

Stormwater Management with Pervious Concrete Pavement ■■■■

Pervious Concrete Pavement

■ Description

Pervious concrete pavement is a permeable pavement, often with an underlying stone reservoir, that captures rainfall and stores runoff before it infiltrates into the subsoil. This pervious surface replaces traditional pavement, allowing stormwater to infiltrate directly, permitting a naturally occurring form of water treatment. Pervious concrete consists of specially formulated mixtures of hydraulic cementitious materials, uniform open graded coarse aggregate such as ASTM C-33 #8 or #89 ($\frac{3}{8}$ inch) (10 mm), #67 ($\frac{3}{4}$ inch) (19 mm), to #5 or #56 (1 inch) (25 mm), and water. When properly designed and installed, pervious concrete has a high percentage of void space (15% or more) which can accommodate stormwater from any significant storm event (see Figure 1).

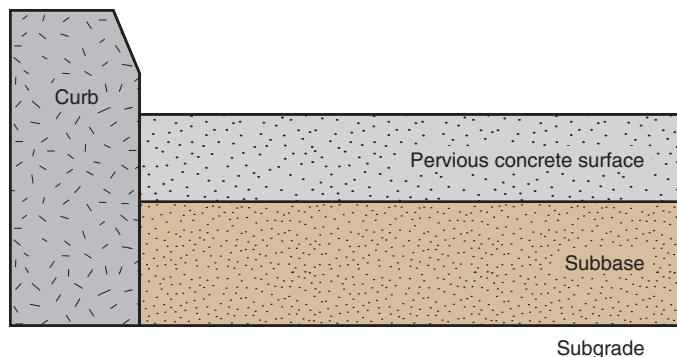


Figure 1. Typical cross-section of pervious concrete pavement. On level subgrades, stormwater storage is provided in the pervious concrete surface layer (15% to 25% voids), the subbase (20% to 40% voids), and above the surface to the height of the curb (100% voids). Source: Tennis, et al, 2004, adapted from Paine 1990.

■ Application

The ideal application for pervious concrete pavement is around buildings (walkways, courtyards, etc.) and parking areas, as well as low-volume roadways. Pervious concrete pavement may also have some application on highways, where it could be used in shoulder and median construction for stormwater runoff mitigation. There may also be application for its use as a surface material to reduce hydroplaning, splash and spray, and mitigate tire-pavement noise.

Regional Applicability

Pervious concrete pavement can be applied in most regions of the country, but the practice has unique challenges in cold climates. Design of the system should ensure that washout from adjacent (soil) areas is not allowed to drain onto the pervious concrete surfaces. Care should be taken with regard to sand being applied to the pavement surface for deicing, as the sand may become lodged into the surface of the material. This difficulty does not imply that it is impossible to use pervious concrete pavement in cold climates. Anecdotal evidence suggests that snow-covered pervious concrete pavement may actually clear more quickly than impervious surfaces, reducing the need for snow plowing. Additionally, melted snow will drain through the pervious concrete pavement rather than ponding and refreezing as is common with traditional impervious pavements. This may minimize the need to apply deicing materials to the pervious concrete pavement.

Another concern in cold climates is that infiltrating runoff below the pavement may cause frost heave, although design modifications that provide for an

adequate base layer can reduce this risk. Pervious pavement has been used successfully in Norway (Stenmark, 1995), incorporating design features to reduce frost heave. Successful longer term installations of pervious concrete pavements in regions of cold weather have also been documented in North America (NRMCA, 2004).

ULTRA-URBAN AREAS

Ultra-urban areas are densely developed urban areas in which pervious and naturally draining surface area is reduced. Pervious concrete pavements are a good option in these areas because they allow for additional use of land by eliminating the need for stormwater retention systems.

STORMWATER HOT SPOTS

Stormwater hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater. These areas may include commercial nurseries, auto recycle facilities, fueling stations, storage areas, industrial rooftops, marinas, outdoor container storage of liquids, outdoor loading/unloading facilities, public works storage areas, hazardous materials generators (if containers are exposed to rainfall), vehicle service and maintenance areas, and vehicle and equipment washing/ steam cleaning facilities. Pervious concrete pavement should not be used as an infiltration practice on stormwater hot spots due to the potential for ground water contamination.

STORMWATER RETROFIT

A stormwater retrofit is a stormwater management practice (usually structural) put into place after development has occurred, to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. The best application of pervious concrete pavement for retrofits may be on individual projects where a parking lot or low-volume road is being reconstructed.

