2.14 Underground Storage Facility

Photo credit: David Reutter, Franklin SWCD

Description

An underground storage facility is a large subsurface reservoir located under pavement, athletic fields, plazas, or other open space to manage stormwater runoff through infiltration, extended detention, or a combination of the two. The underground storage facility may simply be backfilled with stone or may utilize chambers (vaults, large-diameter pipe, crates, arches, etc.) to maximize storage in the space available.

All underground storage facilities **must** be coupled with an appropriate pretreatment practice to be planned as a post-construction stormwater management practice. Pretreating stormwater prior to an underground storage facility serves a dual purpose. By isolating initial (coarse grain) sediment deposition in a readily accessible area, a forebay facilitates maintenance of the larger practice. The treatment train approach also improves the efficacy of the practice.

Credits

Table 2.14.1 Credits for an Underground Storage Facility Meeting the Criteria in this Chapter

Objective	Credit	
Runoff Reduction Volume (RRv)	Infiltration Facility	The design infiltration volume up to 100 percent of the WQv for the practice's drainage area.
	Extended Detention Facility	None.

Planning and Feasibility

An underground storage facility may be a viable stormwater management practice where space to locate a large surface practice is limited and there are no other practical alternatives. It can be placed under pavement, hardscape, or greenspace where it will not conflict with buried utilities or infrastructure. Do not locate an underground storage facility beneath a building or similar structure unless the operation and maintenance plan clearly demonstrates maintenance of the underground storage facility will not be impeded.

Design an underground storage facility to infiltrate wherever feasible to gain the hydrologic benefits of runoff volume reduction, peak discharge reduction, and ground water recharge. An infiltration facility will work well on most new development sites with hydrologic soil group (HSG) A, B, or C soil. Soils classified as HSG-D typically have limitations such as low hydraulic conductivity, a seasonal high-water table, or a shallow impermeable layer that may make it necessary to consider extended detention.

Where an infiltration facility is planned, an on-site geotechnical investigation is required to determine the design saturated conductivity of the underlying soil. Factors that may influence infiltration capacity including shallow bedrock or a shallow ground water table must be evaluated as well as the potential for ground water contamination through high conductivity soil.

Routine maintenance may be overlooked because an underground practice is not easily inspected via casual observation. Inspection and maintenance procedures must be thoroughly detailed in an operation and maintenance plan that ensures long-term performance.

Pretreatment

An underground storage facility must utilize a pretreatment practice or a treatment train of practices. Select a pretreatment practice capable of addressing the expected stormwater pollutants and loading. Use bioretention or another practice capable of providing diverse treatment mechanisms where the contributing drainage area includes a pollutant hot spot or to address a specific total maximum daily load established for the receiving waters. At a minimum, the pretreatment practice must:

- be proven capable of removing at least 50 percent [80 percent for an infiltration facility] of the total suspended solids (TSS) as defined in Ohio EPA's NPDES general permit for construction activities;
- prevent large debris that could clog the water quality outlet from entering the underground storage; and
- provide sustainable storage for accumulated sediment and debris with direct access for its routine removal.

Pretreat all individual inlets to the underground storage facility. Minor inlets may be excluded but may not in sum exceed five percent of the facility's total contributing drainage area and must not include area that will contribute an excessive sediment load. An underground storage facility with multiple inlet locations may require multiple pretreatment practices. valuable

A catch basin with a basket-type insert or a deep sump, while beneficial, are not adequate pretreatment practices for an underground storage facility. Table 2.14.2 lists common pretreatment options for underground storage facilities.

