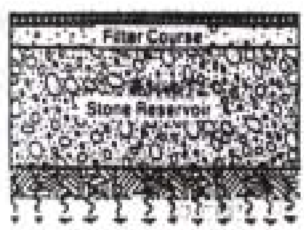
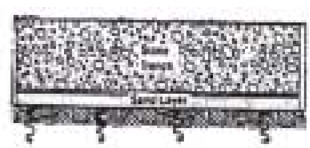
5. Infiltration

Infiltration systems recharge the groundwater, helping to mitigate the impacts of development on the hydrologic cycle. In addition, they use the soil as a filter, treating polluted runoff as it percolates into the ground. In cold areas, the use of infiltration systems is challenging. Frozen soils can dramatically reduce, or stop, the rate of infiltration, chlorides may pose a risk to groundwater and sand used as abrasives on roads may clog infiltration practices. Consequently, designers need to make modifications to these BMPs to make them effective in cold climates.

5.1 Types of Infiltration BMPs

Porous pavement, infiltration trenches and infiltration basins all accomplish pollutant removal through stormwater infiltration. Although they accomplish the same goal, they are used in different situations and scales (see Table 5.1). Some other infiltration practices, such as deep injection wells and dry wells, are not discussed. Deep injection wells provide no stormwater treatment, and dry wells have historically failed due to clogging.

TABLE 5.1 TYPES OF INFILTRATION BMPS
(SOURCE: FIGURES FROM SCHUELER, 1987)

	Porous Pavement	Infiltration Trench	Infiltration Basin
Schematic			
Scale	Very small (Parking Lot)	Small (<5 acres)	Large (Up to 50 acres)
Purpose	Water Quality Recharge	Water Quality Recharge	Water Quality Flood Control Recharge

5.2 Base Criteria

Design criteria for infiltration BMPs are outlined by CWP et al. (1997) [See Table 5.2]. The primary goals of these criteria are to verify that the underlying soils are well suited for infiltration, provide sufficient protection against groundwater contamination and avoid clogging of the facility. These criteria apply in both cold and moderate climates.

TABLE 5.2 BASE CRITERIA FOR INFILTRATION BMPS

- Underlying soils have an infiltration rate of 0.5 inches per hour (1.5 to 2 inches per hour for facilities with greater than a 10 acre drainage) .
- Soils should have a clay content of less than 30% and a silt/clay content of less than 40%
- Infiltration not located on steep slopes
- "Hotspot" (e.g., gas station) runoff should not be infiltrated
- Bottom of infiltration facility separated from water table by 2'-4'.
- Facilities separated from water supply wells by 100'
- Stabilize the overflow channel if erosive velocities are anticipated
- Infiltration practices should fully dewater the water quality volume in 48 hours
- Pretreatment is imperative.
- Best used in combination with other treatment practices
- Avoid clogging of the practice during construction
- A porosity of 0.32 is used for stone reservoirs of infiltration trenches

5.3 Cold Climate Modifications

Because of additional challenges in cold climates, infiltration BMPs need design modifications to function properly. These modifications address the problems of infiltration into frozen soils and maintenance and contamination concerns associated with road sanding and salting.

5.3.1 Feasibility

In some cases, infiltration may not be the best BMP option for cold regions. Porous pavement is the most restricted infiltration BMP, but infiltration trenches and basins are also somewhat restricted in cold regions (Table 5.3).

TABLE 5.3 INFILTRATION BMP FEASIBILITY MODIFICATIONS

	LIMITATION
POROUS PAVEMENT	ONLY USE ON NON-SANDED SURFACES ONLY USE WHEN MAINTENANCE IS EXPLICITLY AGREED TO.
INFILTRATION TRENCH/ BASIN	DO NOT USE IN REGIONS THAT EXPERIENCE PERMAFROST. MONITOR GROUNDWATER FOR CHLORIDES IN ALL COLD CLIMATES DO NOT DIRECT ROAD OR PARKING LOT SNOWMELT RUNOFF TO THIS PRACTICE IF GROUNDWATER CONTAMINATION IS A CONCERN INCREASE PERCOLATION REQUIREMENTS SET BACK A MINIMUM OF 20 FEET FROM ROAD SUBGRADE WHEN DEPTH OF FROST >3'

Porous Pavement

Porous pavement should be used with caution in cold climates. Although the practice has been applied successfully in very cold climates, such as in Sweden (Stenmark, 1995), the maintenance requirements may be too high for many communities. Even in moderate climates, the failure rate of porous pavement is quite high, primarily because regular maintenance is not performed. In cold climates, additional challenges such as clogging with sand, damage by plows or an impermeable layer beneath the pavement make this practice's use more challenging. In the CWP (1997) survey of stormwater professionals, only four of the fifty-five participants recommended the use of porous pavement.

