Chapter 5
Permanent Storm Water Management Controls

5.0 Introduction

This chapter describes several factors that are important for identifying the most appropriate permanent storm water control for a site. The factors that should be evaluated in selecting permanent BMPs are discussed in Section 5.1. LID or environmental site design concepts (Section 5.2) can be used to reduce the volume of runoff discharged to permanent BMPs, thereby reducing their size and cost. For projects in high pollutant source areas, source controls must also be implemented (Section 5.3). In Alaska, the diversity of climate, soils, terrain and other factors make designing permanent storm water controls particularly challenging. Section 5.4 describes permanent BMPs applicable to the five climatic regions in Alaska, as well as design adaptations for those BMPs. Finally, Section 5.5 discusses maintenance issues related to permanent BMPs.

Water quality impacts from urban runoff can be significant, but selecting appropriate permanent storm water controls during the design phase can help mitigate such effects. The Center for Watershed Protection, in cooperation with the EPA, has published *Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program* (see Link 63 in Appendix A). Although the guide was written for municipalities developing a post-construction program, it has many useful sections for engineers designing permanent storm water controls. The following sections provide relevant guidance:

- Chapter 3 describes how land-use planning and watersheds should be considered when selecting storm water BMPs.
- Chapter 4 describes different design criteria and the hierarchy of permanent storm water BMP selection—from site planning and design to source control/pollution prevention to storm water collection and treatment.
- Tool No. 6 includes checklists for construction and maintenance of various BMPs.

- Tool No. 8 includes a checklist to help assess the performance of manufactured and proprietary BMPs.

5.1 Selecting Permanent Storm Water Controls

There are many issues that affect the selection of a permanent storm water control for a specific site. The *Minnesota Stormwater Steering Committee* (MSSC 2006) describes the following systematic approach consisting of eight steps that project designers should consider during BMP selection:

1. **Investigate Pollution Prevention Opportunities:** Evaluate the site to look for opportunities to prevent pollution mobilization by runoff.
2. **Design Site to Minimize Runoff:** Assess whether any better site design techniques can be applied at the site to minimize runoff and reduce the size of structural BMPs.
3. **Identify Receiving Water Issues:** Understand the regulatory status of the receiving water to which the site drains. Depending on the nature of the receiving water, certain BMPs might be promoted, restricted or prohibited, or special design or sizing criteria could apply.
4. **Identify Climate and Terrain Factors:** Climate and terrain conditions vary widely across the state, and designers need to explicitly consider how each regional factor will influence the BMPs proposed for the site.
5. **Evaluate Storm Water Treatment Suitability:** Not all BMPs work over the wide range of storm events that need to be managed at the site, so designers need to choose the type or combination of BMPs that will provide the desired level of treatment. (See the storm water treatment suitability matrix below.)
6. **Assess Physical Feasibility at the Site:** Each development site has many physical constraints that influence the feasibility of different kinds of BMPs; designers confirm feasibility by assessing eight physical factors at the site. Such physical factors include surface area of the BMP, drainage area, soil infiltration rate, hydraulic head, separation from bedrock, depth to seasonally high water table, maximum slope, and whether the BMP is appropriate for ultra-urban settings.
7. **Investigate Community and Environmental Factors:** Each group of BMPs provides different economic, community and environmental benefits and drawbacks; designers need to carefully weigh these factors when choosing BMPs for the site.
8. **Determine Any Site Restrictions and Setbacks:** Check to see if any environmental resources or infrastructure are present that will influence where a BMP can be located at the development site.

Storm Water Treatment Suitability Matrix

Table 5-1 is intended to be used by design engineers as a screen for whether a BMP can meet the runoff hydrology and water quality benefits needed. This table (adapted from the *Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates* (Metropolitan Council 2009) St. Paul, MN, see Web Link 64 in Appendix A.) rates the runoff rate control or volume reduction as high, medium or low. It also rates the water quality benefit provided for four common pollutants [TSS, phosphorus (P) and nitrogen (N), metals, and fecal coliform]. *Primary* indicates that this is the primary benefit of the BMP. *Secondary* indicates that the BMP has some benefit, but this is not its primary purpose. A *minor* benefit indicates that little or no water quality benefit is expected for that pollutant.

Site designers should first identify the primary pollutant of concern at the site (this is the pollutant expected to be generated by the project after construction) and then select the type of BMP whose primary purpose is the control of that pollutant. For example, a site that would be expected to generate primarily nutrients should consider infiltration BMPs, where feasible.

Site designers should also consider using BMPs in sequence (e.g., a treatment train approach). For example, a site designer could use a check dam, grass channel and wet pond in series to produce the required results, instead of relying on a wet pond only.

Table 5-1. Storm water treatment suitability matrix

BMP family	BMP list	RUNOFF HYDROLOGY		WATER QUALITY BENEFIT			
		Rate control	Volume reduction	TSS	P&N	Metals	Fecal coliform
Retention	Wet Pond	High	Low	Primary	Secondary	Secondary	Secondary
	Extended Storage Pond	High	Low	Primary	Secondary	Secondary	Secondary
	Wet Vaults	Medium	Low[a]	Primary	Secondary	Secondary	Minor
Detention	Dry Pond	High	Low	Secondary	Minor	Minor	Minor
	Oversized Pipes	High	Low	Minor	Minor	Minor	Minor
	Oil/Grit Separator	Low	Low	Secondary	Minor	Minor	Minor
	Dry Swale	Medium	Low[a]	Primary	Secondary	Primary	Minor
Infiltration	On-Lot Infiltration	Medium	High	Primary	Primary	Primary	Secondary
	Infiltration Basin	Medium	High	Primary	Primary	Primary	Secondary
	Infiltration Trench	Medium	High	Primary	Primary	Primary	Secondary
Wetland	Storm Water Wetland	High	Medium	Primary	Secondary	Secondary	Primary
	Wet Swale	Low	Low	Primary	Secondary	Secondary	Minor
Filtration	Surface Sand Filters	Low	Low[a]	Primary	Secondary	Primary	Secondary
	Underground Filters	Low	Low	Primary	Secondary	Primary	Secondary
	Bioretention	Medium	Medium	Primary	Primary	Primary	Secondary
	Filter Strips	Medium	Medium	Secondary	Minor	Minor	Minor

Source: Metropolitan Council, 2009, see Web Link 64 in Appendix A

P&N = phosphorus and nitrogen

a. Might provide some volume reduction depending on permeability of native soil.

5.2 Low Impact Development/Environmental Site Design Concepts

The need for *traditional* permanent BMPs such as infiltration basins or wet ponds can be reduced through the use of LID or environmental site design concepts. Like other alternative development strategies, LID seeks to control storm water at its source. Rather than moving storm water off-site though a conveyance system, the goal of LID is to restore the natural, pre-developed ability of an urban site to absorb storm water.

LID integrates small-scale measures distributed throughout the development site. Constructed green spaces, native landscaping, and a variety of innovative bioretention and infiltration techniques capture and manage storm water on-site. LID reduces peak runoff by allowing rainwater to soak into the ground, evaporate into the air, or collect in storage receptacles for irrigation and other beneficial uses. In areas with slow drainage or infiltration, LID captures the first flush of runoff before excess storm water is diverted into traditional storm conveyance systems. The result is development that more closely maintains predevelopment hydrology. Furthermore, LID has been shown to be cost-effective, and in some cases, less expensive than using traditional storm water management techniques.

Additional information on LID is available from a number of sources: USEPA (see Web Link 65 in Appendix A), the Low Impact Development Center (Link 66 in Appendix A), and the Puget Sound Action Team (Link 67 in Appendix A).

LID Techniques

LID can be simple and effective. Instead of relying solely on complex and costly collection, conveyance, storage and treatment systems, LID employs a range of economical devices that control runoff at the source.

Bioretention cells, commonly known as *rain gardens*, are relatively small-scale, landscaped depressions containing plants and a soil mixture that absorbs and filters runoff.

Cisterns and rain barrels harvest and store rainwater collected from roofs. By storing and diverting runoff, these devices help reduce the flooding and erosion caused by storm water runoff. And because they contain no salts or sediment, they can provide *soft*, chemical-free water for garden or lawn irrigation, reducing water bills and conserving municipal water supplies.

Green roofs are rooftops partially or completely covered with plants. Used for decades in Europe, green roofs help mitigate the urban *heat island* effect and reduce peak storm water

flows. The vegetated cover also protects and insulates the roof, extending its life and reducing energy costs.

Permeable and porous pavements reduce storm water runoff by allowing water to soak through the paved surface into the ground beneath. Permeable pavement encompasses a variety of mediums, from porous concrete and asphalt, to plastic grid systems and interlocking paving bricks suitable for driveways and pedestrian malls. Permeable pavement helps reduce runoff volumes at a considerably lower cost than traditional storm drain systems.

Dry swales are broad, open channels sown with erosion-resistant and flood-tolerant grasses. Used alongside roadways for years primarily as storm water conveyances, swales can slow storm water runoff, filter it and allow it to soak into the ground. Swales and other biofiltration devices like grass filter strips improve water quality and reduce in-stream erosion by slowing the velocity of storm water runoff before it enters the stream. Swales also cost less to install than curbs, storm drain inlets and piping systems.

5.3 Source Control Practices for High Pollutant Source Hotspots

For some high pollutant source hotspots (e.g., some industries and commercial businesses, such as gas stations or large parking lots—for more information, see Section 2.7), the primary focus should be on reducing the exposure of the pollutants to storm water before permanent storm water controls are selected. Source control practices are used to minimize exposure of potential pollutants to storm water runoff. Examples of source control nonstructural and structural BMPs include using less toxic chemicals and covering an activity area that might be a pollutant source. Source control BMPs are preferred over treatment control BMPs because they prevent pollutants from being introduced into storm water (therefore treatment is not required to remove the pollutant), and source controls are usually, but not always, less costly than treatment control BMPs.

Common source control practices include the following:

- Housekeeping Practices
- Public Education/Participation
- Employee Training
- Conserving Natural Areas/Vegetation Controls

- Protecting Slopes & Channels
- Providing Storm Drain System Stenciling & Signage
- Trash Storage Areas
- Outdoor Material Handling and Storage Areas
- Covering Loading/Unloading Dock Areas
- Covering Waste Handling & Disposal
- Improving Vehicle Fleet Management
- Repair/Maintenance Bays
- Sweeping Parking Area

Additional information on different source control BMPs for pollutant hotspots is at

- California Stormwater Quality Association *Industrial and Commercial Stormwater BMP Handbook* (see Link 68 in Appendix A).
- Center for Watershed Protection *Pollution Source Control Practices* (see Link 69 in Appendix A).

5.4 Permanent Storm Water BMPs

Table 5-2 lists the feasibility of various storm water practices on the basis of the five Alaskan climatic regions. Following this table are design adaptations for 13 common permanent BMPs.

Table 5-2. Feasibility of storm water BMPs, based on climatic region

Storm water treatment practices (STP)	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
Bioretention	○	○	□	○	✪
Infiltration	□	□	□	□	■
Filtering Practices	□	□	■	□	■
Dry ED Ponds	□	○	○	○	■
Constructed Wetlands	○	□	✪	✪	✪
Wet Ponds	○	□	■	■	■
Green Roofs	✪	□	■	■	■
Rain Tank/Cistern	✪	■	■	■	■
Permeable Pavers	□	□	■	■	■
Dry Swale	○	□	■	○	■
Filter Strips	✪	○	○	○	✪
Underground	□	□	■	■	■

Feasibility symbols:

○ Widely feasible

□ Might be feasible in certain situations

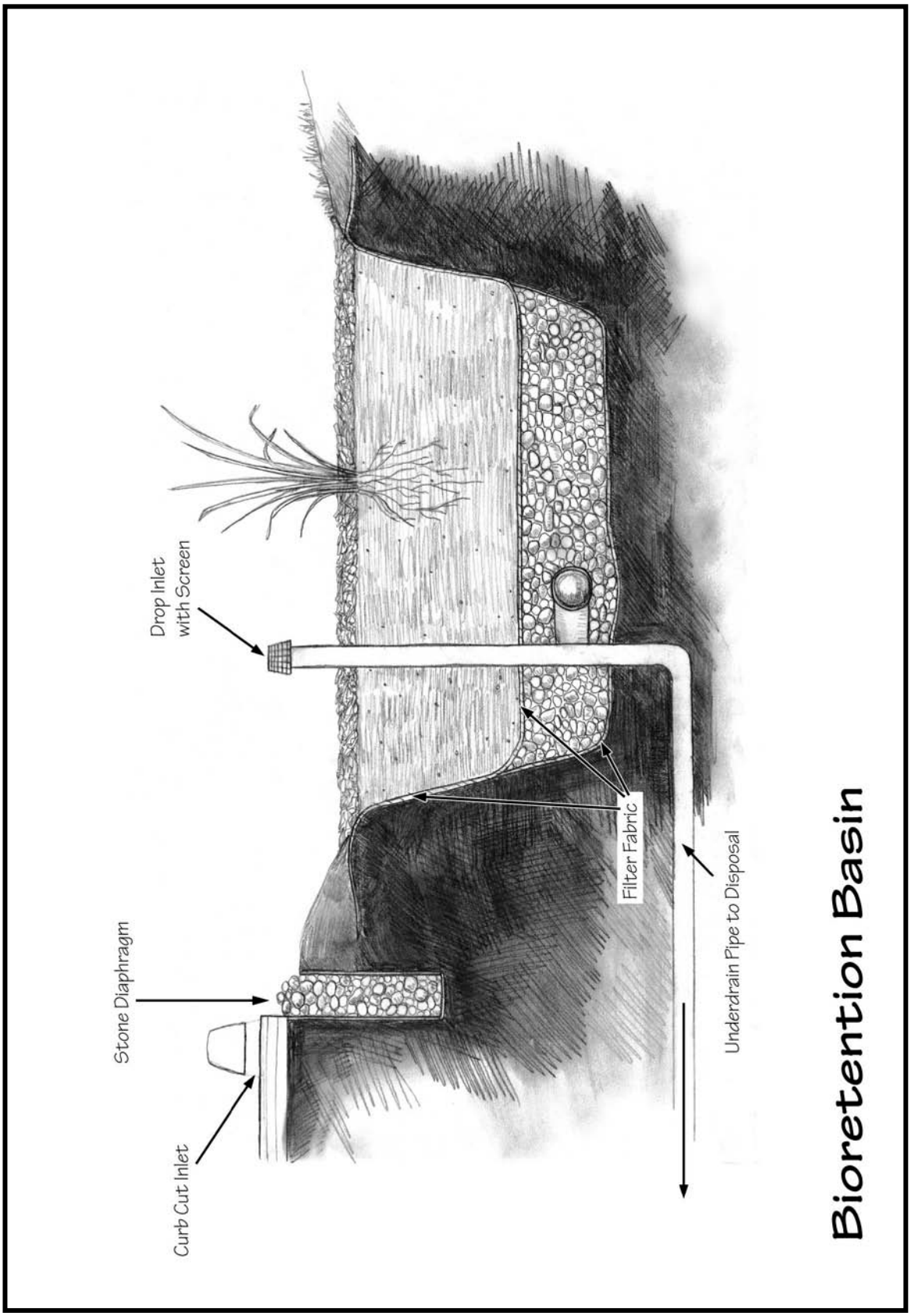
✪ Feasible only with major design adaptation

■ Infeasible and not recommended

Sources: Shannon and Wilson 2006; *Extremely Cold Climate Stormwater Survey*, Caraco and Claytor 1997; MOA 2007

Note: These recommendations are general guidance; site-specific conditions will dictate proper BMP selection

This page intentionally left blank.