Table 2.14.2 Pretreatment Practices for Underground Storage Facilities

Practice	Description	Suitability for Pretreatment
Bioretention	Bioretention is an effective pretreatment that can be easily located within parking islands and landscaping. If bioretention meets the WQv and sediment storage requirements, an underground storage facility may only be needed to address local peak discharge regulations.	All underground storage facilities.
Grass Filter Strip or Grass Swale	The use of an underground storage facility implies surface space for a grass filter strip or a grass swale is also limited, but either can be effective pretreatment when designed to the criteria given in Chapter 2.2 or 2.3.	Extended detention underground storage facility.
Manufactured Treatment Device	A manufactured treatment device meeting the design and certification criteria to follow is typically compatible with an underground storage facility where expected pollutants are limited to solids unless outfitted with additional measures to remove other pollutants.	Extended detention underground storage facility when certified* at 50 percent TSS removal. Infiltration underground storage facility when certified* at 80 percent TSS removal.
Geotextile Filter Forebay	A geotextile filter forebay meeting the design criteria to follow can settle and filter solids in a confined, accessible location.	Extended detention underground storage facility.

** By NJDEP, Washington TAPE, or STEPP programs (NJCAT verification is not considered certification).*

Pretreatment Design Criteria - Manufactured Treatment Device

A manufactured treatment device is any one of a number of proprietary treatment technologies that typically utilize vortex flow or a filter media to remove coarse sediment and larger solids (and in some cases fine sediment) from stormwater runoff as it flows through the practice. Most manufactured treatment devices do not provide detention time or peak discharge control. Hydrodynamic separators and cartridge media filters are two common types of manufactured treatment devices.

The capability of a manufactured treatment device to reduce TSS delivered to the underground storage facility must be verified through an independent, third-party using standard scientific field or laboratory test protocol and qualified testing personnel. Detailed test protocol is given in Appendix 2.A.4 and in Ohio EPA's NDPES stormwater general permit for construction activity.

A manufactured treatment device certified by the State of New Jersey Department of Environmental Protection (NJDEP), the State of Washington's Technology Assessment Protocol - Ecology (TAPE) program's General Use Level Designation, or the National Municipal Stormwater Alliance's Stormwater Testing and Evaluation for Products and Practices (STEPP) program meets the testing requirements and is acceptable for use if the maximum treatment flow rate (MTFR) and applicable design criteria conditions (for example hydraulic loading and drainage area) given in the certification are met[1]. Review the certification letter to ensure applicable design conditions are met. Only product models and sizes included in the certification letter are approved unless it specifies a method to scale other sizes.

A manufactured pretreatment device must convey, without bypass, a peak flow equal to or greater than the WQf in order to pretreat the entire WQv (the underground storage facility must still provide extended detention of the WQv). The device's certified MTFR must equal or exceed the WQf associated with the contributing drainage area of inlet to the facility where the device is located (see chapter 2.18 for instruction on calculating the WQf and refer to example calculation 2.14.1). Flow exceeding the WQf and up to the specified storm sewer design capacity must be conveyed through an internal high-flow bypass without causing 1) adverse hydraulic impact to the upstream drainage system and 2) scour or resuspension of previously captured solids. Otherwise, the device must be placed offline. Additionally, place the device offline if the inflowing sewer design capacity exceeds the maximum flow tested for scour (commonly 200 percent of the MTFR). Inflow may be divided equally among multiple manufactured treatment devices installed in parallel at any inlet to accommodate large design flows.

The stormwater pollution prevention plan (SWP3) must include a site-specific and device-specific plan for operation and maintenance of a manufactured pretreatment device. Include detailed maintenance procedures and a cleaning schedule that ensures continuous, long-term performance.

Example Calculation 2.14.1 Manufactured Treatment Device Sizing

A particular manufactured treatment device will be used for pretreatment of an inlet to an underground storage facility with extended detention of the WQv. The contributing drainage area of the inlet is 0.50 acres of pavement with a calculated tc of five minutes. The NJDEP certification letter approves this particular device at 50 percent TSS removal to the following flow criteria:

Unit Size	MTFR (cfs)
#2	0.35
#4	1.15
#6	3.75
#8	5.85

Calculations:

1. **Calculate the WQf for the contributing drainage area of the inlet to the underground storage facility.**

$$WQf = CiA = 0.95 \times 2.37 \text{ in/hr} \times 0.50 \text{ ac} = 1.13 \text{ cfs}$$

Where C = 0.95 for impervious pavement,

i = 2.37 in/hr [from Ohio EPA Construction General Permit Appendix C] for a t_c of 5 minutes, and

A = the contributing drainage area to the inlet (acres).

