Pinelands Commission Basin Failure Assessment and Investigation

Keithe J. Merl, PE

Princeton Hydro, LLC, 1105 Laurel Oak Road, Voorhees, NJ

856-346-0060, kmerl@princetonhydro.com

Abstract

Recently promulgated New Jersey Stormwater Regulations (N.J.A.C. 7:8) emphasize the use of infiltration facilities for adequate site stormwater management. The Pinelands Commissions has been requiring and approving these same infiltration facilities throughout the Pinelands Management Area since before 1986. With more than 100 of these infiltration stormwater facilities in the Pinelands Management area, the general consensus that infiltration is "easy" in the Pinelands area, and a staggering 70% failure rate, understanding natural features that can predict inappropriate facility siting and reasons for infiltration failures is extremely important to the Pinelands Commission. Further understanding of failure modes and mechanisms can be used to determine proper placement, design, and construction of infiltration facilities. This paper summarizes the results of the Mullica River Watershed Stormwater Basin Assessment Project, and two (2) significantly impaired (>75% of basin area with ponded water) infiltration facilities inspected in detail, by the author, for the purposes of the assessment project. The methods, procedures, and information collected during those assessments are provided, in detail for this paper, as an approved protocol for infiltration facility investigations in the Pinelands Management Area and other areas of the country.

Introduction

Infiltration facilities are becoming more common around the country to deal with stormwater volume and groundwater recharge management concerns. These facilities are regularly design and installed without the benefit of thorough and adequate site study and testing, and construction phase oversight and management. This is apparent, especially in the New Jersey's Pinelands Commission Management Area, by the quantity of failed infiltration facilities.

In order to assess and understand the failures of these facilities, the Pinelands Commission, with a grant from the New Jersey Department of Environmental Protection (NJDEP) Bureau of Watershed Management, completed a targeted assessment of the infiltration basins located within the Mullica River Watershed. The final report is entitled "Mullica River Watershed Stormwater Basin Assessment Project", published in 2005 and available on the web at "http://www.state.nj.us/pinelands/images/pdf%20files/StormwaterAssessment_All.pdf" and "http://www.state.nj.us/pinelands/images/pdf%20files/0579001FinalReport.pdf".

New Jersey Stormwater Regulations

According to the New Jersey Administrative Code (N.J.A.C.) §7:8 the general definition of infiltration basin failure consists of:

1. Basins that provide no infiltration capacity;
2. Basin does not infiltrate the design storm within 72 hours of storm cessation (± 10%);
3. Groundwater mound, resultant from the infiltrated stormwater, influences adjacent structures and site features to detrimental effect; and
4. Groundwater mound, resultant from the infiltration of stormwater, is calculated to permanently saturate the bottom of the basin.

The administrative code also provides some guidance on siting or placing of infiltration basins:

1. Infiltration facilities should be sited and designed for small drainage areas;
2. Soils should be sufficiently permeable to provide adequate infiltration rate, therefore siting only in soils classified as (Hydrologic Soil Group)HSG A or B.

When siting and designing infiltration basins there are several important factors that tend to be overlooked by designers and constructors. Basic, almost common sense, methods of design and construction can be implemented prior, during, and post construction to insure proper operation of infiltration facilities.

Detrimental Results of Failing Basins

Flooding – can be exasperated by failing infiltration basins by reducing the effective storage and infiltration capacity (volume reduction) basins. Not only is this a safety hazard, but it is also a criteria for non-conformance.

Water quality – issues can concentrate in infiltration basins that do not discharge completely. Typically the top one to two feet of soils provide treatment for pathogens, nutrients, suspended solids, and some other toxic substances. When the vertical flow of water is impeded this treatment does not occur.
When this is compounded with the aforementioned flooding issues significantly concentrated contaminants can be discharge to surface water features. Therefore, affecting the health and welfare of the public downstream of the basin.

Standing water – facilitates mosquito breeding, provides a drowning hazard for young children, and prime grazing and procreation grounds for geese.

Aesthetic – issues including excess erosion features, sediment accumulation, aquatic plant growth, development of "pond scum", and security features (chain-link fence) can be perceived as a reduced quality of life and an "eye-sore".

Basin Assessment Project

The basin assessment project revealed several interesting and key issues related to the siting, design, and implementation of infiltration stormwater facilities.

USDA Soils Mapping

Regional soil mapping (typically supplied by USDA) can be a useful tool in initial basin siting, and determination of basin type suitability. The assessment project provides some interesting results and guidance on the use of the USDA soils maps during the process of designing infiltration facilities.