Drop Inlet
with Screen
Stone Diaphragm
Curb Cut Inlet
Filter Fabric
Underdrain Pipe to Disposal
Bioretention Basin

Bioretention Design Adaptations for Alaska

STP	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
	○	○	□	○	✪
Basic Bioretention Design Adaptation for Alaska	• A two-cell design is recommended, with the first cell designed as a pretreatment cell to capture sediments and the second cell designed as the bioretention filter. • Bioretention areas should be used for snow storage only if an overflow is provided and they are planted with salt-tolerant, non-woody plant species. To reduce the potential for freezing, the filter bed and underdrain pipe should be extended below the frost line, or the underdrain should be oversized by one pipe size, or both. • For a plant species list, see Web Link 70 in Appendix A. • Tree and shrub locations cannot conflict with plowing and piling of snow into storage areas. • A combination of peat and sand should be used for soil media (or loamy sand or sandy loam). • The surface layer can consist of river stone or hardwood mulch.				
Extreme Design	• In high rainfall areas, an oversized overflow and underdrain are needed so the bioretention area does not become continuously saturated and soggy. The plant mix should be adapted to rainforest conditions. • For areas with permafrost, the filter depth can be shallow (one foot) with a 9-inch underdrain layer.				

Feasibility symbols:

○ Widely feasible

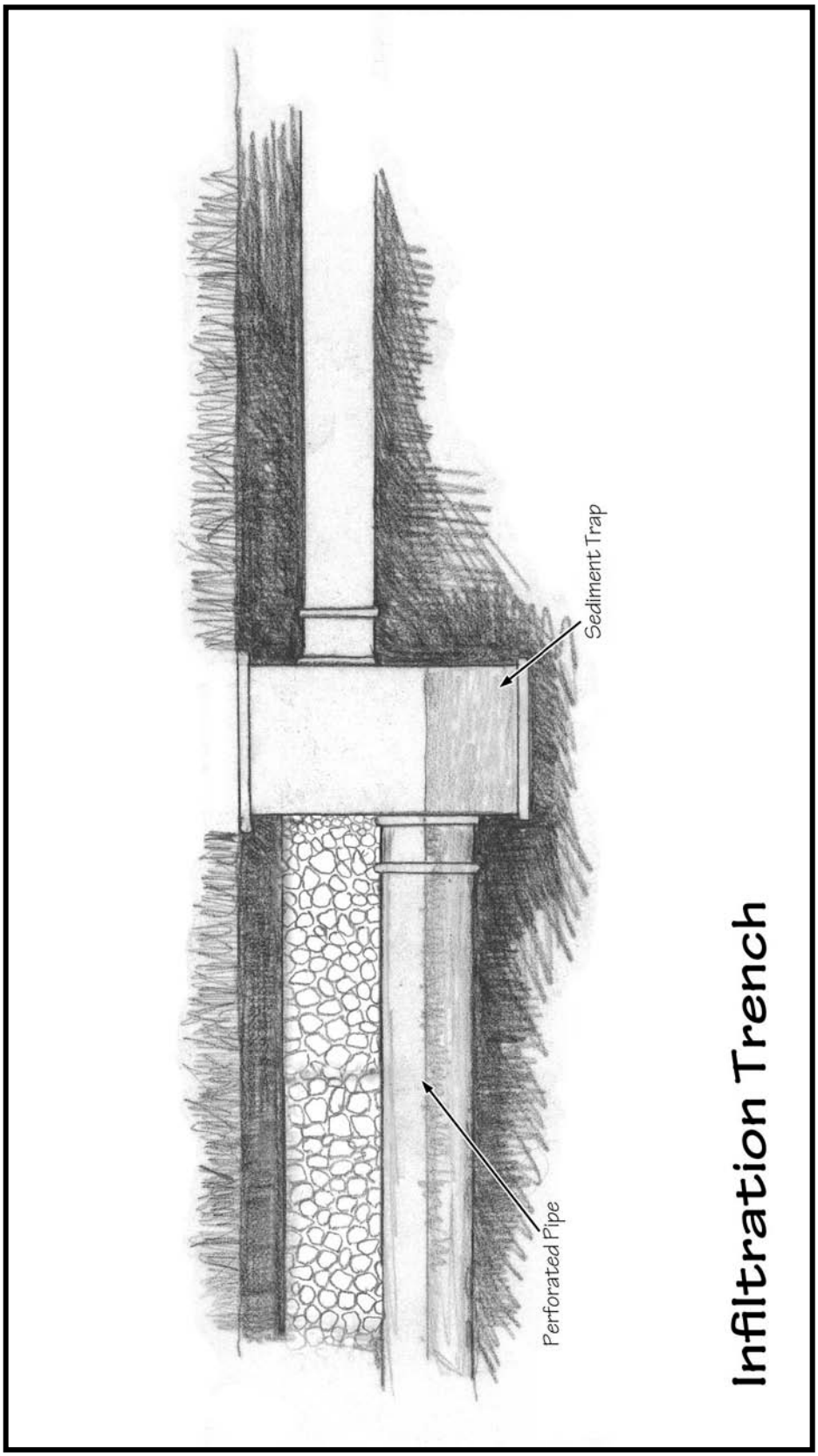
□ Might be feasible in certain situations

✪ Feasible only with major design adaptation

■ Infeasible and not recommended

Notes

Performance studies show that bioretention effectively captures and treats runoff during winter months with average daily temperatures in the –5 to 10 degree Celsius (° C) range (Traver 2005; UNH 2005). Frost penetration of filter media occurred and varied from zero to 17 cm in studies at the University of New Hampshire (Roseen 2007). While bioretention frequently captures runoff containing high chloride concentrations, the chloride will pass through without treatment.


Sediment Trap
Perforated Pipe
Infiltration Trench

Infiltration Design Adaptation for Alaska

STP	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
	☐	☐	☐	☐	■
Basic Infiltration Design Adaptation for Alaska	• Infiltration practices are generally not feasible in extremely cold climates that experience permafrost. • In high precipitation zones (Climatic region A), infiltration might not be feasible in areas with shallow, saturated, nonporous soils or a prevalence of bedrock near the surface. • In less extreme climates, infiltration can work if the bottom of the practice extends below the frost line. • If the infiltration practice treats roadside runoff, a flow diversion might be desired to divert flow in the winter to prevent movement of chlorides into groundwater and to prevent clogging by road sand. • Pretreatment cells must be oversized to account for the additional sediment load caused by road sanding and sparse vegetative cover (up to 40% of the WQv). • Infiltration practices should have at least a 25-foot setback from roadways and foundations to prevent potential frost-heaving. • Infiltration should be avoided if the site is classified as a potential storm water hotspot or is within a sole-source drinking water area.				
Extreme Design	• For areas with permafrost, excavation should not extend to within 3 feet of the permafrost layer. • For high rainfall areas, acceptable soil infiltration rates are 1 to 4 inches per hour.				

Feasibility symbols:

○ Widely feasible

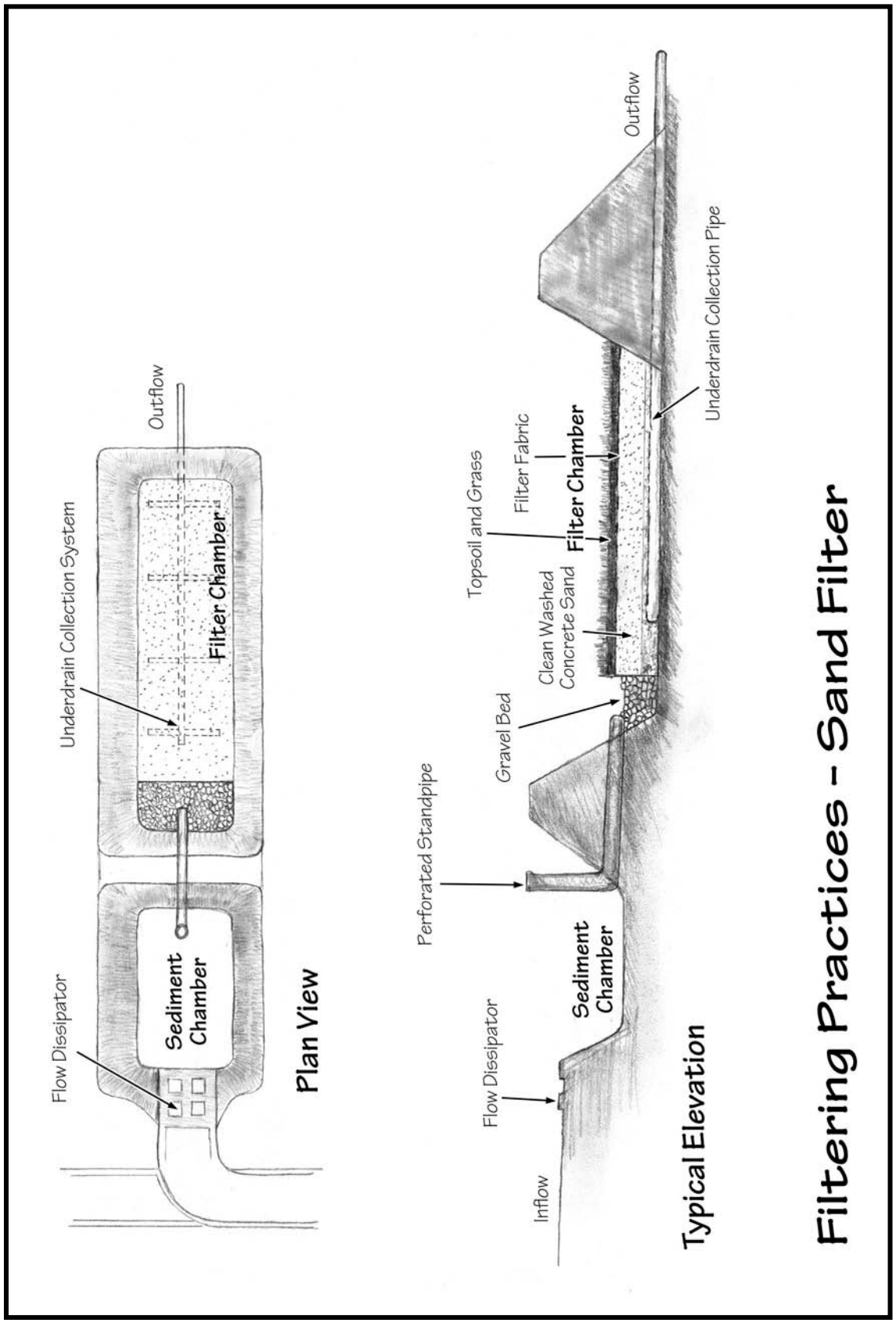
✪ Feasible only with major design adaptation

☐ Might be feasible in certain situations

■ Infeasible and not recommended

Note

Infiltration can be designed to withstand more moderate winter conditions. The main problem is ice forming in the voids or the subsoils below, which could briefly cause nuisance flooding when spring melt occurs.


Outflow
Underdrain Collection System
Filter Chamber
Flow Dissipator
Sediment Chamber
Plan View
Outflow
Underdrain Collection Pipe
Filter Fabric
Topsoil and Grass
Filter Chamber
Clean Washed Concrete Sand
Gravel Bed
Perforated Standpipe
Sediment Chamber
Flow Dissipator
Inflow
Typical Elevation
Filtering Practices - Sand Filter

Sand Filter Design Adaptation for Alaska

STP	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
	□	□	■	□	■
Basic Sand Filter Design Adaptation for Alaska	• Sand filters have two primary applications in Alaska—treatment of designated storm water hotspots in the summer and treatment of snow storage melt water in the spring. • The design should include two excavated cells, and the use of concrete should be minimized. • A weir should be placed between the pretreatment chamber and the filter bed as a more effective substitute for a traditional standpipe orifice because it will reduce ice formation. • Sand filters should be operated in a seasonal mode.				
Extreme Design	• For areas with permafrost, extend the filter bed below the frost line to prevent freezing in the filter bed. • The underdrain should be oversized to encourage more rapid drainage that will minimize freezing of the filter bed. • The sediment chamber should be expanded to account for road sanding. Pretreatment chambers should be sized for up to 40% of the WQv.				