COLD WATER (TROUT) STREAMS

Pervious concrete pavement can help to reduce the increased temperature commonly associated with impervious cover. Stormwater ponding on or around the surface of conventional pavement is subsequently

heated by the sun and hot pavement surface. By allowing rainfall to rapidly infiltrate, pervious concrete pavement eliminates this problem, helping to mitigate the potential for “thermal shock” events caused by heated stormwater flowing into nearby streams and estuaries.

■ Siting and Design Considerations

Siting Considerations

Pervious concrete pavement has the same siting considerations as other infiltration practices (see Infiltration Trench fact sheet). The site needs to meet the following criteria:

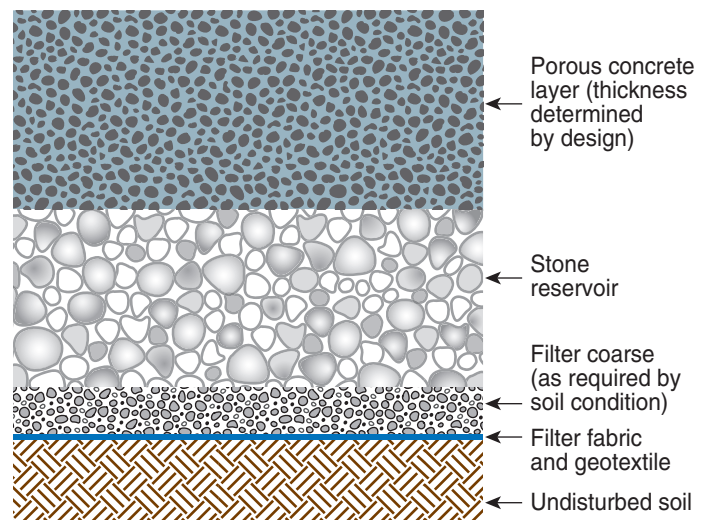


Figure 2. Pervious concrete pavement systems should be designed incorporating various aspects of the infiltration basin shown here and is dependent on soil permeability.

- When pervious concrete pavement systems are designed with a stone reservoir, the reservoir should be of sufficient depth to accommodate stormwater storage for the designed storm event.
- Design options include installation of wells or drainage channels through the subgrade and/or underground storage chambers for below surface storage of stormwater.
- If used to treat off-site runoff, pervious concrete pavement should incorporate pretreatment, as with all structural management practices.

- Pervious concrete pavement should be sited at least 3 feet above the seasonally high ground water table, and at least 100 feet away from drinking water wells.

Design Considerations

Some basic features should be incorporated into all pervious concrete pavement practices. These design features can be divided into five basic categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

1. **Pretreatment.** In pervious concrete pavement designs, the pavement itself acts as pretreatment to the stone reservoir below. Because the surface serves this purpose, periodic maintenance of the surface is an important factor in optimal performance.
2. **Treatment.** The stone reservoir directly below the pavement surface should be sized to attenuate storm flows for the storm event to be treated. Typically, pervious concrete pavement is sized to treat a small event, such as a water quality storm (i.e., the storm that will be treated for pollutant removal), which can range from 0.5 to 1.5 inches. As in infiltration trenches, water can be stored only in the void spaces of the stone reservoir.
3. **Conveyance.** Water is conveyed to the stone reservoir through the surface of the pavement and infiltrates into the ground through the bottom of this stone reservoir. A geosynthetic liner should be placed below the stone reservoir to prevent preferential flow paths and to maintain a flat bottom. Designs also may incorporate some method to convey larger volumes of stormwater runoff to the storm drain system, such as the inclusion of drain pipes below the pavement, diverting stormwater flow to supplementary catchment areas for potential reuse, or other innovative devices.
4. **Maintenance Reduction.** One nonstructural component that can help ensure proper maintenance of pervious concrete pavement is the use of a carefully worded maintenance agreement that provides specific guidance, including how to

conduct routine maintenance. Ideally, signs should be posted on the site identifying pervious concrete pavement areas. Maintenance is typically vacuuming (preferred) or pressure washing the surface at least annually based on site specific conditions.

5. **Landscaping.** For pervious concrete pavement, the most important landscaping feature is a fully stabilized upland drainage. Reducing sediment loads entering the pavement can help prevent clogging.