Porous pavement should never be used on areas that are sanded. There are two types of porous pavement: porous asphalt and block pavement, such as "grass crete". Porous asphalt looks very similar to conventional asphalt, but is relatively pervious. Concrete block pavement has larger holes (about 1" square) and is constructed of concrete instead of conventional asphalt. When pavement is sanded, either porous pavement option will become clogged very rapidly, particularly porous asphalt. In addition, snow removal from concrete block pavement is challenging because plow blades can catch the edge of individual blocks, damaging the pavement and the plow. Because of the restriction on using sand with concrete block pavement, higher salt use will be necessary if the pavement is to remain clear. This option may not be acceptable in some communities, both because of the costs associated with salting roads and the potential environmental impacts.

Regardless of which type of porous pavement is used, maintenance is essential, especially considering the clogging potential caused by materials that build up in the snow pack. Before porous pavement is constructed, a maintenance agreement is needed. These materials must be vacuum swept and inspected every spring to prevent clogging.

Infiltration Trench/ Infiltration Basin

While infiltration trenches and infiltration basins have more applications in cold climates than porous pavement, there are still many cases where they cannot be applied. These limitations are described below. Only 24% and 29% of stormwater professionals in cold areas recommended the use of infiltration basins and infiltration trenches, respectively (CWP, 1997). To give some perspective, 67% recommended stormwater ponds in the same survey. While many of the respondents cited soils as the reason for disallowing the practices, some pointed out that frozen ground conditions restricted the use of these BMPs.

- Do Not Use in Regions with Permafrost

  In regions with permafrost, infiltration cannot be used, because the ground is relatively impermeable all year. In addition, infiltration BMPs may cause melting of the permafrost, which can cause cave-ins.

- Monitor Groundwater for Chlorides

  If infiltration is chosen as a stormwater practice, groundwater chloride concentrations should be monitored in the region, especially if shallow wells are used for drinking water. Groundwater monitoring can act as a "flag". If groundwater chloride concentration exceed a certain level, new development should use an alternative other than infiltration. Human health risks for drinking water are critical at 20 mg/l (Gales and VanderMeulen, 1992), so a lower threshold may be appropriate.

- Do Not Infiltrate Road or Parking Lot Snowmelt If Chlorides Are a Concern

  If groundwater contamination from chlorides is determined to be a problem, infiltration trenches and basins should not be used to treat snowmelt runoff from parking lots or roads. One option is to restrict the use of these BMPs for highly salted roadways, allowing them only for residential land uses. Alternative designs in the *Conveyance (5.3.2)* and *Treatment (5.3.4)* sections can avoid this restriction.

- Increase Percolation Requirements

  In cold regions the minimum soil infiltration should be 1" per hour for infiltration trenches, and 3" per hour for infiltration basins. This increased infiltration rate (from base criteria) accounts for the clogging potential from road abrasives. It also accounts somewhat for the reduced infiltration rates during the winter season.

- Use a Minimum 20 Foot Setback Between the Road Subgrade and Infiltration Practices

  When infiltration practices are used next to a road or pavement, they should be set back in order to avoid potential frost heave conditions. This restriction applies primarily in areas with a deep freeze depth. Infiltrated water can contribute to ice lenses that form beneath the road surface, aggravating frost heave and potentially causing damage.

  Substitutes for the twenty foot guideline can be developed using subsurface groundwater modeling, or geohydrologic calculations. Alternatively, setback restrictions can be avoided by using other measures to protect pavement. For example, pavement can be insulated or underlain with a very thick gravel to protect against frost damage.

5.3.2 Conveyance

In addition to the measures taken to protect pipes from frost heaving (Chapter 3), other modifications can be made to the conveyance systems of infiltration BMPs. These measures, described in Table 5.4, protect groundwater supplies or preserve the infiltration capacity of these systems.

TABLE 5.4 CONVEYANCE MODIFICATIONS TO INFILTRATION BMPS

	BMP	Purpose	Drawbacks
Winter Diversion	**Infiltration Trench**	**Bypass snowmelt**	**Requires seasonal operation** **Snowmelt is not treated**
Underdrain System	**Infiltration Basin**	**Promote infiltration *or* Bypass snowmelt**	***Requires seasonal operation*** ***Snowmelt may not be treated***
Sand or Gravel Floor	***Infiltration Basin/ Infiltration Trench***	***Promote infiltration***	***Extra Expense***

- Winter Diversion to Prevent Infiltration of Chlorides

  Pitt (1996) recommends diverting snowmelt runoff past infiltration devices because of its soluble salts concentration. In regions where chloride concentration in groundwater is a concern, a diversion structure can prevent infiltration of these salts. Each BMP would have a valve or gate at its inlet to prevent the infiltration of winter runoff. If such a design is used, careful maintenance agreements are needed to ensure that the diversion structure is appropriately moved at the beginning of the winter season and after snowmelt.