Feasibility symbols:

○ Widely feasible

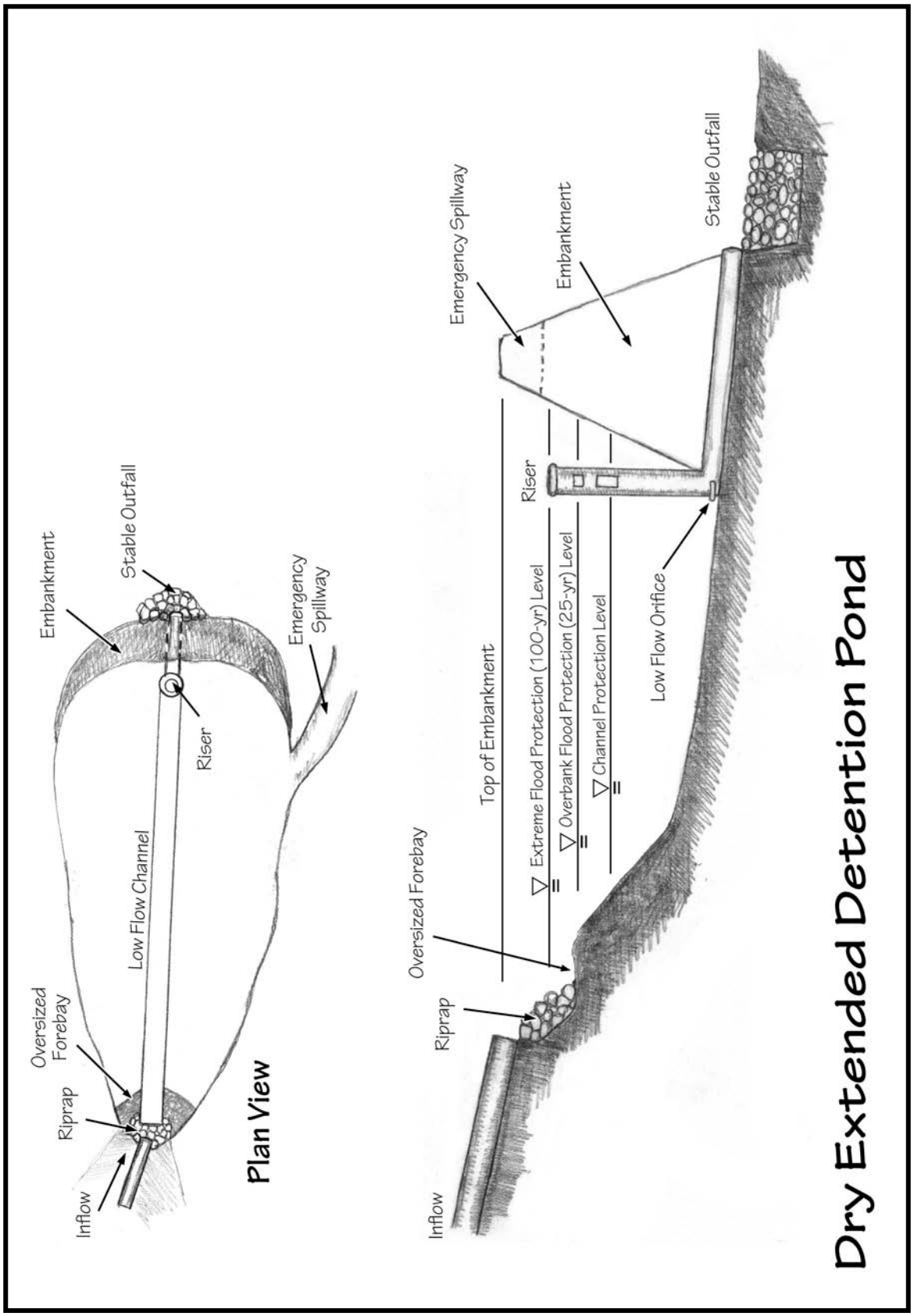
□ Might be feasible in certain situations

✪ Feasible only with major design adaptation

■ Infeasible and not recommended

Notes

Sand filters might not always be effective during the winter months. The main problem is ice that forms over and within the filter bed. Ice formation can briefly cause nuisance flooding if the filter bed is still frozen when spring melt occurs. To avoid these problems, filters should be inspected and maintained before the onset of winter (before the first freeze) to dewater wet chambers and scarify the filter surface.


Embankment
Stable Outfall
Emergency Spillway
Riser
Low Flow Channel
Oversized Forebay
Riprap
Inflow
Plan View
Emergency Spillway
Embankment
Stable Outfall
Riser
Top of Embankment
Extreme Flood Protection (100-yr) Level
Overbank Flood Protection (25-yr) Level
Channel Protection Level
Low Flow Orifice
Oversized Forebay
Riprap
Inflow
Dry Extended Detention Pond

Extended Detention Wetland Design Adaptation for Alaska

STP	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
	□	○	○	○	■
Basic Dry Extended Detention (ED) Pond Design Adaptation for Alaska	Winter conditions can lead to ice formation within inlets, flow splitters, and ED outlet pipes. Designers can minimize these problems with the following practices: • Oversize the forebay to account for the higher sedimentation rate. • Operate in a seasonal mode that provides ED storage to treat snowmelt runoff in the spring. During the summer, the facility will act as a shallow wetland. • Do not submerge inlet pipes, and increase the slope of inlet pipes by a minimum of 1% to discourage standing water and prevent potential ice formation in upstream pipes. • Place all pipes below the frost line to prevent frost heave and pipe freezing. • Design low-flow orifices to withdraw at least 6 inches below the typical ice layer. • Place trash racks at a shallow angle to prevent ice formation.				
Extreme Design	• Ponds should not be excavated below permafrost layer; rather, they should be excavated below the frost line. • If operated as an ED wetland, it is acceptable for excavation to intersect with the water table. • If soils are so permeable that a constant water table cannot be maintained in the summer, designers should consider an infiltration basin as an alternative.				

Feasibility symbols:

○ Widely feasible

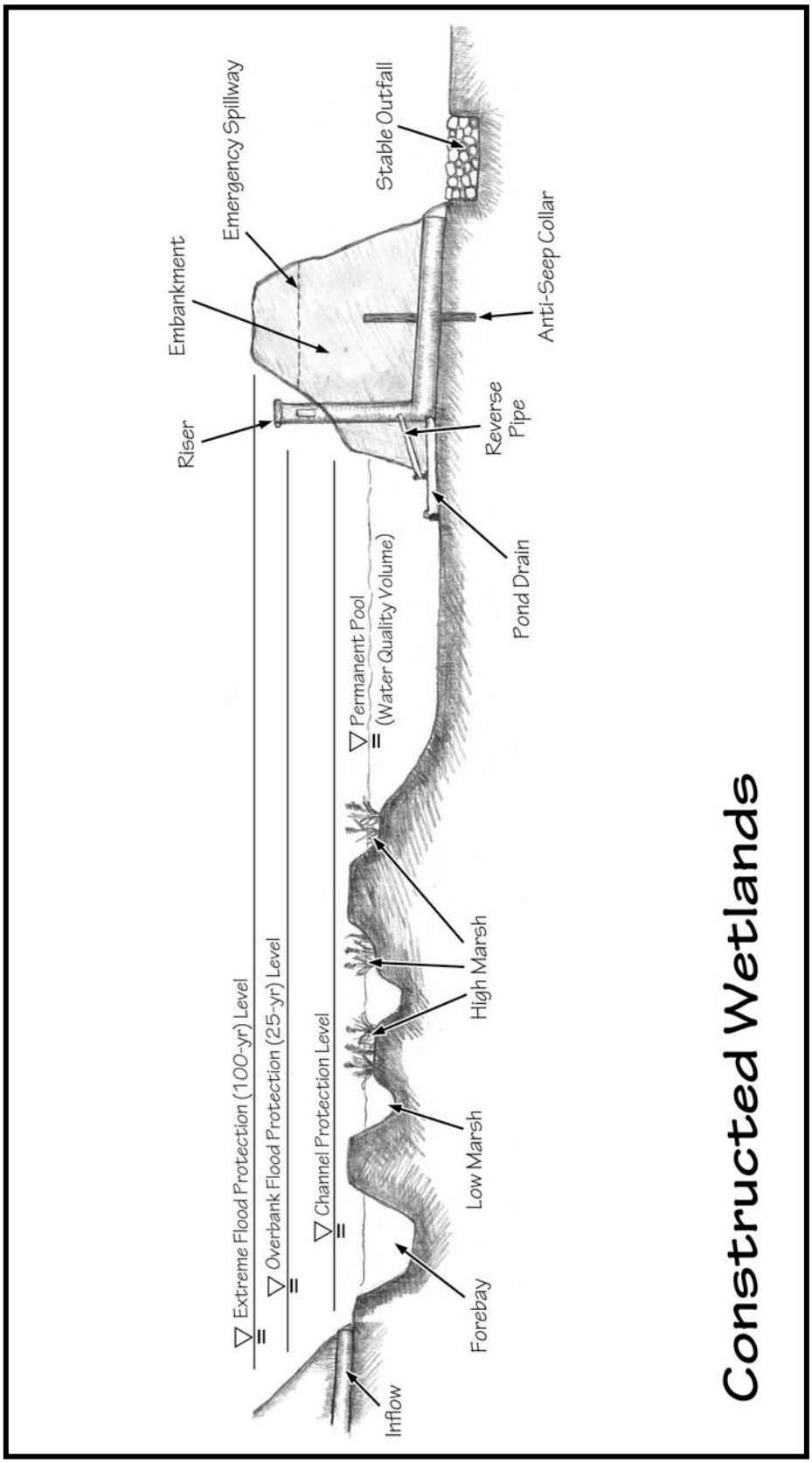
✪ Feasible only with major design adaptation

□ Might be feasible in certain situations

■ Infeasible and not recommended

Note

Several alternative outlet designs are in MSSC (2005) and Caraco and Claytor (1997).


Extreme Flood Protection (100-yr) Level
Overbank Flood Protection (25-yr) Level
Channel Protection Level
Permanent Pool
(Water Quality Volume)
Riser
Embankment
Emergency Spillway
Stable Outfall
Anti-Seep Collar
Reverse Pipe
Pond Drain
High Marsh
Low Marsh
Forebay
Inflow
Constructed Wetlands

Constructed Wetland Design Adaptation for Alaska

STP	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
	○	□	✪	✪	✪
Basic Constructed Wetland Design Adaptation for Alaska	• Shallow, forested constructed wetlands are a good option for many precipitation zones if space is available. • Designs should minimize the amount of complex inflow and outflow devices and should serve smaller drainage areas (5 to 20 acres). • In regions Southcentral, Western, Interior and Arctic, wetlands should be designed with two stages and operated seasonally. The top stage should be designed to provide ED for spring snowmelt, and the bottom wetland stage will serve as summer storm treatment. • The vertical elevation of both stages should not exceed 4 or 5 feet to reduce the likelihood of difficulties with excavation. • Wetlands should contain multiple cells and maximize plant/water contact. For design guidance, see Cappiella et al. (2008). • Wetland bottoms can contain sand or peat amendments. • Wetlands can be planted with native trees and shrubs, or they can be prepared to enable native plant species to colonize. Contact the local COE office to obtain information on native plants.				
Extreme Design	• For basic restrictions in cold climates, see the dry ED pond guidelines. • For areas with permafrost, maintain a total depth of one foot or less, use surface or gravel berms to create cells close to the ground elevation, and do not excavate into the permafrost.				

Feasibility symbols:

○ Widely feasible

□ Might be feasible in certain situations

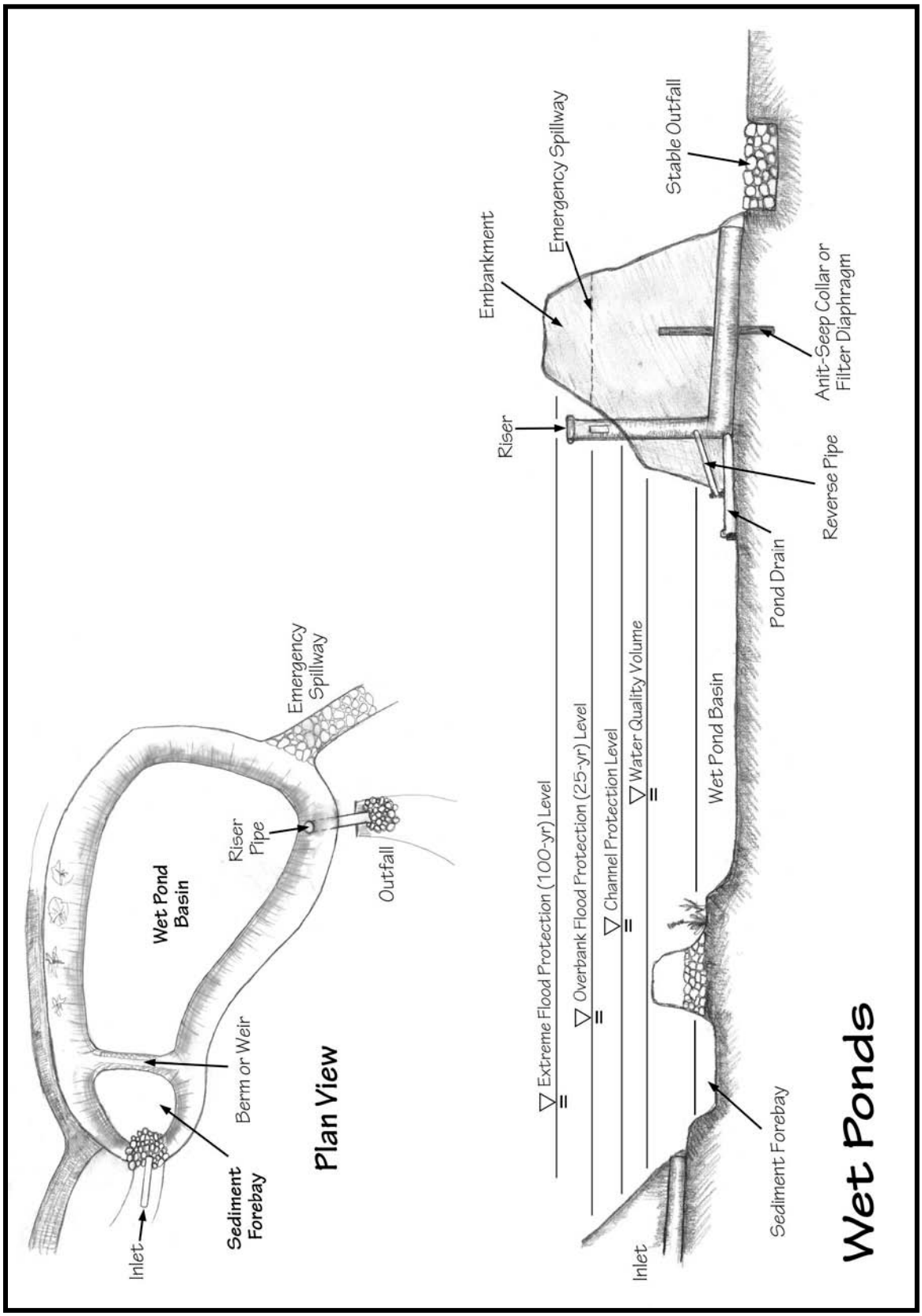
✪ Feasible only with major design adaptation

■ Infeasible and not recommended

Notes

Wetland performance decreases when snowmelt runoff delivers high pollutant loads. Shallow constructed wetlands can freeze in the winter, which allows runoff to flow over the ice layer and exit without treatment. Inlet and outlet structures close to the surface could also freeze, further diminishing wetland performance.