2. **Per the certification letter, the #4 unit with a MTFR of 1.15 cfs exceeds the WQF and is acceptable for pretreatment on this inlet.**

[1] Lists of manufactured treatment devices certified under each program are available at njstormwater.org and ecology.wa.gov.

A manufactured treatment device cannot be interchanged after regulatory approvals without redemonstrating the substituted device's certification and unit sizing to the WQf.

Pretreatment Design Criteria - Geotextile Filter Forebay

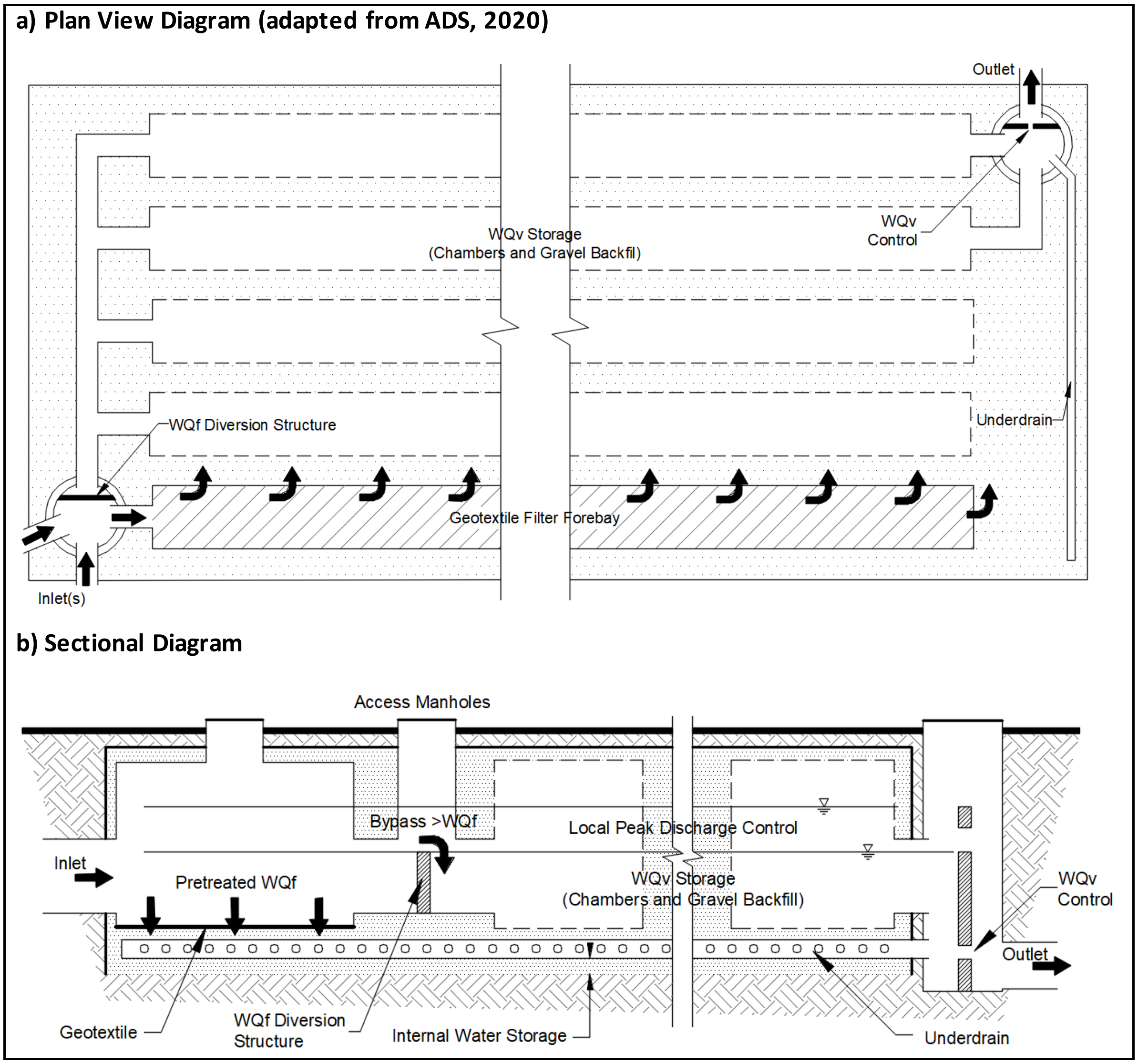

Figure 2.14.1 Conceptual illustrations of a geotextile fabric forebay as pretreatment for an underground storage facility with extended detention (not to scale).

A geotextile lined chamber can serve as a forebay to pretreat stormwater through sedimentation and filtration prior to the WQv storage reservoir. To pretreat the WQv in this manner, design a weir or other structure to divert the WQf into a geotextile filter forebay. Size the forebay's geotextile bottom area to pass the WQf at a maximum hydraulic loading rate of 1.0 gallon per minute (gpm) per square foot of geotextile filter area (0.0022 cfs/ft^2) in order to pretreat the WQf. The WQf must discharge through the filter fabric directly into the extended detention storage. It must not bypass the water quality outlet control (orifice).

The filter media must include a minimum of two layers of woven geotextile meeting the material specification provided in Table 2.14.3 (Maine, 2016). Place the geotextile filter over a supporting aggregate base that will not rip the fabric. Bind all fabric ends, seams, and splices to prevent tearing or gaps. If the forebay chamber is perforated, place geotextile over the sidewalls.

