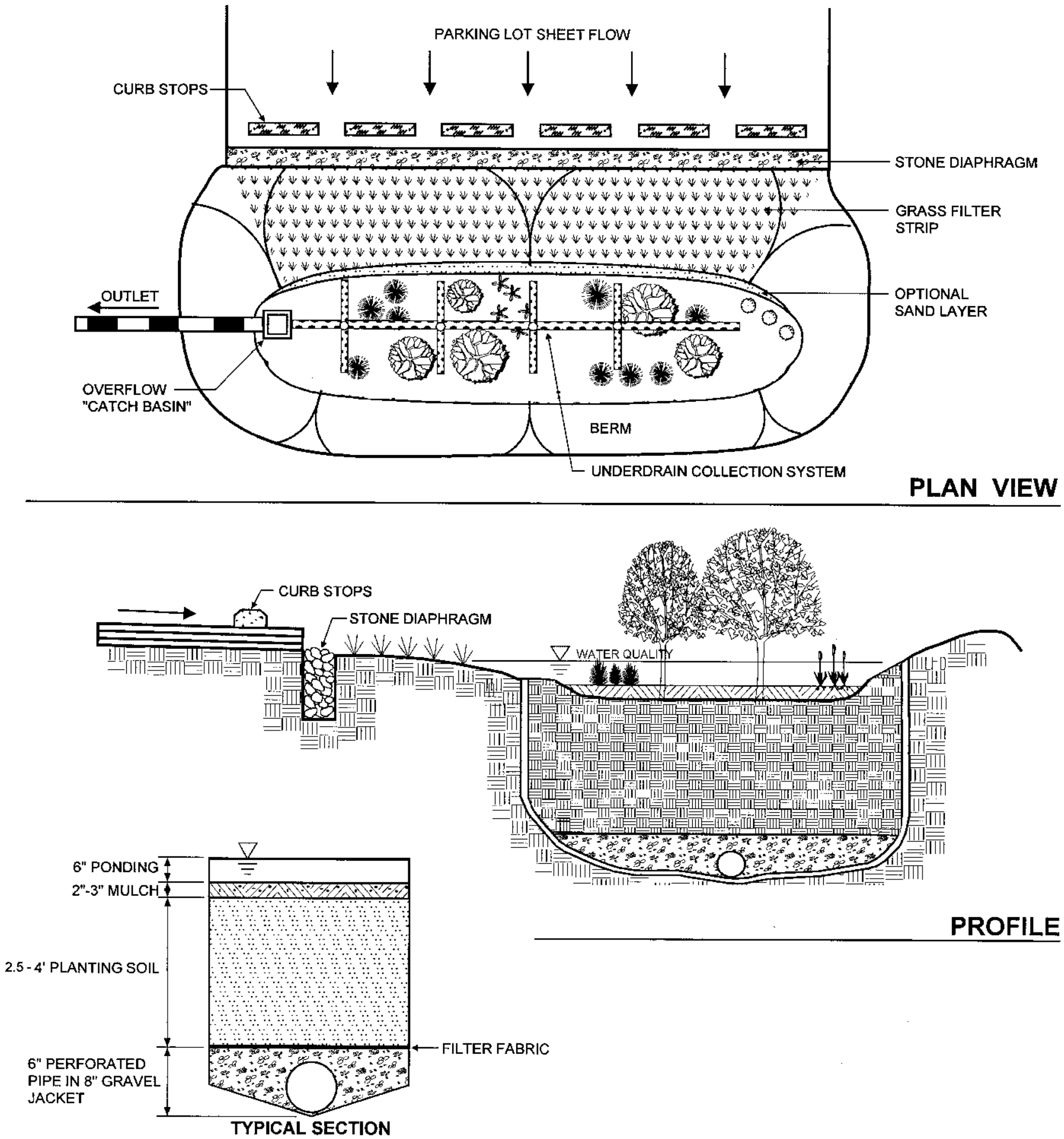


Figure 6.19 Bioretention (F-5)



6.4.1 Feasibility

Design Guidance

- Most stormwater filters require four to six feet of head, depending on site configuration and land area available. The perimeter sand filter (F-3), however, can be designed to function with as little as 18” to 24” of head.
- The recommended maximum contributing area to an individual stormwater filtering system is usually less than 10 acres. In some situations, larger areas may be acceptable.
- Sand and organic filtering systems are generally applied to land uses with a high percentage of impervious surfaces. Sites with imperviousness less than 75% will require full sedimentation pretreatment techniques.