Design Variations

SLOPING SURFACES

When the surface is not level, the depth of the pavement and subbase must be designed to meet the desired runoff goals, or more complex options for handling water flow may be used. Pervious concrete pavements have been placed successfully on slopes up to 16%. In these cases, trenches have been dug across the slope, lined with 6-mil visqueen, and filled with rock (see Figure 3). Pipes extending from the trenches carry water traveling down the paved slope

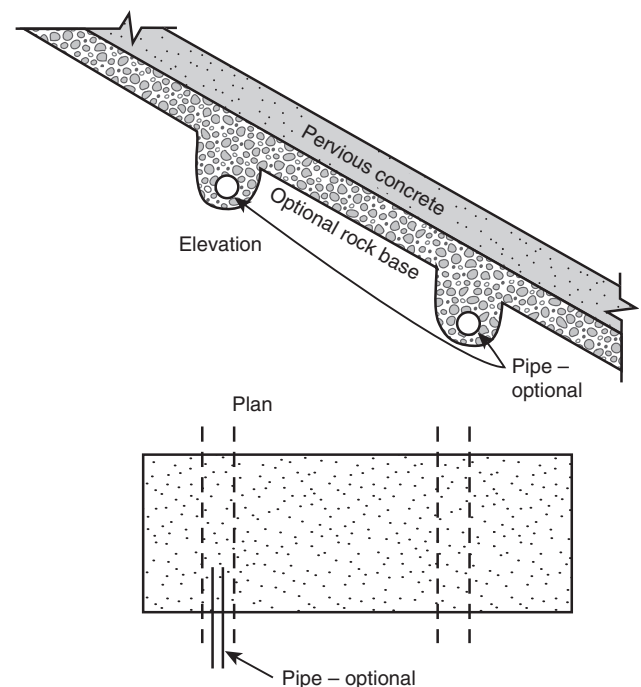


Figure 3. Elevation and plan view drawings of sloped installation. For sloped pavements, storage capacity calculations must consider depth of pavement, infiltration rate of subbase, and desired runoff goals. Source: Tennis, et al, 2004.

out to the adjacent hillside. Use of soil filter fabric is also recommended to prevent wash out of the subgrade. (Tennis et al, 2004).

REGIONAL ADAPTATIONS

In cold climates, the base of the stone reservoir should be below the frost line. This modification will help to reduce the risk of frost heave.

POORLY DRAINING SOILS

While more suitable for well-draining soils (minimum percolation rate of 0.5 inch per hour), pervious concrete pavement can be utilized in poorly draining soils, provided special design considerations are followed (see Figure 4), (Tennis, et al, 2004).

Limitations

Understanding installation procedures and innovations in pervious concrete mixtures and placement techniques has made this a very viable option for stormwater management. Installation procedures differ from conventional concrete pavement. However, when the methods are recognized and proper procedures followed, very successful installations have been documented. Care should be taken to pre-qualify suppliers and installers for pervious concrete pavement systems. Guidance on applications, specifications and installation techniques are continually evolving and being published (ACI Committee 522-R06, 2006, NRMCA Pervious Contractor Certification Manual, 2006).