Frequent cleanout of accumulated sediment from the geotextile filter forebay is expected to be necessary to prevent clogging of the fabric which reduces treatment efficacy. At a minimum, locate a manhole to provide direct access to the diversion/inlet to the forebay chamber and at the opposite end. If a forebay consists of multiple rows of chambers, each row requires a separate access structure. Additional access structures are recommended if the length of the forebay exceeds 300 feet. Specify site-specific maintenance procedures for the geotextile filter forebay in an operation and maintenance plan that requires sediment be removed beyond an accumulated depth and, at a minimum, once every five years.

Table 2.14.3 Geotextile Material Specification

Test	Test Method	Units	Rating
Grab Strength	ASTM D 4632	lbf	315
Tear Strength	ASTM D 4533	lbf	113
Puncture Strength	ASTM D 6241	lbf	620
Permittivity	ASTM D 4491	sec^{-1}	0.05
Apparent Opening Size (AOS)	ASTM D 4751	Mm (US sieve)	0.43 (40 sieve)
Reference: American Association of State Highway and Transportation Officials (AASHTO) Standard M288 for Stabilization, Class I, Woven, <50% elongation			

Example Calculation 2.14.2 Geotextile Filter Forebay Sizing

A geotextile filter forebay will provide pretreatment at an inlet to an underground storage facility with extended detention of the WQv. The contributing drainage area of the inlet is 0.50 acres of pavement with a calculated tc of five minutes.

Calculations:

1. **Calculate the WQf for the contributing drainage area of the inlet to the underground storage facility.**

$$WQf = CiA = 0.95 \times 2.37\ in/hr \times 0.50\ ac = 1.13\ cfs$$

Where C = 0.95 for impervious pavement,

i = 2.37 in/hr [from Ohio EPA's NPDES Construction General Permit Appendix C] for a t_c of 5 minutes, and

A = the contributing drainage area to the inlet (acres).