6.4.2 Conveyance

Required Elements

- If runoff is delivered by a storm drain pipe or is along the main conveyance system, the filtering practice shall be designed off-line (see Appendix K).
- An overflow shall be provided within the practice to pass a percentage of the WQ_v to a stabilized water course. In addition, overflow for the ten-year storm shall be provided to a non-erosive outlet point (i.e., prevent downstream slope erosion*)*.
- A flow regulator (or flow splitter diversion structure) shall be supplied to divert the WQ_v to the filtering practice, and allow larger flows to bypass the practice.
- Stormwater filters shall be equipped with a minimum 4" perforated pipe underdrain (6" is preferred) in a gravel layer. A permeable filter fabric shall be placed between the gravel layer and the filter media.
- Require a minimum 2’ separation between the filter bottom and groundwater.

6.4.3 Pretreatment

Required Elements

- Dry or wet pretreatment shall be provided prior to filter media equivalent to at least 25% of the computed WQ_v. The typical method is a sedimentation basin that has a length to width ratio of 1.5:1. The Camp-Hazen equation is used to compute the required surface area for sand and organic filters requiring full sedimentation for pretreatment (WSDE, 1992) as follows:
- The required sedimentation basin area is computed using the following equation:

$$A_s = -1 * \left(\frac{Q_0}{W}\right) \ln(1 - E)$$

Where:

A_s = Sedimentation basin surface area (ft^2)
E = sediment trap efficiency (use 90%)
W = particle settling velocity (ft/sec)
use 0.0004 ft/sec for imperviousness (I) $\leq$75%
use 0.0033 ft/sec for I > 75%
Qo = Discharge rate from basin = (WQ_v/24 hr/3600s)
WQv = Water Quality Volume (cf)

This equation reduces to:

As = (0.066) (WQv) ft2 for I $\leq$75%
A_s = (0.0081) (WQ_v) ft^2 for I > 75%

Design Guidance

- Adequate pretreatment for bioretention systems should incorporate all of the following: (a) grass filter strip below a level spreader or grass channel, (b) gravel diaphragm and (c) a mulch layer.
- The grass filter strip should be sized using the guidelines in Table 6.2.

Table 6.2 Guidelines for Filter Strip Pretreatment Sizing

Parameter	Impervious Parking Lots				Residential Lawns			
Maximum Inflow Approach Length (ft.)	35		75		75		150	
Filter Strip Slope	$\leq$2%	$\geq$2%	$\leq$2%	$\geq$2%	$\leq$2%	$\geq$2%	$\leq$2%	$\geq$2%
Filter Strip Minimum Length	10’	15’	20’	25’	10’	12’	15’	18’

- The grass channel should be sized using the following procedure:

  1- Determine the channel length needed to treat the WQ_v, using sizing techniques described in the Grass Channel Fact Sheet (Chapter 5).

  2- Determine the volume directed to the channel for pretreatment

  3- Determine the channel length by multiplying the length determined in step 1 above by the ratio of the volume in step 2 to the WQ_v.

6.4.4 Treatment

Required Elements

- The entire treatment system (including pretreatment) shall be sized to temporarily hold at least 75% of the WQ_v prior to filtration.
- The filter media shall consist of a medium sand (meeting ASTM C-33 concrete sand). Media used for organic filters may consist of peat/sand mix or leaf compost. Peat shall be a reed-sedge hemic peat.
- Bioretention systems shall consist of the following treatment components: A four foot deep planting soil bed, a surface mulch layer, and a six inch deep surface ponding area. Soils shall meet the design criteria outlined in Appendix H.