Salt loadings are higher in cold climates due to winter road maintenance. High chloride inputs have a detrimental effect on native wetland vegetation and can shift the wetland to more salt-tolerant species (Wright et al. 2006). Designers should choose salt-tolerant species when crafting their planting plan.


Wet Ponds
Plan View
Wet Pond Basin
Inlet
Sediment Forebay
Berm or Weir
Riser Pipe
Outfall
Emergency Spillway
Inlet
Sediment Forebay
Wet Pond Basin
Extreme Flood Protection (100-yr) Level
Overbank Flood Protection (25-yr) Level
Channel Protection Level
Water Quality Volume
Riser
Embankment
Emergency Spillway
Pond Drain
Reverse Pipe
Anit-Seep Collar or Filter Diaphragm
Stable Outfall

Wet Pond Design Adaptation for Alaska

STP	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
	○	□	■	■	■
Basic Wet Pond Design Adaptation for Alaska	• Basic wet ponds are generally not recommended in four of the five climatic regions because of a lack of capacity to accept spring snowmelt, poor winter performance from ice and stratification, and difficulty in maintaining a constant water level in the summer. • A wet ED pond design might work more effectively, particularly if the ED treats larger runoff volumes in the spring (see MSSC 2006). • Salt-tolerant vegetation should be planted in pond benches. • Inlet pipes should not be submerged. • A minimum 1% pipe slope should be provided to discourage ice formation. • Low-flow orifices should be located so they withdraw at least 6 inches below the typical ice layer. • Trash racks should be angled to prevent ice formation. • Riser and weir structures should be oversized to avoid ice formation and to prevent freezing of the pipe. • The forebay size should be increased if road sanding is prevalent in the contributing drainage area.				
Extreme Design	• Several designers report difficulty in maintaining ponds in summer without resorting to the use of expensive liners. If soils are so permeable that a constant water table cannot be maintained in summer, designers should consider ED wetlands or an infiltration basin as alternatives.				

Feasibility symbols:

○ Widely feasible

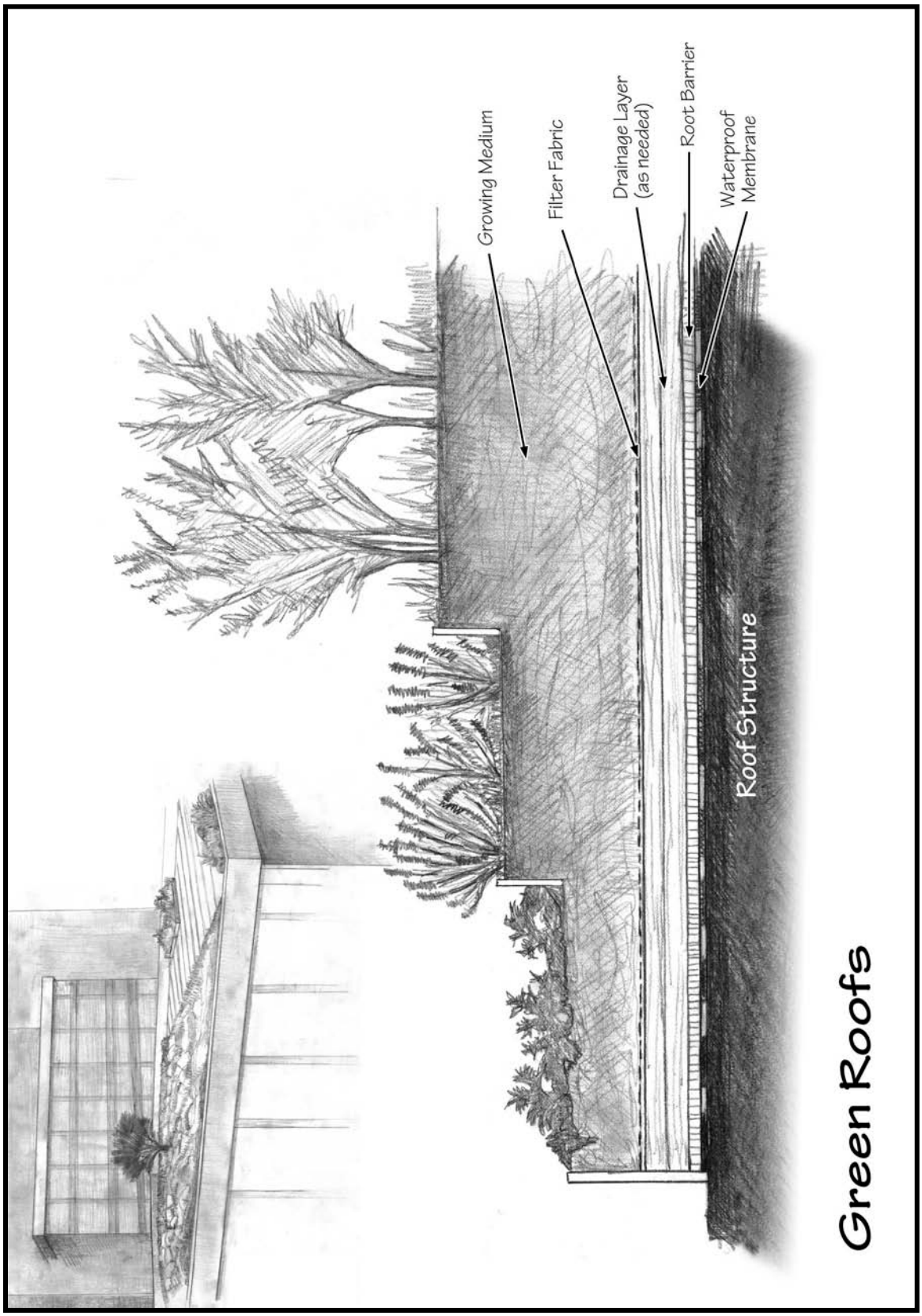
✪ Feasible only with major design adaptation

□ Might be feasible in certain situations

■ Infeasible and not recommended

Note

For an extensive discussion of pond performance in extremely cold climates, see MSSC (2005) and Oberts (2007).


Growing Medium
Filter Fabric
Drainage Layer
(as needed)
Root Barrier
Waterproof
Membrane
Roof Structure
Green Roofs

Green Roof Design Adaptation for Alaska

STP	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
	✪	□	■	■	■
Basic Green Roof Design Adaptation for Alaska	• Green roofs can be installed on building roofs with slopes up to 25 percent. • The load-bearing capacity of the roof must account for the weight of the soil, vegetation, ponded water and accumulated snow. • Native vegetation should be selected to ensure plant survival during weather extremes and for quick establishment in short growing seasons. • Excess runoff can be diverted to a second storm water BMP, such as bioretention, a rain tank or cistern, or another filtering practice.				
Extreme Design	• For high rainfall areas, an oversized overflow and rooftop drainage system are needed to avoid continuous saturation. The plant mix should be adapted to rainforest conditions.				

Feasibility symbols:

○ Widely feasible

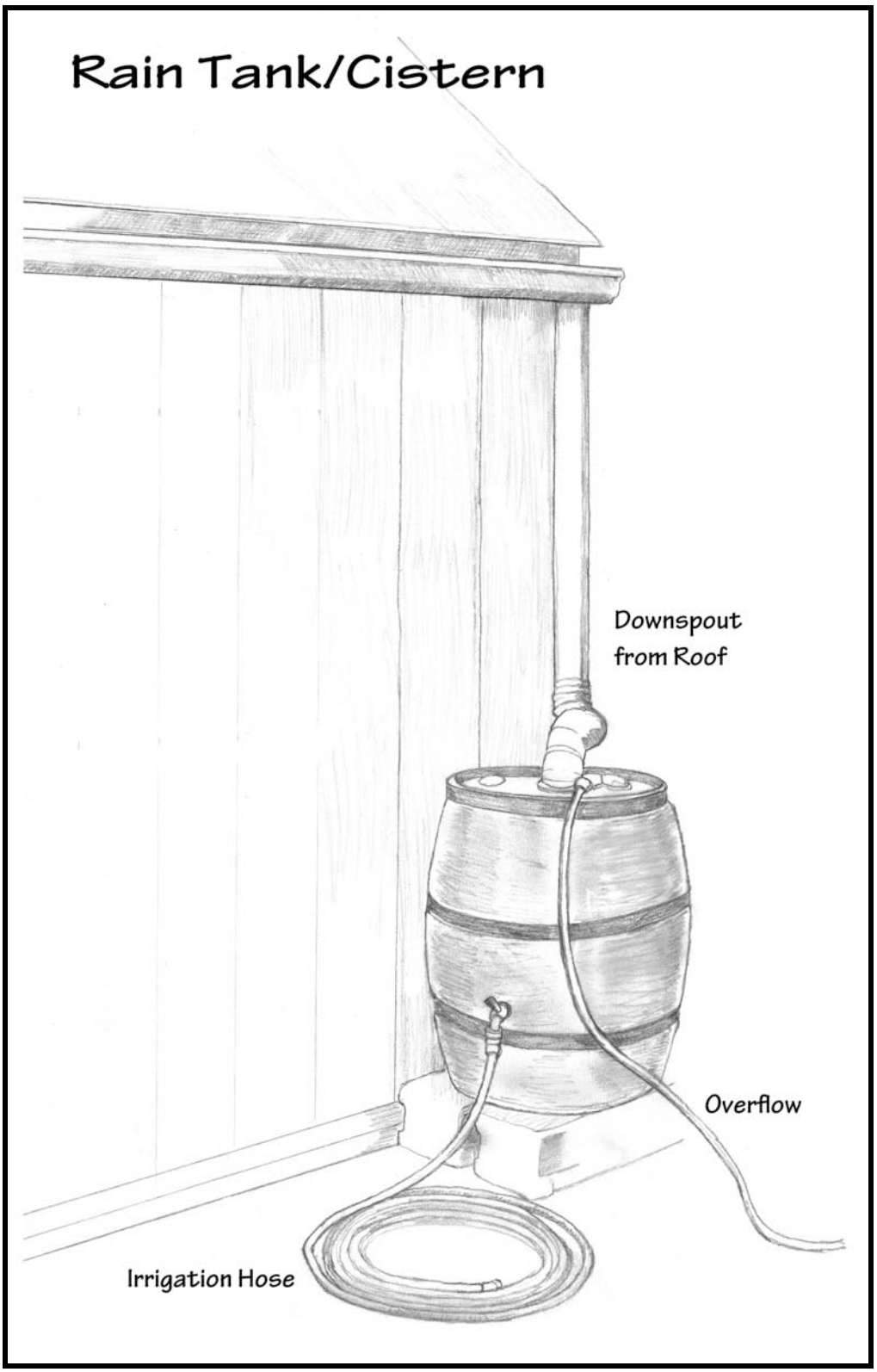
□ Might be feasible in certain situations

✪ Feasible only with major design adaptation

■ Infeasible and not recommended

Note

Snow cover will protect the vegetation during winter months.


Rain Tank/Cistern
Downspout
from Roof
Overflow
Irrigation Hose

Rain Tank/Cistern Design Adaptation for Alaska

STP	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
	✪	■	■	■	■
Basic Rain Tank/Cistern Design Adaptation for Alaska	• Gutters and downspouts should be sized and configured to minimize overflow events, just as they would be for a building without a rainwater harvesting system. • Rain tanks can be used throughout the winter if placed inside a building or buried underground.				
Extreme Design	• The rain tank overflow system should be designed to safely divert water away from the rain tank during intense storms or rain-on-snow events.				

Feasibility symbols:

○ Widely feasible

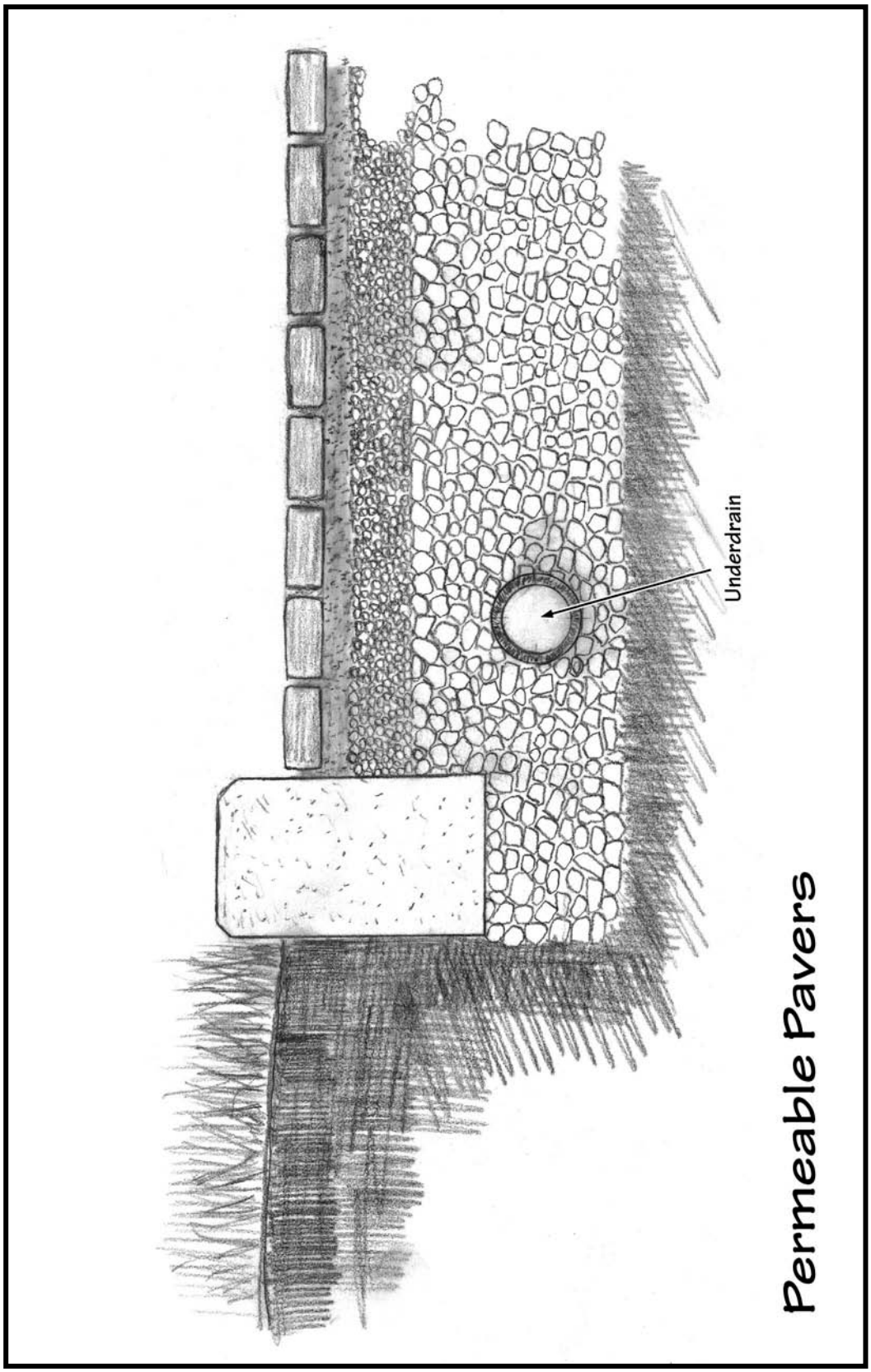
☐ Might be feasible in certain situations

✪ Feasible only with major design adaptation

■ Infeasible and not recommended

Note

The size of the rain tank/cistern will depend on the frequency and volume of rain and snow events, intended use of the captured storm water, budget and aesthetics.