2. **Size the geotextile filter forebay area (bed) to pass the WQf at the required hydraulic loading rate of 1.0 gpm/ft².**

$$\text{Forebay area} = [1.13\ cfs \times 448.8\ gpm/cfs] \div 1.0\ gpm/ft^2 = 397.2\ ft^2 \simeq 400\ ft^2$$

Design Criteria – All Underground Storage Facilities

To meet post-construction stormwater management objectives and maximize the functional life of the practice, design all underground storage facilities according to the following general criteria, then consult the specific design criteria for an extended detention facility or an infiltration facility that follows.

Structural Integrity

All practices must be structurally sound to operate effectively in the long-term, but an underground storage facility is subject to structural engineering criteria beyond the scope of this manual. The engineer of record is responsible for the structural integrity of an underground storage facility and any surface infrastructure it supports. The designer must consult appropriate structural engineering standards and adhere to applicable State and local code.

Structural design matters should not impinge on the water quality objectives of the underground storage facility including maintenance access. If structural design concerns interfere with water quality objectives, a surface practice should be considered. Where proprietary pretreatment or underground storage facility infrastructure is utilized, follow the manufacturer's design guidance in addition to meeting the following stormwater practice design criteria.

Water Quality Volume Storage

Provide a temporary storage volume equal to the water quality volume (WQv) prior to the invert of a locally required peak discharge control or the auxiliary (emergency) spillway. Calculate the WQv for the drainage area to the practice as described in Chapter 2.16 and as required in the Ohio EPA NPDES general permit for construction activities.

Develop storage for the WQv within the void space of aggregate backfill, enclosed chambers, or a combination of perforated chambers and aggregate backfill. Underground storage facility infrastructure tends to have irregular geometry. Report stage-storage (volume-depth) data specific to the design and in sufficient detail (maximum three-inch or 0.25-foot depth increments) to demonstrate the WQv storage, its corresponding elevation, and its drawdown curve.

Local Peak Discharge Control

Where local regulations require additional peak discharge control for moderate to large storm events (often with the critical storm method described in Appendix 2.A.3), design a multi-stage outlet (see figure 2.14.1) with additional storage volume. It is not necessary to stack the storage volume needed for peak discharge control above WQv except where required by local regulation, however the WQv storage must be developed prior to activation of an upper peak discharge control outlet.

Aggregate Backfill Storage

All aggregate used for stormwater storage shall be crushed stone or river rock that is course, uniform, and open-graded to create a significant void content. Use a maximum aggregate porosity of 0.40 (0.30 for coarse sand) when calculating storage volume. Aggregate shall be clean and free from fines, having less than 0.5 percent wash loss, by mass, when tested per the AASHTO T-11 wash loss test.

Storage Structures

Structural pipe, chambers, or vaults may be used to develop an efficient storage volume. Often, these are proprietary systems of prefabricated modules with adaptable configurations and a unique stage-storage relationship. The use of a proprietary system requires careful coordination between the designer and the manufacturer to assure the proper storage volume and drawdown time are provided. Site-specific volumes, dimensions, elevations, layout, inlet details, and outlet details must be determined and given in both the construction plans and the SWP3 whether provided by the project engineer or the manufacturer. Do not rely solely upon manufacturer's typical, stock, or cut sheet drawings to convey an underground storage facility design or to demonstrate regulatory compliance. Due to a potentially differing stage-storage relationship, storage systems or module sizes cannot be interchanged after regulatory approvals without redemonstrating the substitution still achieves WQv storage and drawdown criteria.

Hydraulic By-Passing

Prevent stormwater detained in the facility from bypassing the water quality outlet control through nearby sub-surface (footer) drains or unconsolidated backfill. Either maintain a horizontal separation distance of 10 feet of in-situ soil from all utilities and foundations or install an impermeable liner. Use disconnection measures such as anti-seep collars or compacted trench breakers to prevent bypassing through the unconsolidated backfill of in-coming and out-going storm pipe. Avoid locating an underground storage facility above other utilities.