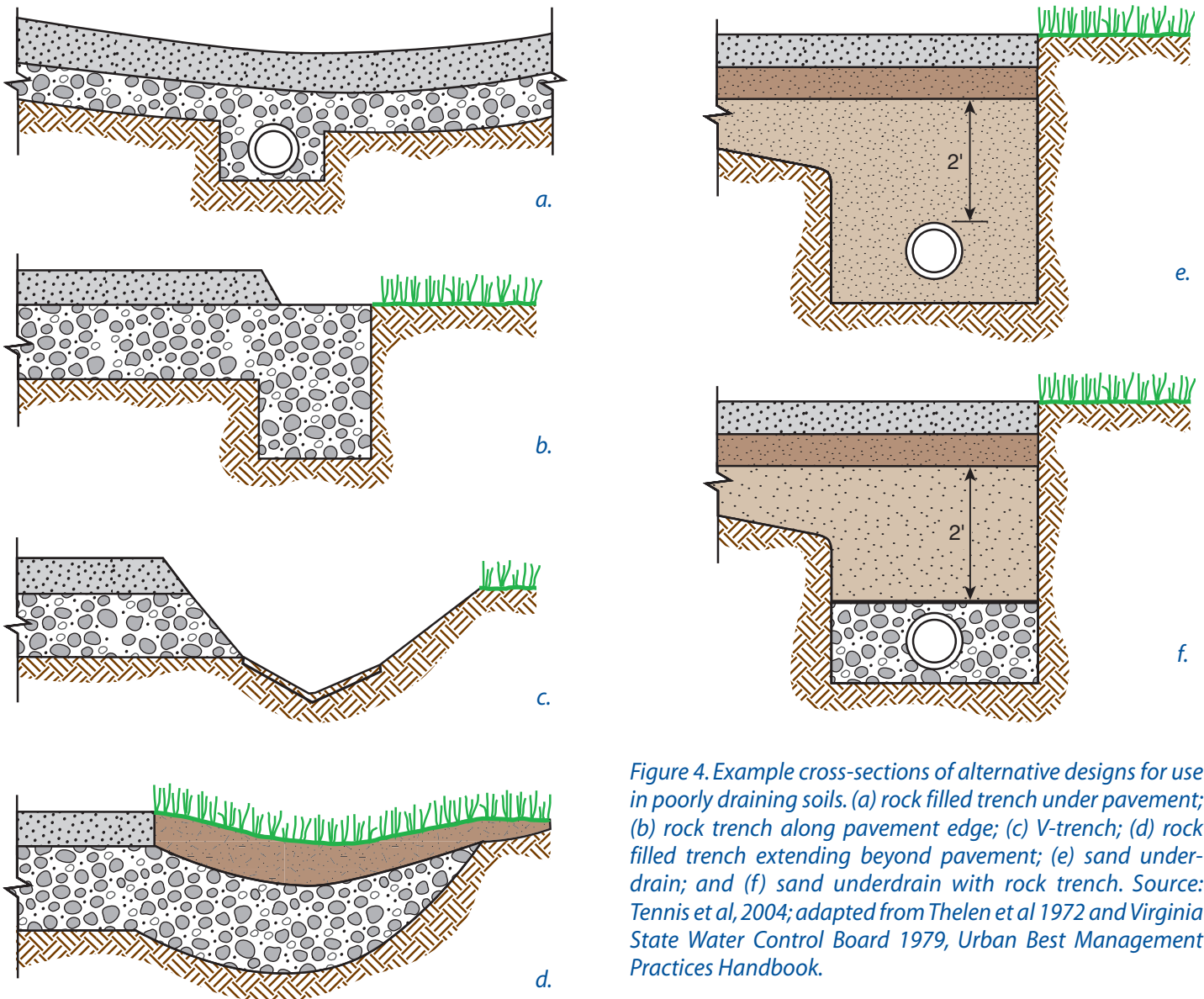


Figure 4. Example cross-sections of alternative designs for use in poorly draining soils. (a) rock filled trench under pavement; (b) rock trench along pavement edge; (c) V-trench; (d) rock filled trench extending beyond pavement; (e) sand underdrain; and (f) sand underdrain with rock trench. Source: Tennis et al, 2004; adapted from Thelen et al 1972 and Virginia State Water Control Board 1979, Urban Best Management Practices Handbook.

Table 1. Typical maintenance activities for pervious concrete pavement (Source: WMI, 1997)

Activity	Schedule
<ul style="list-style-type: none"> • Avoid sealing or repaving with impervious materials. 	N/A
<ul style="list-style-type: none"> • Ensure that paving area is clean of debris. • Ensure that paving dewaterers between storms. • Ensure that the area is clean of sediments. 	As needed
<ul style="list-style-type: none"> • Mow upland and adjacent areas, and seed bare areas. • Vacuum/sweep to keep the surface free of sediment. 	As needed
<ul style="list-style-type: none"> • Inspect the surface for deterioration or spalling. 	Annually

■ Maintenance Considerations

Pervious concrete pavement requires specific maintenance compared with other practices. In addition to owners not being aware of pervious pavement on a site, not performing these maintenance activities is the chief reason for failure of this practice. When maintenance requirements are realized by the owners, the longevity of this pavement option is very viable. Typical requirements are shown in Table 1.

■ Effectiveness

Pervious concrete pavement can be used to substantially reduce the volume of runoff, to provide ground water recharge and to reduce pollutants in storm water runoff. Some data suggest that pervious pavement systems can be responsible for as much as 70 to 80 percent of annual rainfall going toward ground water recharge. This data will vary depending on design characteristics and underlying soils.