Underdrain
Permeable Pavers

Permeable Pavers Adaptation for Alaska

STP	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
	□	□	■	■	■
Basic Permeable Pavers Design Adaptation for Alaska	• Permeable pavers are unsuitable in most Alaskan regions because of permafrost, salt and sand application for ice and snow control, and snow plowing. • Suitable sites for porous pavements are generally limited to low-traffic areas with a minimum soil infiltration capacity of 0.27 inches/hour. • Pavers can be heated from below to encourage snowmelt and infiltration.				

Feasibility symbols:

○ Widely feasible

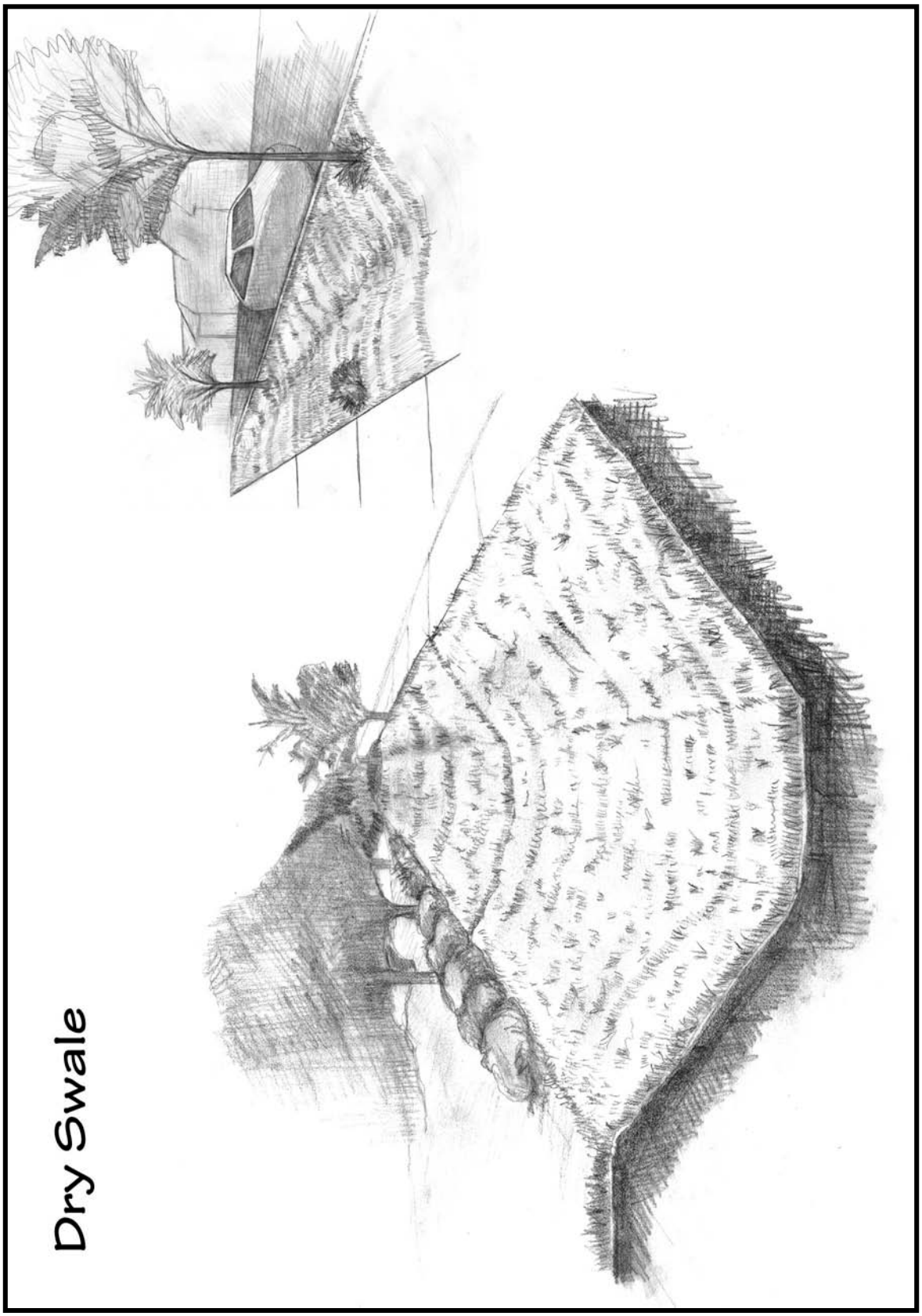
✪ Feasible only with major design adaptation

□ Might be feasible in certain situations

■ Infeasible and not recommended

Note

In Norway, permeable pavers have been implemented successfully using design adaptations that mitigate frost heave (Stenmark 1995).


Dry Swale

Dry Swale Design Adaptation for Alaska

STP	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
	○	□	■	○	■
Basic Dry Swale Design Adaptation for Alaska	• Permafrost in the Interior and Arctic climatic regions makes infiltration of runoff difficult or impossible. • Select appropriate native vegetation to ensure plant survival during weather extremes and rapid establishment during a short growing season. • The swale should be designed to convey the locally required design storm at non-erosive velocities and without overflow. • Oversize the underdrains to promote rapid drainage and prevent freezing of the filter media and underdrains. • Soil amendments such as peat or sand should be added to promote greater filtration and infiltration.				

Feasibility symbols:

○ Widely feasible

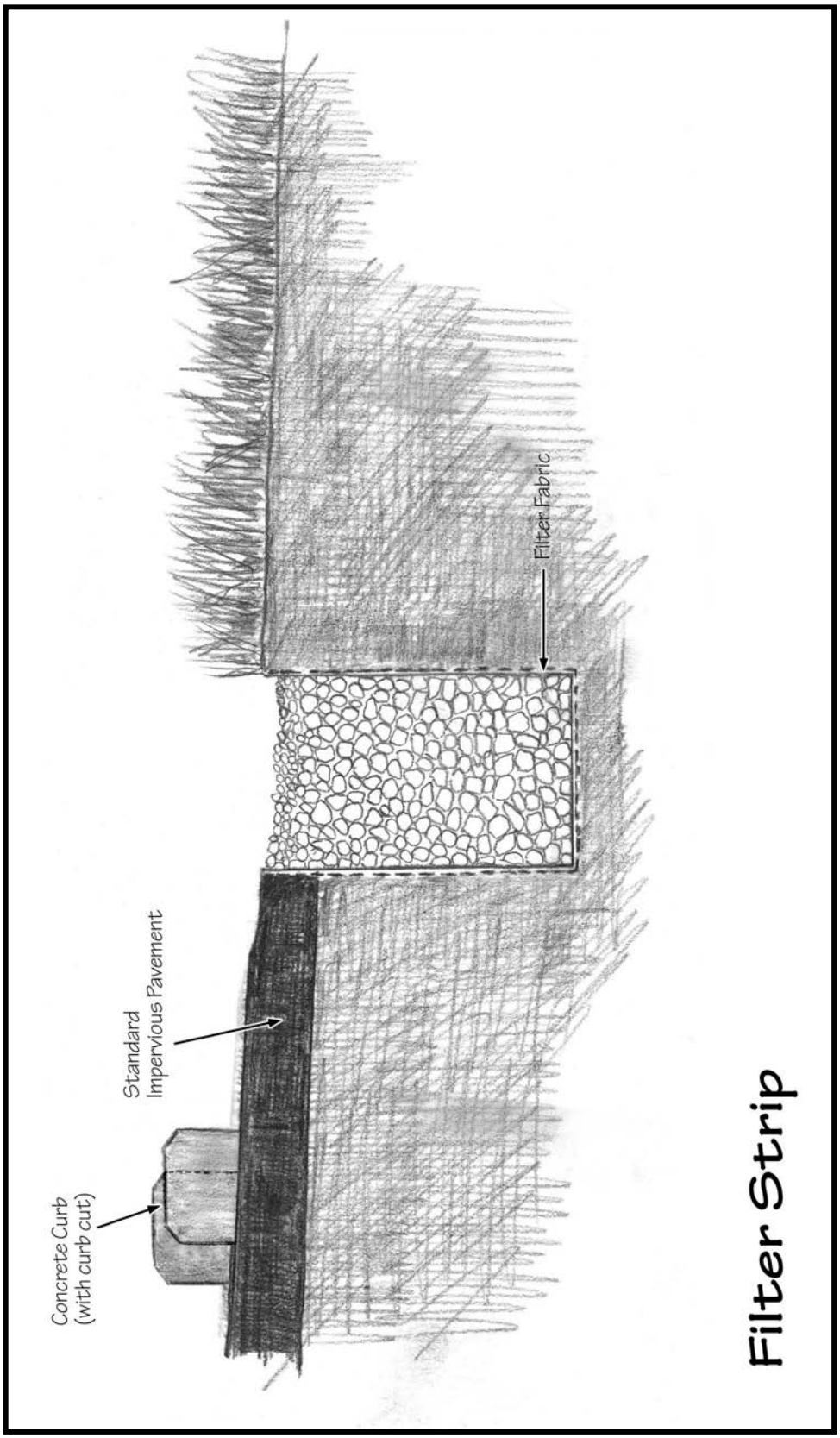
□ Might be feasible in certain situations

✪ Feasible only with major design adaptation

■ Infeasible and not recommended

Note

Few modifications are needed for dry swales and other open channel systems because their designs include few pipes or other structures.


Concrete Curb
(with curb cut)
Standard
Impervious Pavement
Filter Fabric
Filter Strip

Basic Filter Strip Design Adaptations for Alaska

STP	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
	✪	○	○	○	✪
Basic Filter Strip Design Adaptation for Alaska	• The maximum contributing sheet flow path from adjacent pervious areas should not exceed 150 feet. • The maximum contributing sheet flow path from adjacent impervious areas should not exceed 75 feet. • The contributing flow path should not have a slope greater than 3% for any 50-foot segment. • Runoff should enter the boundary of the filter strip as sheet flow for the one-inch storm. • A depression, berm or level spreader can be used to spread out concentrated flows generated during larger storm events.				
Extreme Design	• In areas with permafrost, infiltration will be limited, reducing the effectiveness of the filter strip. • In areas of high rainfall, level spreading measures are essential to prevent erosion from concentrated flows.				

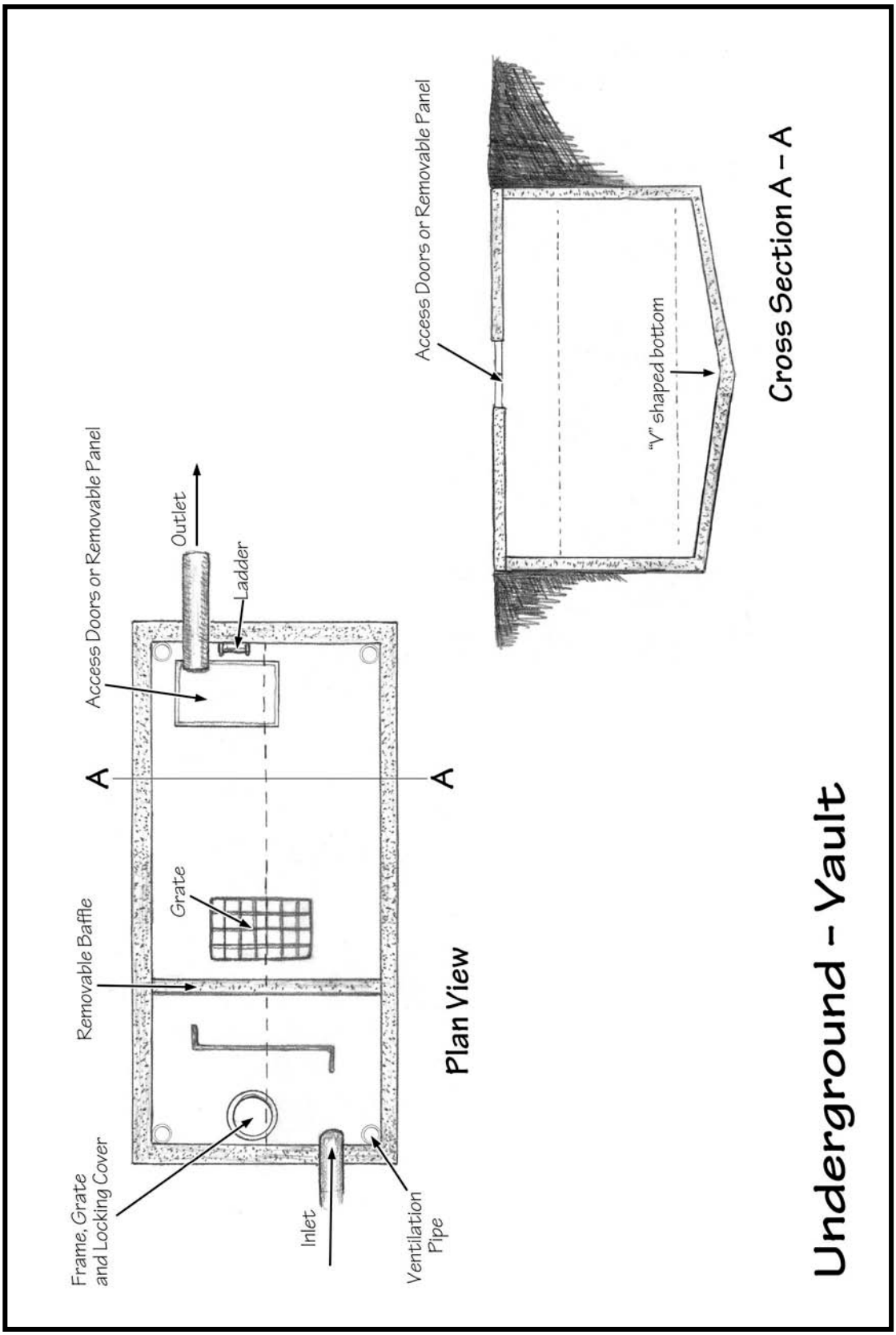
Feasibility symbols:

○ Widely feasible

☐ Might be feasible in certain situations

✪ Feasible only with major design adaptation

■ Infeasible and not recommended


Access Doors or Removable Panel
Outlet
Ladder
A
A
Grate
Removable Baffle
Frame, Grate and Locking Cover
Inlet
Ventilation Pipe
Plan View
Access Doors or Removable Panel
"V" shaped bottom
Cross Section A – A
Underground – Vault

Underground Vault Design Adaptation for Alaska

STP	Alaskan climatic regions				
	Coastal	Southcentral	Western	Interior	Arctic
	□	□	■	■	■
Basic Underground Vault Design Adaptation for Alaska	• Underground vaults are generally only applicable for use in areas without permafrost, i.e., the coastal region and parts of southcentral Alaska. • Vaults, inlet pipes, and outlet pipes should be drained before winter to prevent damage from freezing. • Vaults should be constructed below the frost line to minimize the risk of frost heaves.				