Inspection and Maintenance Access

All underground storage facilities must include sufficient access to routinely conduct inspections of the practice and anticipated maintenance activity. The type, location, and number of access points necessary depends on the type of facility, facility size, the interconnectivity of any storage chambers or units, and the prescribed maintenance methods. The operation and maintenance plan must detail the process to remove accumulated sediment from and clearly demonstrate the necessary accessibility to all storage areas. Consider the practical reach (length and maneuverability through bends, manifolds, and other constrictions) of vacuum hoses, pressure jets, and other cleaning equipment when developing a plan. Access to an underground storage facility must comply with all local storm sewer system design requirements. A manhole for access, inspection, and maintenance must be located 1) at or above the main inlet(s) to the underground storage facility and 2) at the outlet providing direct and unimpeded access to the water quality outlet control (orifice) including both sides of a weir wall. An additional manhole to the interior of the facility is highly recommended for every 10,000 square feet of underground storage area or infiltration bed.

Manholes permit ingress by maintenance personnel or equipment for sediment and debris removal. Manholes must have at least a 20-inch diameter or larger clear opening that conforms with all local storm sewer design and safety requirements. Provide safe, adequate surface space and overhead clearance for maintenance operations at all manholes. Locating manholes in parking stalls and critical travel lanes should be avoided where feasible. Manholes designed for cleanout must be reachable by a vacuum truck and similar large equipment associated with sediment removal.

Observation wells are not considered access points for maintenance operations but facilitate monitoring sediment accumulation as well as the level and drain time of stormwater stored within the facility. Observation wells should be placed as necessary to check sediment buildup and verify its cleanout through the storage volume. They must be at least six-inch diameter ports and large enough to insert a camera or basic inspection equipment. Extend perforated pipe to the elevation of a designed infiltration bed or through facilities provide storage solely in stone void space.

Design Criteria - Extended Detention Practices

An underground storage facility that provides extended detention of the WQv alone may be ineffective at removing fine grain sediment, dissolved pollutants, and other pollutant forms (ASCE/WEF, 2012). However, Ohio EPA believes post-construction water quality objectives can be met by coupling an extended detention facility with a pretreatment practice as required in the NPDES construction stormwater general permit and discussed on page 2.

Water Quality Drawdown

Design an outlet structure to drain or draw down the WQv storage over a minimum 24-hour period with less than 50 percent of the WQv storage emptying within the first eight hours. Targeting a 24-hour drawdown period extends detention of the WQv long enough to provide treatment but short enough to provide storage for subsequent rainfall events. It also reduces the energy of runoff to limit erosion in receiving channels. Any underdrains within the aggregate backfill must outlet through the water quality outlet control. For partially infiltrating systems, place the water quality outlet above the internal water storage. To limit mosquito breeding and other nuisances a maximum WQv drain time of 72 hours is recommended.

Water Quality Outlet

The extended drawdown of the WQv often results in a small orifice or outlet control also located underground that must be designed to be non-clogging and easily maintainable. A trash rack or other mechanism to prevent blockage by large debris must be installed over any control orifice less than three inches in diameter and is recommended for all diameter outlets. The water quality outlet control must be accessible from the surface, requiring no confined-space entry for routine inspection and clearing of blockages. An orifice or weir control located within a manhole separate from the reservoir may be easier for the responsible party to locate and service.

An outfall to a stream or ditch must be stable for the maximum (pipe-full) design discharge. Use outlet protection consistent with state or local guidance to prevent erosion of the receiving channel bed or banks. Minimize any necessary modifications to the receiving stream.