Design Guidance

- The filter bed typically has a minimum depth of 18". The perimeter filter may have a minimum filter bed depth of 12".
- The filter area for sand and organic filters should be sized based on the principles of Darcy's Law. A coefficient of permeability (k) should be used as follows:

Sand:	3.5 ft/day (City of Austin 1988)
Peat:	2.0 ft/day (Galli 1990)
Leaf compost:	8.7 ft/day (Claytor and Schueler, 1996)
Bioretention Soil:	0.5 ft/day (Claytor and Schueler, 1996)

The required filter bed area is computed using the following equation

$$A_f = \frac{WQ_v d_f}{k(h_f + d_f)t_f}$$

Where:

Af	=	Surface area of filter bed (ft2)
WQv	=	Water Quality Volume(cf)
df	=	Filter bed depth (ft)
k	=	Coefficient of permeability of filter media (ft/day)
hf	=	Average height of water above filter bed (ft)
tf	=	Design filter bed drain time (days) (1.67 days or 40 hours is recommended maximum t_f for sand filters, two days for bioretention)

6.4.5 Landscaping

Required Elements

- A dense and vigorous vegetative cover shall be established over the contributing pervious drainage areas before runoff can be accepted into the facility.

- Landscaping is critical to the performance and function of bioretention areas. Therefore, a landscaping plan must be provided for bioretention areas.

Design Guidance

- Surface filters can have a grass cover to aid in pollutant adsorption. The grass should be capable of withstanding frequent periods of inundation and drought.

- Planting recommendations for bioretention facilities are as follows:

  - Native plant species should be specified over non-native species.
  - Vegetation should be selected based on a specified zone of hydric tolerance.
  - A selection of trees with an understory of shrubs and herbaceous materials should be provided.
  - Woody vegetation should not be specified at inflow locations.
  - Trees should be planted primarily along the perimeter of the facility.
  - A tree density of approximately one tree per 100 square feet (i.e., 10 feet on-center) is recommended. Shrubs and herbaceous vegetation should generally be planted at higher densities (five feet on-center and 2.5 feet on center, respectively).

6.4.6 Maintenance

Required Elements

- A legally binding and enforceable maintenance agreement shall be executed between the facility owner and the local review authority to ensure the following:

  - Sediment shall be cleaned out of the sedimentation chamber when it accumulates to a depth of more than six inches. Vegetation within the sedimentation chamber shall be limited to a height of 18 inches. The sediment chamber outlet devices shall be cleaned/repaired when drawdown times exceed 36 hours. Trash and debris shall be removed as necessary.

  - Silt/sediment shall be removed from the filter bed when the accumulation exceeds one inch. When the filtering capacity of the filter diminishes substantially (i.e., when water ponds on the surface of the filter bed for more than 48 hours), the top few inches of discolored material shall be removed and shall be replaced with fresh material. The removed sediments shall be disposed in an acceptable manner (i.e., landfill).

- A stone drop (pea gravel diaphragm) of at least six inches shall be provided at the inlet of bioretention facilities (F-6). Areas devoid of mulch shall be re-mulched on an annual basis. Dead or diseased plant material shall be replaced.

Design Guidance

- Organic filters or surface sand filters that have a grass cover should be mowed a minimum of three times per growing season to maintain maximum grass heights less than 12 inches.

6.4.7 Cold Climate Design Considerations

In cold climates, stormwater filtering systems need to be modified to protect the systems from freezing and frost heaving. The primary cold climate concerns to address with regards to filtering systems are:

- Freezing of the filter bed
- Pipe freezing
- Clogging of filter

NOTE

ALTHOUGH FILTERING SYSTEMS ARE NOT AS EFFECTIVE DURING THE WINTER, THEY ARE OFTEN EFFECTIVE AT TREATING STORM EVENTS IN AREAS WHERE OTHER SMPS ARE NOT PRACTICAL, SUCH AS IN HIGHLY URBANIZED REGIONS. THUS, THEY MAY BE A GOOD DESIGN OPTION, EVEN IF WINTER FLOWS CANNOT BE TREATED. IT IS ALSO IMPORTANT TO REMEMBER THAT THESE SMPS ARE DESIGNED FOR HIGHLY IMPERVIOUS AREAS. IF THE SNOW FROM THEIR CONTRIBUTING AREAS IS TRANSPORTED TO ANOTHER AREA, SUCH AS A PERVIOUS INFILTRATION AREA, A PRACTICE'S PERFORMANCE DURING THE WINTER SEASON MAY BE LESS CRITICAL TO OBTAIN WATER QUALITY GOALS.

