REPORT REVIEW: DESIGN CONSIDERATIONS FOR IMPROVED PERFORMANCE OF UNDERGROUND INFILTRATION SYSTEMS IN LOW-PERMEABLE SOILS

By Sara Gilbert, PE, LEED, AP, Envision SP
President of Pinewoods Engineering, PC

QUICK READ

Study Overview

-Review & Summary of: 'Evaluation of Underground Storm Infiltration Systems Final Report': http://www.sustainabletechnologies.ca/wp/wp-content/uploads/2013/03/Infiltration-Chambers-and-Trenches_2013-Final.pdf-

-Study evaluated infiltration volume performance of 2 separate chamber systems and one trench system.

-Study period ranged from 2-3 years and concluded in 2011.

Design Considerations:

1. **Volume Infiltrated Tied to Practice Sizing and Accurate Native Soil Infiltration Rate**
2. **Provide Adequate Separation From Perched or High Water Tables**
3. **Increase Hydrologic Head for Increased Infiltration Rates**
4. **Design for Longer System Drainage Time**
5. **Inlet Manhole Modifications for Pest Control & Sediment Capture**

WHAT DESIGN FACTORS SHOULD BE CONSIDERED?

A study evaluating the performance of underground infiltration systems in low permeable soils yielded some interesting findings, and design considerations, for increasing their effectiveness. In New York State, underground infiltration systems that meet the 'NYSDEC Design Manual' standards can satisfy requirements for providing; Runoff Reduction Volume, Water Quality Volume and Peak Runoff Rate Reduction. However, designers are often unsure of how well these systems will perform on sites with low infiltration rates. A study conducted by the Toronto and Region Conservation Authorities' 'Sustainable Technology Evaluation Program' (STEP) and detailed in a report entitled; 'Evaluation of Underground Storm Infiltration Systems' sheds some light on potential factors related to underground infiltration systems' performance, and how it may be improved. A copy of the report may be found here.

The study looked at three different systems and evaluated their respective infiltrated volume compared with their design parameters, and site constraints related to; soil permeability and groundwater elevation. The following table provides an interpretive summary of the study:

System	Type	Manuf.	Soils Perm.	Water Table Elev.	Infiltrated?
#1	Chambers	ADS	Medium	Seasonal may reach chambers	Yes, at Design Volume
#2	Trench	N/A	Low	Far below trench base	Yes, below Design Volume
#3	Chambers	Cultec	None	Frequently at or above chambers	No, as anticipated

The study found that System #3 essentially did not infiltrate, despite the opportunity provided. While not confirmed, the report attributes this to the possibility that the system may have raised the seasonally high water table; or, created a perched water table which did not dissipate between storm events. The report concluded that System #2 was undersized, and had it been designed to the actual natural soil infiltration rate, may have met the design volume.

Taken from the study findings and report conclusions; the following design considerations may increase the performance of underground infiltration systems in low-permeable soils:

1. Use an Accurate Native Soil Permeability Rate

Interestingly, the study found that native soil infiltration rates were 2.5 times higher when the system was more than half full, and that infiltration rates decreased exponentially as water levels in the system decreased. It also found no significant seasonal variation in the native soil infiltration rate, a factor it attributed to the depth of the systems. The report considered the potential of System #2's sub-par performance to a possibly undersized system, due to an inaccurate (and too large) calculation of the native soil infiltration rate. This leads to the consideration of the best way to calculate an accurate soil permeability rate. The 'NYSDEC Stormwater Management Design Manual' indicates infiltration testing should be done by filling a casing to a depth of 24-inches and measuring the drop over an hour. Presumably though in low-permeable soils, the test result may not reach an elevation of low hydraulic head over the period of this test, yielding a higher rate. If it is imperative to completely drain the system between storm events (see item #3 for why this may not be desired) then perhaps infiltration testing should represent the hydraulic head at which the system will need to perform to get an accurate native soil permeability rate. This assumes all other factors that can lead to inaccurate testing results have been accounted for.

2. Provide Adequate Separation From Perched or High Water Tables

System #3's complete lack of any noticeable infiltration volume was considered to be potentially due to a water table at the system's base, though this was not confirmed in the study. These results were disappointing in that despite the soils having little-to-no infiltration capacity, with the opportunity made available, some infiltration was not achieved over the course of the study period. I agree with the report's prediction that a high or perched water table most likely caused this result and that the system may have increased the groundwater elevation. The potential for a system to increase the groundwater elevation, or caused perched conditions, seems to be a valid consideration when designing a system bottom with a small separation from potential high water table elevations or impermeable soil strata. The NYSDEC Design Manual requires a 3-ft separation from the practice bottom to high groundwater conditions which seems more than sufficient to address this concern. The report recommends reviewing soil strata for conditions that may result in perched water.