Local Peak Discharge Control

Design a multi-staged outlet and storage volume when local regulations require the peak discharge of moderate to large storm events be controlled with the critical storm or other method in addition to the WQv requirement. It is not necessary to stack the flood control storage volume above WQv except where required by local regulations. The WQv storage must be developed prior to activation of the upper peak discharge control.

Promote Sedimentation

Extended detention can promote settling of suspended solids within the reservoir, but the sediment retention may be minimal without features to store sediment and limit resuspension. Promote gravitational setting within the underground storage facility by maximizing the water retention time within the reservoir. If feasible, use aggregate backfill, structural chamber layout, sumps, internal baffles, and/or other means to dissipate energy from the inlet, distribute flow throughout the reservoir area, and lengthen the internal flow path. Do not short-circuit the reservoir by placing the inlet and outlet in close proximity or directly in-line at a close distance. Consider improving sediment retention by creating up to three inches of dead storage above the reservoir, which may also serve as internal water storage for minor infiltration. This must however be balanced with the potential for mosquito breeding and anaerobic conditions.

Promote partial infiltration

Although site conditions may not be conducive to infiltration of the full WQv, including a dead storage zone of three inches or less to store a smaller volume will allow some infiltration over time. Line the bottom soil with geo-grid or open mesh fabric for stability if necessary but avoid using woven or non-woven geotextiles that may clog. See the subsurface infiltration bed discussion to follow.

Design Criteria - Infiltration Practices

Apply the following criteria if the site presents an opportunity to exfiltrate the entire WQv into the underlying soil.

Pretreatment

Fine grain sediment can clog an infiltration bed. When this bed is underground, beneath other infrastructure, it will be extremely difficult and expensive to conduct restorative maintenance. To preserve the design infiltration capacity, it is critical to locate a pretreatment practice capable of removing at least 80 percent of the TSS at all inlets. Manufactured treatment devices must be certified for 80 percent TSS removal level per the discussion beginning on page two.

Design Soil Infiltration Rate

Accurately predicting the soil infiltration rate is key to estimating the WQv draw down and assuring the practice performs as intended. The design soil infiltration rate must be based on field measurements in taken at the design depth of the infiltration bed using a test method described in Chapter 2.17. Given the challenges routine maintenance, consider applying a factor-of-safety up to one-half of the field-measured infiltration rate to represent the aged (partially clogged) condition.

Monitor construction to ensure 1) the soil tested is consistent over the entire practice area and 2) that incidental compaction or sediment-laden runoff does not reduce or invalidate the design infiltration rate.

Subsurface Infiltration Bed

The soil surface at the bottom of the excavated storage reservoir serves as the infiltration bed. The infiltration bed must be level. Use a stepped or terraced facility to develop multiple level infiltration cells in gently sloping areas.

The walls of the excavation should be lined with a non-woven geotextile filter fabric to restrict sediment from entering the reservoir but **do not cover the infiltration bed with geotextile fabric.** Clogging or masking of the filter fabric will result in a loss of infiltration capacity.

Do not compact the infiltration bed. The load-bearing capacity of the subgrade soil should be addressed according to manufacturer's recommendations and may include adjustments to aggregate depth or the use of a wide-aperture geo-grids to develop structural stability.

The area of the subsurface infiltration bed shall be sized both to drain the WQv at the design infiltration rate within 48 hours and equal or exceed 0.05 times the contributing impervious drainage area or

$$A_{inf} \geq 0.05 \times A_{imp} \qquad \text{Equation 2.14.1}$$

where A_{imp} = area of the contributing impervious surface, and

A_{inf} = area of the subsurface infiltration bed.

Internal Water Storage

All underdrains and outlets must be above the aggregate-adjusted depth of the WQv to create internal water storage. This volume will leave the reservoir through the infiltration bed directly below the internal water storage.

Vertical Separation from High Water Table or Bedrock

The excavated infiltration bed should be at least two feet above than the seasonal high-water table or underlying bedrock. Consider the effect of added impervious cover which may lower the local groundwater table.