Freezing of the Filter Bed

- Place filter beds for underground filter below the frost line to prevent the filtering medium from freezing during the winter.
- Discourage organic filters using peat and compost media, which are ineffective during the winter in cold climates. These organic filters retain water, and consequently can freeze solid and become completely impervious during the winter.
- Combine treatment with another SMP option that can be used as a backup to the filtering system to provide treatment during the winter when the filter is ineffective

Pipe Freezing

- Use a minimum 8" underdrain diameter in a 1' gravel bed. Increasing the diameter of the underdrain makes freezing less likely, and provides a greater capacity to drain standing water from the filter. The porous gravel bed prevents standing water in the system by promoting drainage. Gravel is also less susceptible to frost heaving than finer grained media.

- Replace standpipes with weirs, which can be "frost free." Although weir structures will not always provide detention, they can provide retention storage (i.e., storage with a permanent pool) in the pretreatment chamber.

Clogging of Filter with Excess Sand from Runoff

- If a filter is used to treat runoff from a parking lot or roadway that is frequently sanded during snow events, there is a high potential for clogging from sand in runoff. In these cases, the size of the pretreatment chamber should be increased to 40% of the treatment volume. For bioretention systems, a grass strip, such as a swale, of at least twenty-five feet in length should convey flow to the system.

- Filters should always be inspected for sand build-up in the filter chamber following the spring melt event

Sand/Organic Filters

Description: Multi-chamber structure designed to treat stormwater runoff through filtration, using a sediment forebay, a primary filter media and, typically, an underdrain collection system.

Design Variations: Surface Sand Filter (F-1), Underground Sand Filter (F-2), Perimeter Sand Filter (F-3), Organic Sand Filter (F-4)

KEY CONSIDERATIONS

CONVEYANCE

- If stormwater is delivered by stormdrain, design off-line.
- Overflow shall be provided to pass a fraction of the WQ_v to a stabilized watercourse.
- Overflow for the ten-year storm to a non-erosive point.
- Flow regulator needed to divert WQ_v to the practice, and bypass larger flows.
- Underdrain (4" perforated pipe minimum; 6" preferred)

PRETREATMENT

- Pretreatment volume of 25% of WQ_v.
- Typically a sediment basin with a 1.5:1 L:W ratio, sized with the Camp-Hazen equation (See Section 6.4.3)

TREATMENT

- System must hold 75% of the WQ_v
- Filter media shall be ASTM C-33 sand for sand filters
- Organic filters shall be a peat/sand mix, or leaf compost.
- Peat shall be reed-sedge hemic peat

LANDSCAPING

- Contributing area stabilized before runoff is directed to the facility

MAINTENANCE REQUIREMENTS:

- Legally binding maintenance agreement.
- Sediment cleaned out of sedimentation chamber when it reaches more than 6" in depth.
- Vegetation height limited to 18"
- Sediment chamber cleaned if drawdowns exceed 36 hours.

STORMWATER MANAGEMENT SUITABILITY

- [X] Water Quality
- [ ] Channel Protection
- [ ] Overbank Flood Protection
- [ ] Extreme Flood Protection

Accepts Hotspot Runoff: *Yes*

(requires impermeable liner)

IMPLEMENTATION CONSIDERATIONS

H Capital Cost

H Maintenance Burden

Residential
Subdivision Use: *No*

High Density/Ultra-Urban: *Yes*

Drainage Area: *2-10 acres max.*

Soils: *No restrictions*

Other Considerations: Typically needs to be combined with other controls to provide water quantity control

Key: **L**=Low **M**=Moderate **H**=High

POLLUTANT REMOVAL

G Phosphorus

• Trash and debris removal • Silt/sediment removed from filter bed after it reaches one inch. • If water ponds on the filter bed for greater than 48 hours, remove material, and replace.	**G** Nitrogen **G** Metals - Cadmium, Copper, Lead, and Zinc removal **F** Pathogens - Coliform, Streptococci, E.Coli removal **Key: G**=Good **F**=Fair **P**=Poor

Bioretetion Areas (F-5)

Description: Shallow stormwater basin or landscaped area which utilizes engineered soils and vegetation to capture and treat runoff. The practice is often located in parking lot islands, and can also be used to treat residential areas.

KEY CONSIDERATIONS

CONVEYANCE

- Provide overflow for the 10-year storm to the conveyance system.
- Conveyance to the system is typically overland flow delivered to the surface of the system, typically through curb cuts or over a concrete lip.