  By using this option, none of the snowmelt runoff is treated. If a significant amount of the annual pollutant load is carried by snowmelt, another BMP is needed as a "backup". For example, the diverted flow may lead to a stormwater pond.

- Underdrain System

By draining the ground beneath an infiltration system, underdrains increase cold weather soil infiltration. Infiltration into frozen soils is strongly influenced by the soil moisture at the time of freezing (Granger et al., 1984), with dry soils having significantly higher infiltration rates. A minimumt 8" underdrain pipe, encased in gravel, can be used to drain the soils below infiltration basins. Oberts (1994) recommends using an underdrain system as part of an infiltration/ detention system. (The system is described in more detail in section 5.3.4). The underdrain is used to drain the soils before the winter season begins, and then closed throughout the winter.

In regions where the infiltration of chlorides is a problem, the underdrain system can be used to divert snowmelt past the system. That is, the underdrain system can be left open throughout the winter season, preventing snowmelt from being infiltrated. Under this option, seasonal operation would still be necessary. The runoff would be filtered by the soil above the underdrain system, and the basin would act like a bioretention facility.

- Sand or Gravel Floor

Another method used to encourage infiltration is to line the bottom of the basin or trench with one foot of gravel or sand. The sand or gravel provides a layer of soil that can provides infiltration during cold conditions. This material is also less likely to clog than most soils, and the method can is effective in moderate climates as well.

5.3.3 Pretreatment

Pretreatment needs to be emphasized even more strongly in cold climates than moderate climates. This is because abrasives can clog the infiltration system and infiltration is already reduced in cold climates. The minimum pretreatment should be 0.25" per impervious acre. Pretreatment can be provided using grass channels, filter strips, other vegetative measures or a pretreatment chamber. Redundant pretreatment, using at least two mechanisms in series, should be used in infiltration systems.

5.3.4 Treatment

Providing additional storage, combining infiltration with other BMPs, or operating infiltration BMPs on a seasonal basis can improve their efficiency in cold climates (Table 5.5). All of these measures compensate for slow infiltration during the spring melt.

TABLE 5.5 TREATMENT MODIFICATIONS TO INFILTRATION BMPS

	Description	BMP(s)	Drawbacks
Increased Storage	Increase sizing criteria described in Section 2.	Infiltration basin/ Infiltration trench	Consumes space
Redundant Treatment	Divide treatment between infiltration and another BMP.	Infiltration trench/ Infiltration basin	Not always feasible
Seasonal Operation	Operate an infiltration/ detention basin on a seasonal basis to treat spring snowmelt.	Infiltration basin	Requires seasonal manipulation

- Additional Storage

  In cold climates, if infiltration BMPs are used alone, the computed water quality and water quantity volumes should be increased. As snowmelt occurs, infiltration BMPs become filled with water, and eventually cannot infiltrate the water that ponds in them. In addition, the gradually increasing pool in infiltration basins can become a flood hazard. A few practitioners recommend the use of “back-to-back” design flood events (CWP, 1997). “Back-to-back” sizing assumes that two design storms occur on consecutive days. The BMP is then sized to reduce the peak flows to pre-development levels. Similarly, an application in Alberta, Canada doubled the design volume to account for snowmelt events (Ferguson, 1994).

- Use in Combination with Other BMPs

  The volume increases proposed above may make infiltration an infeasible option. An alternative is to divide the treatment volume between an infiltration BMP and another BMP. For example, the water quality volume can be divided between an infiltration pond and a downstream wet pond. In the winter, only the infiltration portion should be doubled. Two side-by side calculations illustrate how this redundant treatment can reduce the total water quality volume.

Example: Water Quality Volume= 2 acre-feet

Case 1: Use only infiltration
Double WQ_v
WQ_v=4 acre-feet

Case 2: Split WQ_v between a wet pond and infiltration
Assign 1 acre-foot to each BMP.
(1 acre-foot) infiltration + 1 acre-foot wet pond
Double the infiltration WQ_v
WQ_v= (1 acre-feet)•2 + 1 acre-feet
WQ_v= 3 acre-feet

Therefore, 25% less treatment volume is required when redundant treatment is used

- Seasonal Operation

  A seasonally operated infiltration/detention basin (Oberts, 1994; Figure 5.1) combines several techniques to improve the performance of infiltration BMPs in cold climates. Two features, the underdrain system and level control valves, are useful in cold climates. These features are used as follows: In the beginning of the winter season, the level control valve is opened the soil is drained. As the snow begins to melt in the spring, the underdrain and the level control valves are closed. The snowmelt is infiltrated until the capacity of the soil is reached. Then, the facility acts as a detention facility, providing storage for particles to settle.