Feasibility symbols:

○ Widely feasible

✪ Feasible only with major design adaptation

□ Might be feasible in certain situations

■ Infeasible and not recommended

5.5 Maintenance

Proper BMP operation and maintenance (O&M) is an important aspect in assuring the effectiveness of a BMP in mitigating storm water pollution. Routine maintenance or service also contributes to the efficiency and continuous operation of the system. To ensure the effectiveness of permanent, structural BMPs, an O&M plan should be developed and implemented. The O&M plan can be developed by the project operator or according to the BMP manufacturer's manual.

The O&M plan describes how the owner can ensure performance of the BMP over time. O&M plans should specify the following:

- The scope of maintenance activities to be performed at the facilities
- The schedule for performing various maintenance tasks
- The schedule for inspection by the facility owner
- The parties responsible for inspection and maintenance of the facility

Instructions on the proper O&M of the BMPs should be provided to the developer, owner or responsible entities (e.g., homeowners' associations, employees, tenants or subdivision managers) to ensure adequate and appropriate O&M of the system. The O&M plan should be kept on-site for inspection. Maintenance of the BMP is typically the responsibility of the facility's owner or operator or both.

A log should be kept on-site, where practical, to record inspection and maintenance activities. The record should contain the following information: (1) type of maintenance activities or source-control practices, (2) date the activities are completed, and (3) the name of operator performing the activities. During transfer of ownership/operation of the facility, the current owner should notify the new owner/operator of these conditions and required activities.

Some typical maintenance activities for permanent BMPs include

- Cleaning and removing debris
- Mowing vegetation
- Repairing animal burrows
- Removing sediment
- Repairing outlets, risers, or other structures
- Reseeding

Glossary

A

adsorption the adhesion of an extremely thin layer of molecules to the surfaces of solid bodies or liquids with which they are in contact

aggrade the buildup of sediment or eroded material

anaerobic condition operating in a system in which there is the absence of free oxygen available for biologic use

animal waste management practices and procedures that prevent the movement of animal wastes or byproducts from feeding or holding areas into the wider environment

annual load quantity of pollutants, sediment, or nutrients carried by a waterbody over the period of a year

antecedent soil moisture the water content held by a soil before a storm event; this has an effect on the amount of water that will run off as a result of that event

B

bankfull flow in a stream or river where the water level is to the top of its bank; considered to be the channel forming flow and has a recurrence interval of around 2.5 years

bank stabilization activities undertaken to shore up or ensure the integrity of a stream or river bank and protect it from erosion and slumping

base flow the flow coming from ground water inputs to a stream or river system

basin a depression in the surface of the land that holds water

bed load the sand, gravel or rocks that are transported along the stream bottom by traction, rolling, sliding or saltation

Best Management Practice (BMP) one of many different structural or nonstructural methods used to prevent pollution or to treat runoff, including such diverse measures as ponding, street sweeping, filtration through a rain garden and infiltration to a gravel trench

biochemical oxygen demand (BOD) a measure of the amount of oxygen required to biologically degrade organic matter in the water

bioretention a soil and plant–based storm water management best management practice (BMP) used to filter runoff

buffers a vegetative setback between development and streams, lakes and wetlands whose aim is to physically protect and separate the resource from future disturbance or encroachment

C

catch basin an inlet to the storm drain system that typically includes a grate or curb inlet

channel protection actions taken to prevent habitat degradation and erosion that can cause downstream enlargement and incision in urban streams due to increased frequency of bankfull and sub–bankfull stormwater flows

chemical controls includes such activities as salt management, fertilizer/pesticide management, and spill prevention and containment

cistern a receptacle for holding liquids, usually water; often built to catch and store rainwater

cluster design a reduction of average lot size within a residential development in exchange for greater conservation of natural areas

cold climate sizing sizing of stormwater practices to accommodate snowmelt (typically a larger than rainfall–based criteria sizing because snowmelt represents more than 10 percent of annual precipitation)

computable pollutant a pollutant for which enough runoff concentration and BMP performance data is available to perform a site–based pollutant load calculation documenting no increase in loading

conservation easement a restriction placed on a piece of property to protect the resources associated with the parcel; the easement is either voluntarily sold or donated by the landowner and constitutes a legally binding agreement that prohibits certain types of development from taking place on the land

construction sequencing a specified work schedule that coordinates the timing of land–disturbing activities and the installation of erosion–protection and sedimentation–control measures

conveyance a structure or feature used for transferring water from one location to another

curb and gutter system edging along the side of streets meant to quickly convey storm water runoff from the street and adjacent areas into the storm water system

curve number an index combining hydrologic soil group, land use factors, treatment and hydrologic condition that is used in a method developed by the Soil Conservation Service to determine the approximate amount of runoff from a rainfall event in a particular area; typically used in Low Impact Development calculations

D

dead storage the permanent storage volume of a pond

degrade downcutting where softer material is present in a stream channel

design storm streamflow from a storm event used as a standard for which performance of storm water management practices are measured

detention time the theoretical calculated time that a prescribed amount of water is held in a settling basin

disconnection technique to spread runoff generated from rooftops or impervious surfaces into adjacent pervious areas where it can be filtered and infiltrated

drainageway a course or channel along which water moves in draining an area

dry pond a water bearing storm water management facility that controls peak runoff flows to receiving bodies such as rivers and streams that is typically free of water during dry periods, but filled during times of rainfall

dry well a deep covered hole acting as an underground storage facility for storm water until it seeps into the surrounding soil

dry swale a grassed channel that primarily served to transport stormwater runoff away from roadways and rights-of-way and provides some treatment of storm water facilitating infiltration

E

elution washing out of ions in solution from a snowpack

erosion the wearing down or washing away of the soil and land surface by the action of water, wind or ice

erosion control any efforts to prevent the wearing or washing away of the soil or land surface

erosion control blanket a natural or geotextile mat placed in areas susceptible to erosion to hold the soil in place until it can be permanently stabilized through vegetation or armoring

eutrophic an environment that has an excessive concentration of nutrients

evaporation the process of changing from a liquid state into a gas

evapotranspiration loss of water to the atmosphere as a result of the joint processes of evaporation and transpiration through vegetation

event–based load quantity of pollutants, sediment or nutrients carried by a waterbody for particular magnitude storm events

exfiltration uncontrolled outward leakage through cracks and interstices

extended detention provides temporary storage of storm water which attenuates peak flows and because extended detention basins are normally designed as multistage facilities, they promote the settling of pollutants.

extreme event an 100–year, 24–hour rain event or an 100–year, 10–day snowmelt event or greater

extreme flood control for the 100–year, 24–hour or larger events, to maintain the boundaries of the predevelopment 100–year floodplain, reduce flooding risks to life, reduce property damage and protect the physical integrity of the storm water management practices.

F

floodplain land adjacent to a waterbody that is inundated when the discharge exceeds the conveyance capacity of the normal channel (often defined in a regulatory sense as the extent of the 100–year flood)

flow control controlling the rate and volume of water leaving a site

forebay an extra storage space or small basin near the inlet to settle out incoming sediments before water moves on into a pond or detention area

freeze–thaw cycle the alternation between freezing and thawing in the snowpack. This cycle changes the composition and characteristics of the snowpack and can affect its pollutant carrying ability and the amount of runoff generated

frequency curve A derivative of the probability curve that expresses the relation between the frequency distribution plot, with the magnitude of the variables on one axis and the number of occurrences of each magnitude in a given period as the other

frost heave a phenomenon in cold areas in which water that is trapped in soil or cracks in rocks alternately freezes and thaws; this causes the water to expand and contract, which can cause significant movement and upheaval of the soil or rock

G

geomorphology the study of the form and development of the landscape

global warming the progressive gradual rise of the earth's surface temperature thought to be caused by the greenhouse effect, which could be responsible for changes in global climate patterns

grass channels a natural open channel conveyance system which is preferable to curb and gutter where development density, soils and slopes permit

green roof a rooftop treatment practice in which a thin planting media is established on roof surfaces and then planted with hardy, low–growing vegetation

ground water water occupying the sub–surface saturated zone

gully erosion the widening, deepening and head cutting of small channels and waterways (rills) due to erosion by water or snowmelt, typified by channels one foot or more deep

H

head the difference in elevation between two points in a body of water and the resulting pressure of the fluid at the lower point

hotspot a concentrated source of potential storm water pollution generating land uses such as gas stations, chemical storage facilities, industrial facilities and so on

housekeeping (BMP) any of a number of BMPs designed to keep pollutants from entering the waste stream by maintaining clean conditions, including street sweeping, litter pickup and animal cleanup

hydrograph graphical representation of stage or discharge at a point in a drainage as a function of time

hyetograph a graphical representation of the distribution of rainfall over the total duration of a storm event

hydrology the science dealing with the properties, distribution and circulation of water

hydroperiod the length of time an area is inundated or saturated by water

I

impaired waters streams or lakes that do not meet their designated uses because of excess pollutants or identified stressors

impervious surface a surface in the landscape that impedes the infiltration of rainfall and results in an increased volume of surface runoff

infiltration flow of water from the land surface into the subsurface

industrial materials or activities include but are not limited to material handling equipment or activities, industrial machinery, raw materials, intermediate products, by-products, final products or waste products

inlet protection preservation of the integrity and protection from the erosion of the area where water enters into a treatment area usually by vegetation or armoring

intensity–duration–frequency curves (IDF) graphical representation of the intensity, duration and frequency of a differing rainfalls over time

J

K

L

live storage the portion of a storage basin or reservoir that is at or above the outlet and used for temporary water storage

low density residential a low concentration of housing units in a specific area or on a specific property, typical of rural areas

low impact development (LID) the application of nonstructural practices at residential and commercial sites to reduce impervious cover, conserve natural areas and use pervious areas to more effectively treat stormwater runoff; LID hydrology can be tied to the SCS curve number

M

minimum control measures six required components of the SWMP for Phase II MS4 communities. The six minimum control measures are: public education/outreach; public participation/involvement; illicit discharge detection and elimination; construction site runoff control; post–construction site runoff control; and pollution prevention/good housekeeping.

municipal separate storm sewer system (MS4) a conveyance or system of conveyances owned or operated by a state, city, town, county, district, association or other public body having jurisdiction over disposal of sewage, industrial wastes, storm water or other wastes that discharges to waters of the United States; they are required to develop and implement a Storm Water Management Program

muskeg an acidic soil type common in arctic and boreal areas. Muskeg consists of dead plants in various states of decomposition (as peat), ranging from fairly intact sphagnum moss, to sedge peat, to highly decomposed muck. Pieces of wood such as buried tree branches can make up 5 to 15 percent of the peat soil. Muskeg tends to have a water table very near the surface. The sphagnum moss forming it can hold 15 to 30 times its own weight in water, allowing the spongy wet muskeg to form even on sloping ground.

N

native vegetation plants that are adapted to and occur naturally in a specific location

natural area conservation the identification and protection of natural resources and features that maintain the predevelopment hydrology at a site by reducing runoff, promoting infiltration and preventing soil erosion.

no exposure all industrial materials or activities are protected by a storm resistant shelter to prevent exposure to rain, snow, snowmelt or runoff

nonpoint source pollution pollution that enters a waterbody from diffuse origins on the watershed and does not result from discernable, confined or discrete conveyances

O

Ordinary High Water (OHW) 11 AAC 53.120. Technical Survey Standards **(2)** Ordinary High Water Mark. This is to be determined by observing and marking the place on the bank or shore up to which the presence and action of water are so prolonged as to impress on the bank or shore a character distinct from that of the bank or shore with respect to vegetation and the nature of the soil. 11 AAC 53.900. Definitions **(23)** “ordinary high water mark” means the mark along the bank or shore up to which the presence and action of the nontidal water are so common and usual, and so long continued in all ordinary years, as to leave a natural line impressed on the bank or shore and indicated by erosion, shelving, changes in soil characteristics, destruction of terrestrial vegetation, or other distinctive physical characteristics.