Class V Injection Well

An underground storage facility that distributes stormwater over an infiltration bed with pipe or structural chambers meets the definition of subsurface fluid distribution system and is considered a Class V injection well. Per Ohio Administrative Code 3745-34-11(j), it shall be constructed to minimize the injection of contaminants typically in stormwater including, but not limited to, sediment, fecal matter, motor vehicle fluids, fertilizers, and pesticides. General stormwater contamination is addressed through adequate pretreatment, avoidance of excessively permeable soils, and a vertical separation of at least two feet between the infiltration bed and the seasonal high ground water table, however additional measures may be required depending on the expected pollutants and loading. Class V injection wells must be registered with Ohio EPA, Division of Drinking and Ground Water's Underground Injection Control Program by submitting information required under OAC rule 3745-34-11(M). Visit epa.ohio.gov for further instruction.

Design Considerations

In addition to the proceeding design criteria that address the stormwater management function, other design considerations are necessary to ensure a sound and successful practice. Consider the following items when designing an underground storage facility and address them as appropriate.

Occupational Safety and Health Administration (OSHA) regulations for confined space may apply to underground storage chambers or cavities and must be considered in both the design of the facility and its operation and maintenance plan.

The ground water table can cause storage chambers to displace due to uplift forces. Conduct a buoyancy analysis for storage chambers and, where necessary, use anti-floatation measures.

Consider the effect of infiltration or seepage from underground storage reservoirs when evaluating soil bearing strength and slope stability.

Construction Considerations

Instruct the excavator to exercise great care to minimize compaction and smearing of the soil interface when a facility is expected to infiltrate. Smearing by buckets or blades will reduce the infiltration capacity of the practice. Advise to avoid operating equipment on the infiltration bed to prevent compaction. Before placement of any aggregate, rake or scarify the infiltration bed to a depth of three inches to reduce the effects of smearing.

Sediment control during active construction may present a challenge where an underground storage facility with pretreatment is planned. An underground storage facility is typically installed with the stormwater infrastructure soon after site clearing and mass grading destabilizes the site, but it cannot serve as a temporary sediment control (pond or trap) as it lacks the ability to affix a skimmer above a sediment storage zone and to fully clear captured construction sediment.

In some cases, it may be possible to delay installation of the storage facility to use the open excavation as a temporary sediment basin, at least during early clearing and grading phases. Doing so may reduce the risk of damage to chambers and vaults by heavy equipment traffic over a facility without final cover depth. Once the underground facility is installed, it will be important to prevent runoff from entering the underground storage facility during construction. Sediment controls should be redundant and include 1) placing small, excavated sediment traps at surface inlets, 2) using proper inlet protection, 3) using effective upland sediment controls including silt fence, and 4) prioritizing erosion controls and permanent stabilization of the drainage area. Often sites will remain at a subgrade elevation so that surface inlets at finish grade elevations can be kept inactive with minimal additional excavation for sediment traps. Refer to Chapter 6 for sediment control design details.

Maintenance Considerations

An underground storage facility must operate long-term with sustained performance. The designer must develop a detailed operation and maintenance plan for the owner that outlines the maintenance activities necessary and their expected schedule to ensure a consistent level of treatment occurs over the life of the practice.

While maintenance is inevitable, its frequency, level of effort, and cost can be minimized through good planning and design. The designer should consider the following measures to ease the owner's maintenance burden.

- Whenever feasible, design the underground storage facility and pretreatment practices such that all routine inspection and maintenance activities may occur without the need for personnel entering underground chambers and with minimal disruption of surrounding land uses (blocking traffic, restricting parking).
- Include easements for maintenance access where necessary.
- Labeled manhole lids are recommended.
- Maintain all proprietary devices or storage facilities in accordance with the manufacturer's recommendations. The manufacturer's literature may be a key part of but does not substitute for a site-specific operation and maintenance plan.

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