PRETREATMENT

- Pretreatment consists of a grass channel or grass filter strip, a gravel diaphragm, and a mulch layer, sized based on the methodologies described in Section 6.4.2.

TREATMENT

- Treatment area should have a four foot deep planting soil bed, a surface mulch layer, and a 6" ponding layer.
- Size the treatment area using equations provided in Chapter 6.

LANDSCAPING

- Detailed landscaping plan required.

MAINTENANCE

- Inspect and repair/replace treatment area components
- Stone drop (at least 6") provided at the inlet
- Remulch annually

STORMWATER MANAGEMENT SUITABILITY

- [X] Water Quality
- [ ] Channel Protection
- [ ] Overbank Flood Protection
- [ ] Extreme Flood Protection

Accepts Hotspot Runoff: *Yes (requires impermeable liner)*

IMPLEMENTATION CONSIDERATIONS

M Capital Cost

M Maintenance Burden

Residential
Subdivision Use: *Yes*

High Density/Ultra-Urban: *Yes*

Drainage Area: *5 acres max.*

Soils: *Planting soils must meet specified criteria; No restrictions on surrounding soils*

Other Considerations:

- *Use of native plants is recommended*

Key: **L**=Low **M**=Medium **H**=High

POLLUTANT REMOVAL

G	Phosphorus
G	Nitrogen
G	Metals - Cadmium, Copper, Lead, and Zinc removal
F	Pathogens – Coliform, Streptococci, E.Coli removal

Key: **G**=Good **F**=Fair **P**=Poor

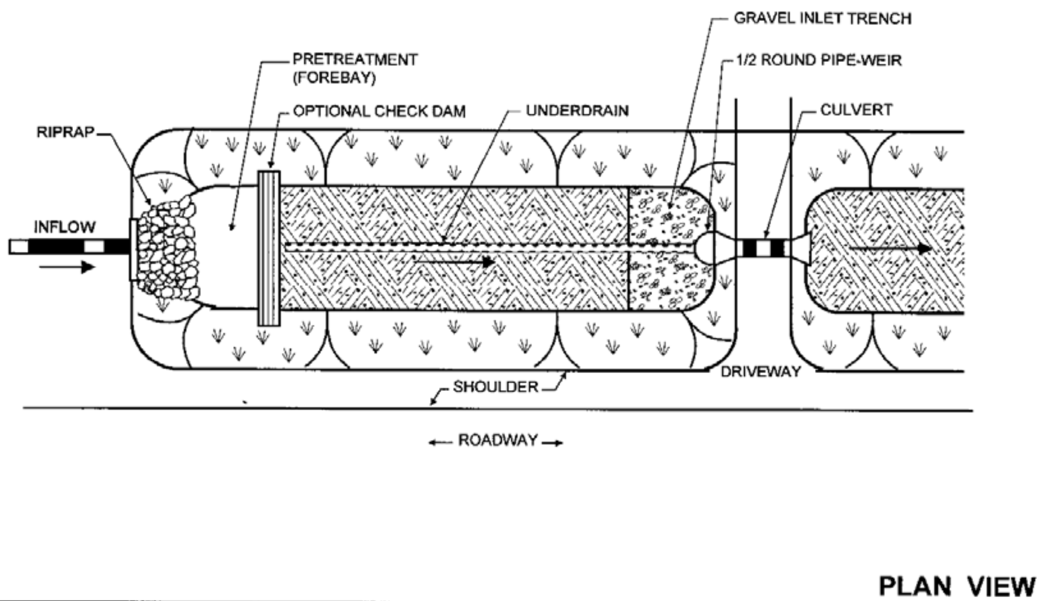
Section 6.5 Open Channel Systems

Open channel systems are vegetated open channels that are explicitly designed to capture and treat the full WQ_v within dry or wet cells formed by check dams or other means. Design variants include:

- O-1 Dry Swale (Figure 6.20)
- O-2 Wet Swale (Figure 6.21)

Treatment Suitability: Open Channel Systems can meet water quality treatment goals only, and are not appropriate for Cp_v or Q_p.