P

peak flow control controlling the timing and magnitude of the largest flow either leaving the site or flowing through the watershed using storm water management techniques to avoid flooding and damage downstream.

permanent storage pool the volume in a pond or reservoir below the lowest outlet level, designed for water quality purposes to settle out particles and nutrients

permeable paver a range of products that enable some fraction of rainfall to be infiltrated into a sub–base underneath the paver

pollution load the product of flow volume times pollutant concentration

pollution prevention practices proactive activities and strategies instituted to avoid introducing pollution into the environment

pollutograph graphical representation of pollution at a point in a drainage as a function of time

Q

R

rainfall distribution describes how the rain fell in a 24–hour period, i.e., whether the precipitation occurred over a 1–hour period or over the entire 24–hour period

rainfall frequency spectrum describes the average frequency of the depth of precipitation events (adjusted for snowfall) that occur during a normal year

rain garden a landscaping feature that is planted with native perennial plants and is used to manage storm water runoff from impervious surfaces such as roofs, sidewalks and parking lots

recharge the addition of water to an aquifer by natural infiltration or artificial means

redevelopment any construction, alteration, or improvement that disturbs greater than or equal to 5,000 square feet of existing impervious cover performed on sites where the existing land use is commercial, industrial, institutional or residential

retention maintaining a permanent pool with additional freeboard for storage in a storm water basin

retrofit the introduction of a new or improved storm water management element where it either never existed or did not operate effectively

return interval the inverse probability that a certain flow will occur; it represents a mean time interval based on the distribution of flows over a period of record

rill erosion an erosion process in which numerous small channels several inches deep are formed

riparian areas areas adjacent to a waterbody acting as transition zones between terrestrial and aquatic systems

runoff the portion of rainfall or snowmelt not immediately absorbed into the soil that drains or flows off the land and becomes surface flow

runoff management techniques, practices and strategies for dealing with runoff and minimizing its effect on the greater environment

S

Soil Conservation Service (SCS) Curve Number a simple, widely used method for determining the approximate amount of runoff from a rainfall or snowmelt even in a particular area. The curve number is based on the area's hydrologic soil group, land use, treatment and hydrologic condition.

sediment any particulate matter that can be transported by fluid flow and that eventually is deposited as a layer of solid particles on the bed or bottom of a body of water

sediment removal the removal, usually by settling or filtering, of suspended sediments from the water column

settleable solids are the particulates that settle out of a still fluid

settling basins remove fine particles from water by means of gravity or decanting

silt fence a fence constructed of wood or steel supports and either natural (e.g., burlap) or synthetic fabric stretched across an area of non–concentrated flow during site development to trap and retain on–site sediment due to rainfall runoff

site constraints conditions unique to the site that that serve to restrain, restrict or prevent the implementation of proposed or desired design features

slope stabilization activities or techniques employed to maintain the integrity or stop the degradation of sloped areas

small storm hydrology study of the effects of the less than 10–year event

snowmelt the sudden release of accumulated snow and ice with the advent of warm weather

snowpack a horizontally layered accumulation of snow from snowfall events that accumulates and persists through the winter and can be modified by meteorological conditions over time

spring snowmelt event large amount of melting of the winter's accumulated snow over a short period of time (~2 weeks); large flow volumes are typical and can be the critical water quality design event

stage the height of a water surface above an established reference point

storm distribution a measure of how the intensity of rainfall varies over a given period of time

storm water water that is generated by rainfall or snowmelt that causes runoff and is often routed into drain systems for treatment or conveyence

storm water pollution prevention plan (SWPPP) a plan for preventing or minimizing pollution generated at construction sites or industrial sites

storm water management program (SWMP) a program that MS4s must develop to control the pollutants in storm water to the maximum extent practicable

storm water treatment train a series of storm water management practices incorporating aspects of pollution prevention, volume control and water quality controls

streambank stabilization activities or techniques employed to maintain the integrity or stop the degradation of streambanks due to erosion and sedimentation

sublimation the process of transforming from a solid directly into a gas without passing through a liquid phase

subwatershed a subdivision based on hydrology corresponding to a smaller drainage area within a larger watershed

swale a wide, shallow, vegetated depression in the ground designed to channel drainage of water

T

Technical Publication 47 (TP–47) U.S. Weather Bureau publication that is the standard reference for frequency analysis in Alaska

Technical Release Number 20 (TR–20) a single–event, rainfall–runoff computer model developed by the U.S. Soil Conservation Service in 1964

Technical Release Number 55 (TR–55) a simplified procedure to calculate storm runoff, volume, peak rate of discharge, hydrographs and storage volumes developed by the U.S. Natural Resources Conservation Service in 1975

temporary construction sediment control techniques practices employed on an active construction site to control movement of sediment within or off of the site until permanent vegetation or sediment controls can be established

thermal impact the effect on streams and waterbodies of storm water runoff addition that are higher in temperature than the ambient stream or waterbody temperature; it causes stress or can result in the death of temperature–sensitive organisms such as trout

thermal protection techniques and practices such as infiltration and shading that act to preserve and protect the ambient temperatures of streams and waterbodies from temperature–raising effects of stormwater runoff and to temperature drops that lead to icing and glaciation when ambient air temperatures are below freezing

total maximum daily load (TMDL) the amount of a pollutant from both point and nonpoint sources that a waterbody can receive and still meet water quality standards

total phosphorus (TP) a nutrient that can also be a contaminant because of its use by nuisance algae

total suspended solids (TSS) a measure of the amount of particulate material in suspension in a water column

transpiration the passage of water vapor into the atmosphere through the vascular system of plants

trash rack a structural device used to prevent debris from entering a pipe spillway or other hydraulic structure

treatment any method, technique or practice used for management purposes

trench a long steep–sided depression in the ground used for drainage or infiltration

turbidity the cloudy appearance of water caused by the presence of suspended and colloidal matter

U

ultra–urban highly developed urban land that has limited space and disturbed soils

under drain an underground drain or trench with openings through which the water can percolate from the soil or ground above

unified sizing criteria statewide criteria for the sizing of storm water management systems

urbanized area per the 2000 census has a population density of more than 1,000 people per square mile

V

vegetative filters the removal of sediment, nutrients or pollutants by plant structures

volume control controlling the overall volume or amount of storm water that is released from a site or localized holding area into the larger conveyance system

W

water balance a hydrological formula used by scientists and land managers to determine water surpluses and deficits in a given area; it includes inputs such as precipitation; outputs such as evapotranspiration, infiltration and runoff; and storage within the system

water quality volume is a water quality-based approach of capturing and treating the 90 percent storm, as defined by an analysis of a local rainfall frequency spectrum, that optimizes runoff capture resulting in high load reduction for many storm water pollutants

watershed a topographically defined area within which all water drains to a particular point

waters of the state All streams, lakes, ponds, marshes, watercourses, waterways, wells, springs, aquifers, irrigation systems, drainage systems and all other bodies or accumulations of water surface or underground, natural or artificial, public or private, that are contained within, flow through or under the state or any portion thereof

waters of the United States those waters coming under federal jurisdiction

weir a spillover dam–like device used to measure or control water flow

wellhead protection area an identified area with restricted or modified land use practices designed to protect the well supply area from the introduction of contaminants

wetland land that is transitional between aquatic and terrestrial ecosystems and must have a predominance of hydric soils, be inundated or saturated by surface water or ground water at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, and under normal circumstances support a prevalence of hydrophytic vegetation (to be a wetland the area must meet wetland criteria for soils, vegetation and hydrology as outlined in the 2007 *U.S. Army Corps of Engineers Wetland Delineation Manual, Supplement for Alaska*)

wetland systems hydrologically interconnected series of wetlands that includes the interrelatedness of habitat, wetland functions and biology

wet pond a permanent pool of water for treating incoming storm water runoff

XYZ

References

ACIAC (Alaska Climate Impact Assessment Commission). 2008. *Final Commission Report*. Alaska State Legislature, Juneau, AK

ADEC (Alaska Department of Environmental Conservation). 2003a. Wetland Functional Assessment Guidebook, Operational Draft Guidebook for Assessing the Functions of Slope/Flat Wetland Complexes in the Cook Inlet Basin Ecoregion, Alaska, Using the HGM Approach. Juneau, AK.

ADEC (Alaska Department of Environmental Conservation). 2003b. Wetland Functional Assessment Guidebook Operational Draft Guidebook for Assessing the Functions of Riverine and Slope River Proximal Wetlands in Coastal Southeast & Southcentral Alaska Using the HGM Approach. Juneau, AK.

ADEC (Alaska Department of Environmental Conservation) and USGS (U.S. Geological Survey). 1999. *Draft Guidebook for Reference Based Assessment of the Functions of Precipitation-Driven Wetlands on Discontinuous Permafrost in Interior Alaska*. Operational Draft Guidebook for Reference Based Assessment of the Functions of Precipitation-Driven Wetlands on Discontinuous Permafrost in Interior Alaska. Anchorage, AK.

ADOT&PF (Alaska Department of Transportation and Public Facilities). 1995. *Alaska Highway Drainage Manual*. <http://www.dot.state.ak.us/stwddes/desbridge/pop_hwydrnman.shtml>. Accessed April 2008.

ADOT&PF (Alaska Department of Transportation and Public Facilities). 2001. *Alaska Highway Drainage Manual—Chapter 16 Erosion and Sediment Control*. Alaska Department of Transportation and Public Facilities. <http://www.dot.state.ak.us/stwddes/desbridge/pop_hwydrnman.shtml>. Accessed June 2008.

ADOT&PF (Alaska Department of Transportation and Public Facilities). 2005. Alaska Storm Water Pollution Prevention Plan Guide. Alaska Department of Transportation and Public Facilities, Juneau, AK.

Brakensiek, D.L., and W.J. Rawls. 1983. Agricultural Management Effects on Soil Water Processes, Part I: Green and Ampt Parameters for Crusting Soils. *Transactions of the American Society of Agricultural Engineers* 26(6):1751–1757.

Cappiella, K., L. Fraley-McNeal, M. Novotney and T. Schueler. 2008. The next generation of storm water wetlands. in *Wetlands and Watersheds Article No. 5.* Center for Watershed Protection. Ellicott City, MD.

Caraco, D. and R. Claytor. 1997. Stormwater BMP Design Supplement for Cold Climates. Center for Watershed Protection. Ellicott City, MD.

CWP (Center for Watershed Protection). 1998. Better Site Design: A Handbook for Changing Development Rules in Your Community. Ellicott City, MD

CWP (Center for Watershed Protection). 2000. *Impacts of Urbanization on Receiving Waters*. Draft. Prepared for USEPA by the Center for Watershed Protection, Ellicott City, MD, under subcontract to Tetra Tech, Inc., Fairfax, VA.

CWP (Center for Watershed Protection). 2003. *Impacts of Impervious Cover on Aquatic Systems.* Center for Watershed Protection, Ellicott City, MD

Cole, H. 2007. The economic impact and consequences of global climate change on Alaska's infrastructure. University of Alaska-Fairbanks, Fairbanks, AK.

COE (U.S. Army Corps of Engineers). 2007. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Alaska Region* (Version 2.0) U.S. Army Corps of Engineers ERDC\EL TR-07-24. U.S. Army Corps of Engineers, Vicksburg, MS.

CSN (Chesapeake Stormwater Network). 2009. Bay-wide Stormwater Design Specification No. 13. Constructed Wetlands.Version 2.0. Chesapeake Stormwater Network, Baltimore, MD. <www.chesapeakestormwater.net>. Accessed April 2009.

Duluth Streams. 2008. Lake Superior Duluth Streams – Understanding Impact: Pollutants. http://duluthstreams.org/understanding/pollutants/runoff.html. Accessed April 25, 2008.

Ferrians, Jr, O.J., R. Kachadoorian, and G.W. Greene. 1969. *Permafrost and Related Engineering Problems in Alaska*. U.S. Geological Survey Professional Paper 678. U.S. Geological Survey, Reston, VA.

Federal Highway Administration. 2004. *Evaluation of Stormwater Treatment in Constructed Wetlands in Alaska.* Federal Highway Administration. FHWA-AK-RD-03-06.

Gallant, A.L., E.F. Binnium, J.M. Omernik, and M.B. Shasby. 1995. Ecoregions of Alaska. U.S. Geological Survey Professional Paper 1567. U.S. Geological Survey, Reston, VA.

Hirschman, D.J. and J. Kosco. 2008. Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program. Center for Watershed Protection and Tetra Tech, Inc. Ellicott City, MD. July 2008.

Iowa. 2007. *Iowa Stormwater Management Manual*, Version 1. Iowa State University, Center for Transportation Research and Education. Ames. IA.

Larsen, P. and S. Goldsmith. 2007. How much might climate change add to future costs for public infrastructure? UA Research Summary. No. 8. Institute of Social and Economic Research. University of Alaska-Anchorage, Anchorage, AK.

Local Ordinances Governing Nonpoint Source Pollution in Alaska. Nonpoint source municipal sources. http://www.dced.state.ak.us/dca/nonpoint/ordinances.cfm?type=Hy. Accessed June 2009.

MDE (Maryland Department of the Environment). 2000. Stormwater Design Manual. Volume 1. Sediment and Stormwater Division. Maryland Department of the Environment, Annapolis, MD.

Metropolitan Council. 2009. *Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates*. St. Paul, MN.

Miller, J.F. 1963. Probable Maximum Precipitation and Rainfall-Frequency Data for Alaska, Technical Paper No. 47. U.S. Department of Commerce, U.S. Weather Bureau, Washington, DC. <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ak4546>. Accessed March 14, 2008.

MSSC (Minnesota Stormwater Steering Committee). 2006. Cold Climate Impacts on Runoff Management. Chapter 9 in *Minnesota Stormwater Manual*.. Minnesota Pollution Control Agency. St. Paul, MN.

MSSC (Minnesota Stormwater Steering Committee). 2008. *Minnesota Stormwater Manual, 2008, Version 2*. <http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html>. Accessed February 2009.

MPCA (Minnesota Pollution Control Agency). 2004. *Stormwater Construction Inspection Guide*. <www.pca.state.mn.us/publications/wq-strm2-10.pdf>. Accessed April 2008.

Moore, A. and M. Palmer. 2005. Invertebrate diversity in agricultural and urban headwater streams. *Ecological Applications* 15(4):1169–1177.

Morley, S. and J. Karr. 2002. Assessing and restoring the health of urban streams in the Puget Sound Basin. *Conservation Biology* 16(6):1498–1509.

Morgan, R. and S. Cushman. 2005. Urbanization effects on stream fish assemblages in Maryland, USA. *Journal of the North American Benthological Society* 24(3):643–655.

MOA (Municipality of Anchorage), Watershed Management Services. 2003. *Fecal Coliform in Anchorage streams: sources and transport processes*. Document APg03001. Municipality of Anchorage, AK.

MOA (Municipality of Anchorage), Watershed Management Services. 2004. *Anchorage Watershed Characterization: A watershed science primer*. Final Draft. Municipality of Anchorage, AK.

MOA (Municipality of Anchorage), Watershed Management Services. 2007. Storm Water Treatment Plan Review Guidance Manual. 2nd ed. Doc. No. PMg04001. <http://wms.geonorth.com/library/Documents/PermitGuidance/Stormwater_Treatment_Plan_Review.pdf>. Accessed April 2008.

NRC (National Research Council). 2008. Urban Stormwater Management in the United States. National Academy Press, Washington, DC. <http://books.nap.edu/openbook.php?record_id=12465&page=R1>. Accessed February 2009.

NHDES (New Hampshire Department of Environmental Services). 2008. New Hampshire Stormwater Manual: Volume 3. Erosion and Sediment Control. Winter Weather Stabilization and Construction Practices. New Hampshire Department of Environmental Services, Concord, NH.