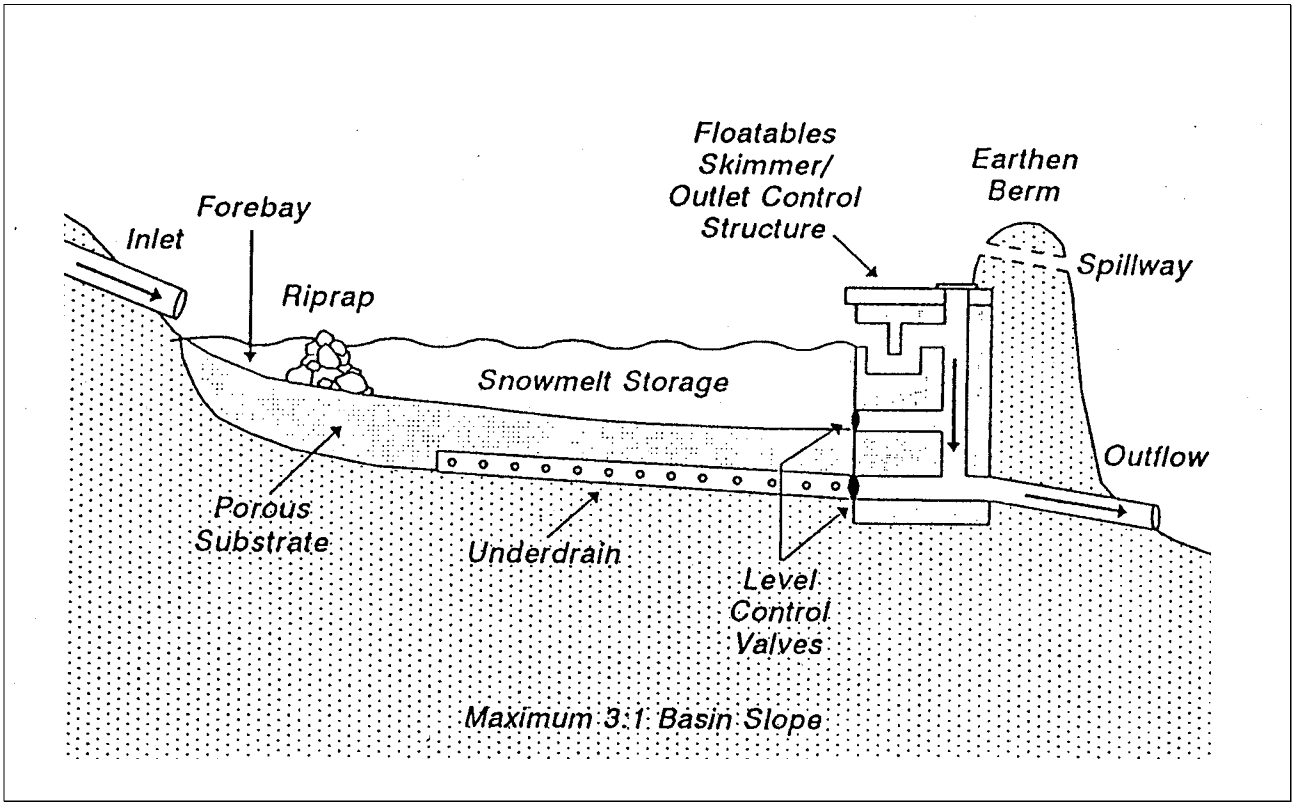
5.3.5 Maintenance

When runoff containing salt-based deicers is directed to an infiltration basin, soil may become less fertile and less capable of supporting vegetation. Incorporating mulch into the soil can help to mitigate this problem.

5.3.6 Landscaping

The selection of upland landscaping materials should reflect the short growing seasons in cold regions (See Section 4.3.5, Table 5). Grass should be planted in the spring, and heavy mulch should be applied on bare ground during the fall.

FIGURE 5.1 SEASONAL OPERATION OF INFILTRATION
(SOURCE: OBERTS, 1994)



5.3.7 Snow Management

In addition to promoting infiltration of snowmelt, infiltration basins are also useful for snow storage. Up to 50% of the basin volume can be used for snow storage. There are some restrictions to this use, however. Infiltration basins should not be used to store snow from highways or parking lots. The sand in this snow can clog the basin. In addition, the chlorides and other pollutants can contaminate the groundwater.