Figure 6.20 Dry Swale (O-1)



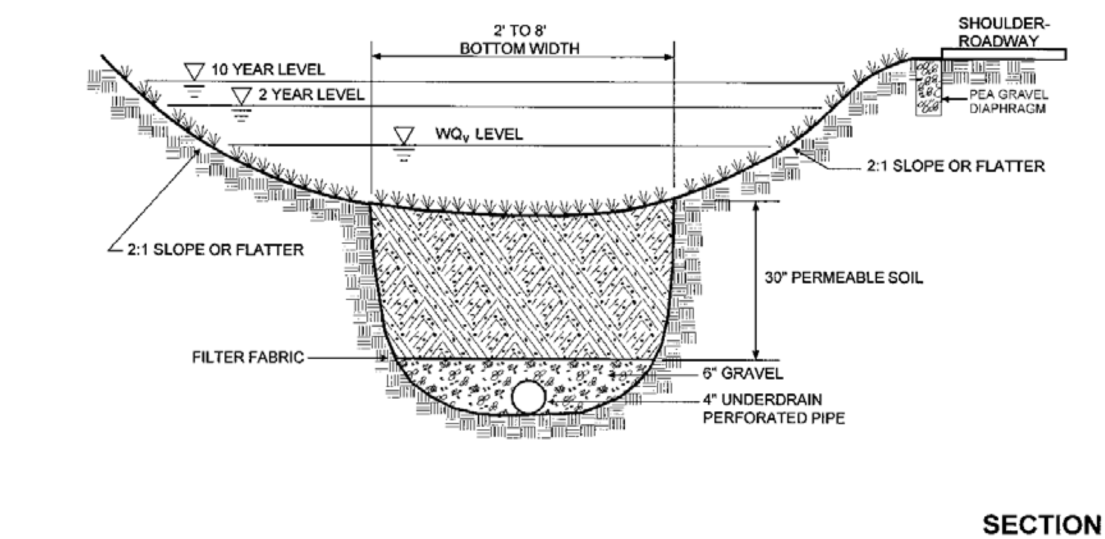
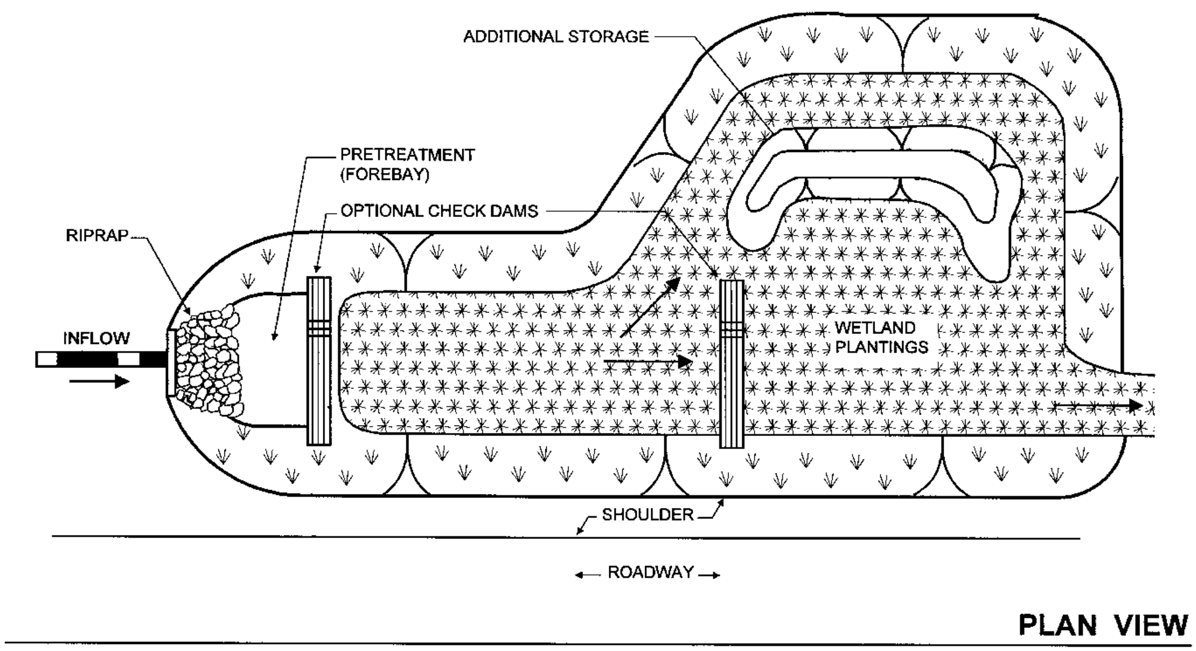
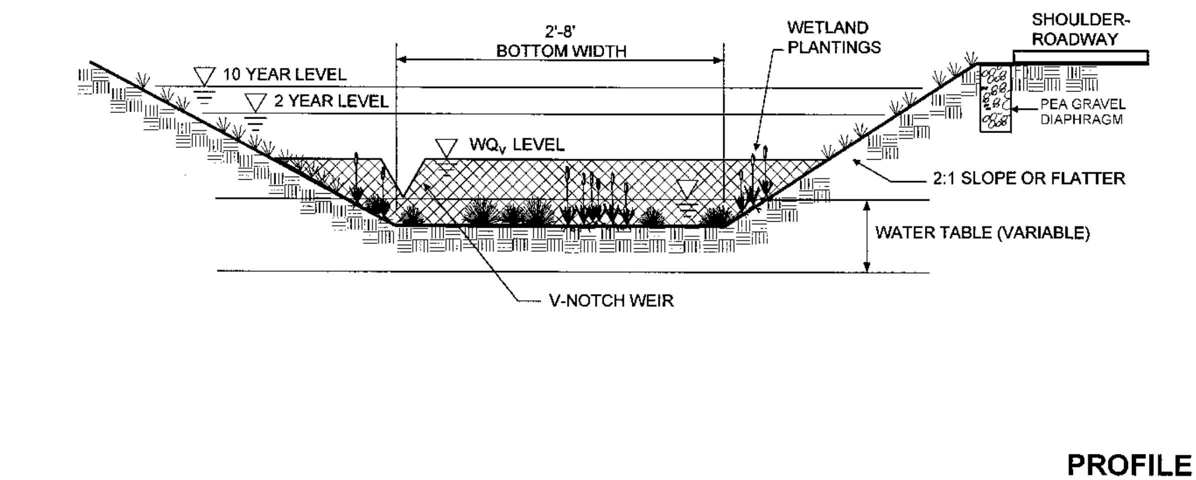