Oberts. 1989. *Performance of Stormwater Ponds and Wetlands in Winter* in CWP (Center for Watershed Protection). 2000. The Practice of Watershed Protection. Article 71. pp. 413-417. Ellicott City, MD.

Oberts. G. 2007. Climate and Stormwater. Stormwater. May/April. <http://www.stormh2o.com/sw_0709_climate.html>. Accessed April 2008.

Ourso, R., and Frenzel, A. 2003. Identification of Linear and Threshold Responses in Streams along a Gradient of Urbanization in Anchorage, Alaska. *Hydrobiologia* 501:117–131.

Pitt, R., A. Maestre, and R. Morquecho. 2004. National Quality Database. Version 1.1. <http://rpitt.eng.ua.edu/Research/ms4/Paper/Mainms4paper.html>. Accessed January 28, 2008.

Rawls, W.J., S.L. Long, and R.H. McCuen. 1981. *Comparison of Urban Flood Frequency Procedures; Preliminary Draft Report* prepared for Soil Conservation Service, Beltsville, MD.

Rawls, W.J., Gimenez, and R. Grossman. 1998. Use of Soil Texture, Bulk Density and Slope of Water Retention Curve to Predict Saturated Hydraulic Conductivity. In *Transactions of American Society of Agricultural Engineers* 41(4):983-988.

Roseen, R., et al. 2007. LID Systems are Less Prone to Seasonal Performance Variations than Conventional Stormwater Management Systems. University of New Hampshire Stormwater Center. Durham, NH.

Roy, A., C. Faust, M. Freeman, and J. Meyer. 2005. Reach-scale effects of riparian forest cover on urban stream ecosystems. *Canadian Journal of Fisheries and Aquatic Science* 62:2312–2329.

Schueler, T., L. Fraley-McNeal, and K. Cappiella. 2009. Is impervious cover still important? A review of recent research. *Journal of Hydrologic Engineering* April, 2009.

Seifert, R. 2007. *Permafrost: a building problem in Alaska*. HCM-00754. University of Alaska-Fairbanks, Cooperative Extension Service, Fairbanks, AK.

Shannon and Wilson. 2006. *BMP Effectiveness Report. Fairbanks, Alaska*. Prepared for Alaska Department of Environmental Conservation, Water Quality Program, Fairbanks, AK.

Shulski, M. and G. Wendler. 2007. *The Climate of Alaska*. Snowy Owl Press, University of Alaska Press. Fairbanks, AK.

Shuster, W.D., J. Bonta, H. Thurston, E. Warnemuende, and D.R. Smith. 2005. Impacts of impervious surface on watershed hydrology: A review. *Urban Water Journal* 2(4):263–275.

Stenmark, C. 1995. An alternative road construction for stormwater management. *Water Science and Technology* 32(1):79–84.

Traver. 2005. Villanova University Stormwater Best Management Practice Section 319 National Monitoring Program Project Year 2 Report. Villanova Urban Stormwater Partnership. Philadelphia, PA.

UNH (University of New Hampshire) Stormwater Center. (UNH). 2005 Data Report. Durham, NH.

USEPA (U. S. Environmental Protection Agency). 1992. *Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices, Summary Guidance*. EPA-833-R-92-001. U. S. Environmental Protection Agency, Washington, DC.

USEPA. (U.S. Environmental Protection Agency). 1993. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. EPA-840-B-92-002. U. S. Environmental Protection Agency, Washington, DC.

USEPA. (U.S. Environmental Protection Agency). 2007. *Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites*. EPA-833-R-060-04. U. S. Environmental Protection Agency, Washington, DC.

USDA. 1986. Technical Release (TR) 55, Urban Hydrology for Small Watersheds. U.S. Department of Agriculture, Natural Resources Conservation Service, Conservation Engineering Division.

VTDEC (Vermont Department of Environmental Conservation). 2006. *Vermont Standards for and Specifications for Erosion and Sediment Control. Winter Construction Limitations*. Vermont Department of Environmental Conservation, Waterbury, VT.

WSDOT (Washington State Department of Transportation) 2005. *Hydraulics Manual*. Washington State Department of Transportation, Olympia, WA.

Wright, T., J. Tomlinson, T. Schueler, Karen Cappiella, A. Kitchell and D. Hirschman. 2006. Direct and indirect impacts of land development on wetland quality. Wetlands and Watersheds Article No. 1. Center for Watershed Protection. Ellicott City, MD.

Wright, S. 2008. *A re-vegetation manual for Alaska*. Alaska Department of Natural Resources, Alaska Plant Material Center, Palmer, AK.

WRCC (Western Regional Climate Center). 2007. Period of Record General Climate Summary—Precipitation. Western Regional Climate Center. <www.wrcc.dri.edu>

Appendix A
Links to Relevant Web Pages

Chapter 1 Links

Link 1 Additional information about the NPDES MS4 program
http://cfpub2.epa.gov/npdes/stormwater/munic.cfm

Link 2 Detailed information on the 2008 MSGP
www.epa.gov/npdes/stormwater/msgp

Link 3 Details about NPDES general permits
http://yosemite.epa.gov/R10/WATER.NSF/NPDES+Permits/General+NPDES+Permits#Oil%20and%20Gas

Link 4 ADEC's electronic NOI system
http://www.dec.state.ak.us/water/wnpspc/stormwater/APDESeNOI.html

Link 5 Additional information about the 2011 CGP
http://www.dec.state.ak.us/water/wnpspc/stormwater/index.htm

Link 6 Additional information about the 6217 Program
http://coastalmanagement.noaa.gov/nonpoint/welcome.html

Link 7 Details about Alaska's Coastal Nonpoint Program (CNP) boundary
http://www.alaskacoast.state.ak.us/GIS/boundary.htm

Link 8 A maintenance and design manual for gravel roads
http://www.epa.gov/owow/nps/gravelroads/

Link 9 June 2008 EPA memo Class V UIC wells
http://www.epa.gov/npdes/pubs/memo_gi_classvwells.pdf

Link 10 BMPs for storm water drainage wells (PDF)
http://www.epa.gov/ogwdw/uic/class5/pdf/page_uic-class5_storm_water_bmps.pdf

Link 11 General information regarding the UIC program
http://yosemite.epa.gov/R10/WATER.NSF/476d8e2e8829cf19882565d400706530/51bbc02148429af1882568730082f6fa!OpenDocument

Link 12 Corps of Engineers (COE) wetlands Web site
http://www.poa.usace.army.mil/reg/

Link 13 EPA-administered NPDES MS4 permit (NPDES Permit #AKS052558)
http://wms.geonorth.com/library/Documents/NewsProjects/Permit.pdf

Link 14 Additional information about the MOA storm water program
http://wms.geonorth.com/

Link 15 A map of the urbanized area (Fairbanks)
http://co.fairbanks.ak.us/pworks/StormWaterManagementProgram/MS4_boundary.pdf

Link 16 Additional information on the individual storm water management programs
http://co.fairbanks.ak.us/PWorks/StormWaterManagementProgram/

Link 17 The Fairbanks North Star Borough, Permit Number AKS-053414
http://co.fairbanks.ak.us/PWorks/StormWaterManagementProgram/FNSB%20AKS053414FP.pdf

Link 18 For current list of local ordinances governing NPS pollution in Alaska
http://www.dced.state.ak.us/dca/nonpoint/ordinances.cfm?type=Hy

Link 19 Specific information for waters in Alaska
http://epa.gov/waterscience/standards/wqslibrary/ak/

Link 20 Summary of the differences between 2009 Alaska water quality standards and the water quality standards effective for CWA purposes
http://www.dec.state.ak.us/water/wqsar/wqs/pdfs/Comparison_of_State_and_Federally_Approved_WQS_2-2-10.pdf

Link 21 Pollutants in Stormwater Runoff Web page
http://duluthstreams.org/understanding/pollutants/runoff.html

Link 22 ADEC's implementation guidance
http://www.state.ak.us/dec/water/wqsar/wqs

Link 23 EPA-approved TMDLs
http://www.dec.state.ak.us/water/tmdl/approvedtmdls.htm

Chapter 2 Links

Link 24 Soil surveys conducted by the Natural Resources Conservation Service of the U.S. Department of Agriculture are available for many areas of Alaska
http://www.ak.nrcs.usda.gov/soils/index.html

Link 25 For more information on the engineering geology for many areas of Alaska
http://www.dggs.dnr.state.ak.us/index.php?menu_link=engineering&link=engineering_overview

Chapter 3 Links

Link 26 Soil surveys conducted by USDA NRCS are available for many areas of Alaska
http://www.ak.nrcs.usda.gov/soils/index.html

Link 27 The Alaska DNR Division of Geological and Geophysical Surveys engineering geology reports
http://www.dggs.dnr.state.ak.us/index.php?menu_link=engineering&link=engineering_overview

Link 28 Useful information on soil characterization
http://www.mt.nrcs.usda.gov/about/lessons/Lessons_Soil/feelmethod.html

Link 29 NRCS soil surveys
http://www.ak.nrcs.usda.gov/soils/index.html

Link 30 The process for defining a wetland provided by the COE
http://www.usace.army.mil/CECW/Regulatory/Documents/erdc-el_tr-07-24.pdf

Link 31 HSG for many U.S. soils is available in the documentation for TR-55
http://www.ecn.purdue.edu/runoff/documentation/tr55.pdf

Link 32 Information on the locations where drinking water protection efforts are underway
http://www.dec.state.ak.us/eh/dw/DWP/source_water.html

Link 33 The ADF&G Division of Habitat anadromous waters information
http://www.sf.adfg.state.ak.us/SARR/FishDistrib/FDD_intro.cfm

Link 34 MOA wetlands atlas
http://wms.geonorth.com/library/LibraryMapsWetlandsAtlas.aspx

Link 35 *Anchorage Storm Water Treatment in Wetlands: 2002 Guidance*
http://wms.geonorth.com/library/Documents/Reports/BMP_Guidance/02_Wetlnd_text.pdf

Link 36 ADEC provides information on the locations where special actions could be required to manage storm water from new construction sites
http://www.dec.state.ak.us/water/tmdl/tmdl_index.htm

Link 37 Current municipal-specific ordinances governing NPS pollution
http://www.dced.state.ak.us/dca/nonpoint/ordinances.cfm?type=Hy

Link 38 MOA's *Stormwater Treatment Plan Review Guidance Manual*
http://www.muni.org/Departments/works/project_management/Documents/SWTPRGM%20Sept2010.pdf

Link 39 End-of-season snowmelt data
www.wrcc.dri.edu

Link 40 Technical Paper 47 (TP-47) for rainfall event totals
http://hdsc.nws.noaa.gov/hdsc/pfds/other/ak_pfds.html

Link 41 *Design Criteria Manual,* Chapter 2 Drainage
http://www.muni.org/Departments/works/project_management/Design%20Criteria%20Manual/DCM%20Chap2%202009%20clean.pdf

Link 42 Information on the locations where wellhead protection efforts are underway
http://www.dec.state.ak.us/eh/dw/DWP/source_water.html

Link 43 *Alaska Highway Drainage Manual*, Chapter 8 Channels
http://www.dot.state.ak.us/stwddes/desbridge/assets/pdf/hwydrnman/ch8_0695.pdf

Link 44 Peak flow regression equations
http://pubs.usgs.gov/wri/wri034188/

Link 45 Soil Conservation Service methods including TR-55
http://go.usa.gov/KoZ

Link 46 EPA SWMM
http://www.epa.gov/athens/wwqtsc/html/swmm.html

Link 47 *Alaska Highway Drainage Manual*, Chapter 7 Hydrology
http://www.dot.state.ak.us/stwddes/desbridge/pop_hwydrnman.shtml

Link 48 *Guidance for Design of Biofiltration Facilities for Stream Water Quality Control*
http://wms.geonorth.com/library/Documents/Reports/CPg96002-Biofiltration_Facilities.pdf

Link 49 MOA efforts to introduce rain gardens
http://www.anchorageraingardens.com

Link 50 Suite of models, calculators and tools available from EPA
http://cfpub.epa.gov/npdes/greeninfrastructure/modelsandcalculators.cfm

Link 51 EPA's *Low-Impact Development: An Integrated Design Approach*
http://www.epa.gov/owow/nps/lidnatl.pdf

Link 52 Cold-weather study of LID results
http://ciceet.unh.edu/unh_stormwater_report_2007/index.php

Link 53 Information about storm water borne pollutants from roadways
http://www.tfhrc.gov/hnr20/runoff/runoff.htm

Link 54 ADT&PF reference documents
http://www.dot.state.ak.us/stwddes/desenviron/index.shtml

Link 55 Green Highway Partnership resources
http://www.greenhighways.org/tools.cfm

Link 56 Evolving environmental developments at AASHTO
http://environment.transportation.org/

Link 57 Evolving environmental developments at FHWA
http://www.fhwa.dot.gov/environment/

Link 58 *Anchorage Parking Lots: 2002 Best Management Practices Guidance*
http://wms.geonorth.com/library/Documents/Reports/BMP_Guidance/02_Pkglot_doc.pdf

Link 59 The Center for Watershed Protection Web site
http://www.cwp.org/

Link 60 ADNR's Office of Project Management and Permitting Web site
www.dnr.state.ak.us/opmp/

Link 61 CWP's *Cold Climate Manual* (requires free registration)
http://www.cwp.org/documents/doc_download/190-stormwater-bmp-design-supplement-for-cold-climates-.html

Chapter 4 Links

Link 62 EPA's Menu of BMPs
www.epa.gov/npdes/stormwater/menuofbmps

Chapter 5 Links

Link 63 *Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program* (requires free registration)
http://www.cwp.org/documents/doc_download/200-managing-stormwater-in-your-community-a-guide-for-building-an-effective-post-construction-program.html

Link 64 *Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates*
http://www.metrocouncil.org/environment/Watershed/bmp/manual.htm

Link 65 Additional information on LID from USEPA
http://www.epa.gov/owow/nps/lid/

Link 66 Additional information on LID from the Low Impact Development Center
http://www.lowimpactdevelopment.org

Link 67 Additional information on LID from the Puget Sound Action Team
http://www.psp.wa.gov/downloads/LID/LID_manual2005.pdf

Link 68 California Stormwater Quality Association's *Industrial and Commercial Stormwater BMP Handbook*
http://www.cabmphandbooks.org/Industrial.asp

Link 69 Center for Watershed Protection's *Pollution Source Control Practices*
www.cwp.org

Link 70 A plant species list for bioretention design
http://www.anchorageraingardens.com/plants.html