Studies conducted on long-term pollutant removal have shown that pervious concrete pavement is very effective in removal of pollutant load (Dierkes, Holte, Geiger, 1999), in some cases demonstrating greater than 80% efficacy in pollutant removal (Rushton, 2001).

■ References

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Watershed Management Institute (WMI), *Operation, Maintenance, and Management of Stormwater Management Systems*, Prepared for U.S. Environmental Protection Agency, Office of Water, Washington, D.C., 1997.

■ Additional Resources

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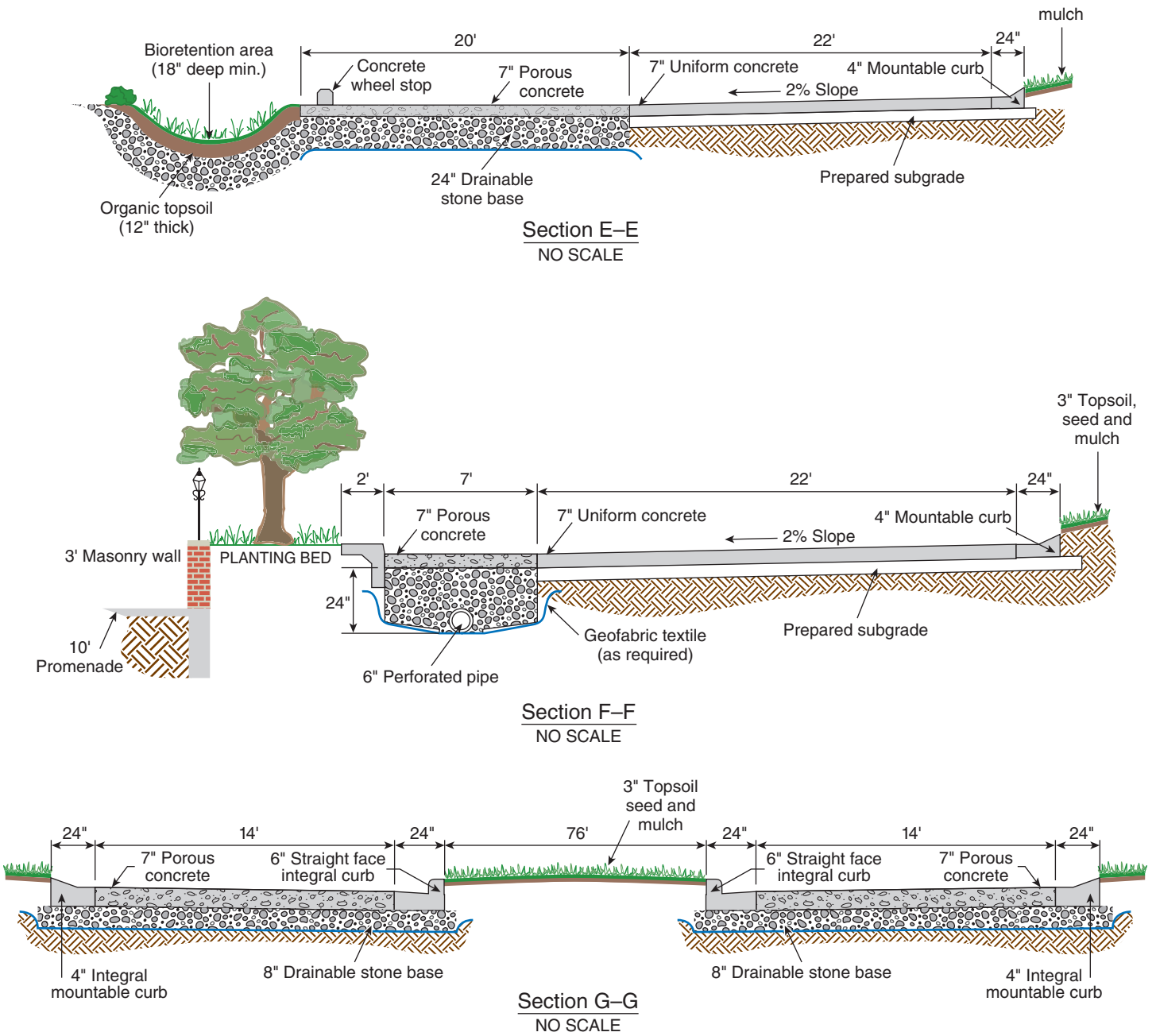


Figure 5. Illustrations from the Lost Peninsula Marina project in Erie Township, Michigan.

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