Figure 6.21 Wet Swale (O-2)





6.5.1 Feasibility

Required Elements

- The system shall have a maximum longitudinal slope of 4.0%

Design Guidance

- Dry Swales (O-1) are primarily applicable for land uses such as roads, highways, residential development, and pervious areas.
- Wet Swales (O-2) should be restricted in residential areas because of the potential for stagnant water and other nuisance ponding.
- Provide a 2' separation distance from groundwater for O-1.

6.5.2 Conveyance

Required Elements

- The peak velocity for the two-year storm must be non-erosive (i.e., 3.5-5.0 fps). (See Appendix L for a table of erosive velocities for grass and soil).
- Open channels shall be designed to safely convey the ten-year storm with a minimum of 6 inches of freeboard. Note that some agencies or local municipalities may design channel to convey a different design storm.
- The maximum allowable temporary ponding time within a channel shall be less than 48 hours. An underdrain system shall be used in the dry swale to ensure this ponding time.
- Channels shall be designed with moderate side slopes (flatter than 3:1) for most conditions. 2:1 is the absolute maximum side slope.

Design Guidance

- Open channel systems which directly receive runoff from impervious surfaces may have a 6 inch (maximum) drop onto a protected shelf (pea gravel diaphragm) to minimize the clogging potential of the inlet.
- The underdrain system should be composed of a 6" gravel bed with a 4" PVC pipe.
- If the site slope is greater than 2%, check dams may be needed to retain the water quality volume within the swale system.

6.5.3 Pretreatment

Required Elements

- Provide 10% of the WQ_v in pretreatment. This storage is usually obtained by providing checkdams at pipe inlets and/or driveway crossings.

Design Guidance

- Utilize a pea gravel diaphragm and gentle side slopes along the top of channels to provide pretreatment for lateral sheet flows.

6.5.4 Treatment

Required Elements

- Temporarily store the WQ_v within the facility to be released over a minimum 30 minute duration.
- Design with a bottom width no greater than eight feet to avoid potential gullying and channel braiding, but no less than two feet.
- Soil media for the dry swale shall meet the specifications outlined in Appendix H.