3. Increase Hydrologic Head for Increased Infiltration Rates

The report makes an interesting recommendation to consider designing a system that does not fully drain in order to maintain a design hydraulic head elevation which will result in a higher infiltration rate. As the report states, this would have the additional benefit of sediment retention. The study noted System #3 included a portion of the gravel bed with no outlet to determine if it would maintain a permanent pool of water. It did maintain a permanent pool however, it seems probably to attribute this to the water table elevation. Holding permanent water in the system has negative attributes as well as discussed in item #5.

4. Design for Longer System Drainage Time

All three systems exhibited lower than expected infiltration rates which resulted in slower emptying. More specifically, greater than 72 hours as designed. The report does not offer an explanation for why this may have occurred but presumably the native soil infiltration rate was calculated correctly and the slower post-development rate may have been a product of more frequently saturated soils. Most underground detention systems are designed for high runoff volume from low frequency storm events; so in theory, even with a slower drainage after a small storm, there should still be sufficient volume in the system to accommodate another small volume, high frequency storm. The study notes that more frequent occurrences of overflows were experienced than anticipated. In addition to using an accurate infiltration rate (per item #1) it seems this could be mitigated by designing for longer detention times. Having a more robust emergency drainage plan to account for more frequent system overflows may be considered if flooding, and not infiltrated volume, is the greater concern.

5. Inlet Manhole Modifications for Pest Control & Sediment Capture

The study found that the all the systems contained standing water through much of the year particularly in the control manhole. They noted sediment and water build-up in the inlet manhole, did not impact hydrologic performance but made observations and measurements difficult. With these findings, the report authors also questioned the effectiveness of underground systems in reducing mosquito breeding. It also suggested that manholes with sumps may assist in the reduction of sediment build-up in the manhole or system. Manhole sumps though would presumably contain standing water, which is attributed to mosquito breeding. The report authors recommend designing a control valve or pump in the control manhole to reduce ponding water. Since an entire mosquito larva population can be supported in just 1 oz of water, it seems impossible to try keep the control manhole completely dry with the goal of discouraging larva. Alternatively, since mosquito larva habitat is not conducive to walls or pools of water greater than 2-ft, this makes the case for considering manhole sumps of 2-3 ft depth with some allowance for evaporation. The report authors recommend using manhole covers without holes or openings to discourage mosquitos from entering. This recommendation would also have the advantage of helping to keep organic matter (ie. grass clippings, food) out of the control manhole. The presence of which, when combined with other favorable elements, encourages larva populations.

Conclusions

I think most designers of underground infiltration systems cannot help but wonder how they are performing years after they have been actively in-service, probably not maintained, and long forgotten about tucked away out-of-sight. Any study, which attempts to answer these questions provides valuable feedback for both designers and owners. Underground systems are often quite expensive and designers feel the need to balance conservative design estimates against regulation requirements and associated costs. I was hoping the study would provide some information regarding how ADS, Inc. StormTech chambers performed in relation to the Cultec, Inc. Recharger chambers but the study did not highlight specific pro's or con's of either system and it doesn't seem comparison conclusions could be drawn from the study.

The results of this study seem to indicate that underground infiltration systems can work successfully in low-permeable soils, when high or perched water table elevations are not a limiting factor. The fact it highlights they underperformed essentially by infiltrating slower than expected gives designers at least something to consider in using a more conservative design or, accounting and accommodating for overflow/sub-par performance.

ABOUT THE AUTHOR

Sara Gilbert, PE, Envision SP, LEED AP BD+C is the president and founder of Pinewoods Engineering, PC located in Rochester, New York. She has over fourteen years of experience in civil/site engineering with a focus on land development, storm water management, hydrology & hydraulics and sustainable design. She may be reached at sgilbert@pinewoodseng.com. *Information on Pinewoods Engineering, PC may be found at: www.pinewoodsengineering.com*

References

'Evaluation of Underground Storm Infiltration Systems Final Report', February 2013, by Dean Young, Tim Van Seters and Christy Graham, commissioned by the Toronto and Region Conservation Authority. (Referred herein as "report")

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