Design Guidance

- Open channels should maintain a maximum ponding depth of one foot at the mid-point of the channel, and a maximum depth of 18" at the end point of the channel (for storage of the WQ_v).

6.5.5 Landscaping

Design Guidance

- Landscape design should specify proper grass species and wetland plants based on specific site, soils and hydric conditions present along the channel (see Appendix H for landscaping guidance for New York).

6.5.6 Maintenance

Required Elements

- A legally binding and enforceable maintenance agreement shall be executed between the facility owner and the local review authority to ensure the following:
- Sediment build-up within the bottom of the channel or filter strip is removed when 25% of the original WQ_v volume has been exceeded.
- Vegetation in dry swales is mowed as required during the growing season to maintain grass heights in the 4 to 6 inch range.

6.5.7 Cold Climate Design Considerations

For open channel systems, the primary cold climate design challenges that need to be addressed are:

- Snowmelt infiltration on frozen ground
- Culvert freezing
- The impacts of deicers on channel vegetation.

Snowmelt Infiltration on Frozen Ground

- In order to ensure that the filter bed remains dry between storm events, increase the size of the underdrain pipe to a minimum diameter of 6" with a minimum 1' filter bed.
- The soil bed permeability of the dry swale should be NRCS class SM (NRCS, 1984), which is slightly higher than in the base criteria. This increased permeability will encourage snowmelt infiltration.

Culvert Freezing

- Use culvert pipes with a minimum diameter of 18".
- Design culverts with a minimum 1% slope where possible.

The Impacts of De-icers on Channel Vegetation

- Inspect open channel systems after the spring melt. At this time, residual sand should be removed and any damaged vegetation should be replaced.
- If roadside or parking lot runoff is directed to the practice, mulching may be required in the spring to restore soil structure and moisture capacity to reduce the impacts of deicing agents.
- Use salt-tolerant plant species in vegetated swales.

Open Channels

Description: Vegetated channels that are explicitly designed and constructed to capture and treat stormwater runoff within dry or wet cells formed by check dams or other means.

Design Options: Dry Swale (O-1), Wet Swale (O-2)

KEY CONSIDERATIONS

FEASIBILITY

- Maximum longitudinal slope of 4%

CONVEYANCE

- Non-erosive (3.5 to 5.0 fps) peak velocity for the 2-year storm
- Safe conveyance of the ten-year storm with a minimum of 6 inches of freeboard.
- Side slopes gentler than 2:1 (3:1 preferred).
- The maximum allowable temporary ponding time of 48 hours

PRETREATMENT

- 10% of the WQ_v in pretreatment, usually provided using check dams at culverts or driveway crossings.

TREATMENT

- Temporary storage the WQ_v within the facility to be released over a minimum 30 minute duration.
- Bottom width no greater than 8 feet, but no less than two feet.
- Soil media as detailed in Appendix H.

MAINTENANCE

- Removal of sediment build-up within the bottom of the channel or filter strip when 25% of the original WQ_v volume has been exceeded.
- Maintain a grass height of 4" to 6" in dry swales.

STORMWATER MANAGEMENT SUITABILITY

[X] Water Quality
[ ] Channel Protection
[ ] Overbank Flood Protection
[ ] Extreme Flood Protection

Accepts Hotspot Runoff: *Yes*
(requires impermeable liner)

IMPLEMENTATION CONSIDERATIONS

[L] Capital Cost
[L] Maintenance Burden

Residential
Subdivision Use: *Yes*

High Density/Ultra-Urban: *No*

Drainage Area: *5 acres max.*

Soils: *No restrictions*

Other Considerations:

- *Permeable soil layer (dry swale)*
- *Wetland plants (wet swale)*

Key: **H**=High **M**=Medium **L**=Low

POLLUTANT REMOVAL

[G] Phosphorus

	$\boxed{\textbf{F}}$	Nitrogen
	$\boxed{\textbf{G}}$	Metals - Cadmium, Copper, Lead, and Zinc removal
	$\boxed{\textbf{P}}$	Pathogens - Coliform, Streptococci, E.Coli removal
		Key: **G**=Good **F**=Fair **P**=Poor