21 different soil types were observed in the vicinity of the 47 inspected basins. The basins were tabulated to relate the basin to the mapped soil units and hydrologic soil group determinations (HSG).

The results indicated that the soil type (series or HSG) is *not* a good indicator of the ability or propensity of soils to infiltrate stormwater. The report provides two (2) primary reasons: (1) USDA mapping is provided for surficial deposits and is not intended to characterize the soil matrix at depth; and (2) the regional scale of the mapping that is not suitably precise for use on a site specific scale.

Comparing the sited basins related to the mapped HSG provided the following results:

1. For HSG soils classified as A, C, C/D, and D soils were consistently observed to have standing water two (2) out of three (3) basins observed;
2. B/D HSG mapped soils were observed to have standing water every one (1) out of three (3) basins assessed; and
3. In soils mapped as HSG type B more than 80% of the basins had standing water observed.

The results revealed no reasonable correlation between HSG classifications provided by the USDA data and the serviceability of basins.

This conclusively provides that soil type only is not the primary factor affecting the ability for these basins to operate as designed and intended.

Type of Development Draining to Basin

It is generally assumed that the more intrusive the development the higher the propensity for basin clogging. The report assessed five (5) different landuse types in the vicinity of the basins:

1. Commercial;
2. Private Institutional;
3. Public;
4. Residential Subdivision;
5. Residential & Commercial.

The results of the assessment revealed 70% of the basins were observed to have standing water regardless of use type draining to the basin.

This lack of specific correlation indicates adjacent landuse (draining towards the basin) is not the primary factor affecting the serviceability of the infiltration facilities.

Age of Facilities

Studies completed by New Jersey, Missouri, and the EPA indicate that older basins tend to fail more rapidly and frequently than younger basins, and that the average operational life of basins are five (5) to ten (10) years with accelerated failures near roadways.

The study surmised the age of the basins by the use of historical aerial data and land use/land cover coverages in GIS. The year groupings assessed included facilities completed within three (3) years, 10 years, 20 years, and greater than 20 years of this study.

The results revealed that the 3 year old basin (only one observed in the study) was operating properly. The remainder, however, had a failure rate of about 70%; with no adequate age/ failure rate correlations.

Summary of Report

The results of the mapping and published information review revealed that there is no reliable correlations with the typically reviewed data sources including USDA soils information, hydrologic soil types, or land use coverage for the serviceability and adequate functioning of infiltration facilities.

Other Contributing Factors

The results of the published data review and analysis revealed that other basin factors must be considered in order to determine the cause of the high failure rate observed in the Pinelands Management Area, including:

1. Improper Construction Procedures and Techniques;
2. Basin Maintenance Plans (or lack thereof); and
3. Site Selection.

Testing Procedures

During the course of field operations several different procedures and methods were utilized to assess and determine (where possible) the other factors that lead to basin failures.

The current Stormwater Regulations in New Jersey allow for infiltration testing methods in compliance with the New Jersey Wastewater Disposal Codes (N.J.A.C. 7:9A). Including several methods for testing the infiltration rate of subsoils.

Subsurface Profiling

The most common method for determining the subsurface profile is the use of excavated test pits. These pits are advanced with a surface operated excavator to the maximum depth of the machine, or to a depth that can be safely opened. This method is typically reasonable for up to ±15' of total depth.

Test pits were completed in the foot print and vicinity of each basin. Those completed in the vicinity of the basin were treated as control test pits, assuming that those areas were not modified as a result of basin construction. The interior test pits were utilized to determine the subsurface conditions as a result of the basin construction.

The details of the profiling are included in the report, the results revealed that hydraulically restrictive horizons were left immediately (within 1') of the basin bottom in both locations. Review of construction information revealed that the designers had observed this layer, and pointed out the need to remove it; but the contractor did not remove it.

Infiltration Rate Testing

Infiltration rate testing was provided by way of the three differing test types: (1) “K class” rating by way of grain size analysis, (2) undisturbed sampling for falling head tests, & (3) in-field peizometer tests (ASTM STP 476)

Testing revealed that K class determinations should not be used for final design, as the applicable range is too great and correlations with actual test results are not conclusive. These may be used for initial basin siting.

Undisturbed sampling provided more realistic results but had reproducibility and consistency issues. The largest percent change (± 6,000%) was realized on samples with excessively low permeability. In addition to the variation of the test results, it can be difficult to collect undisturbed samples of poorly-graded, clean sands.

It was found that the piezometer tests provided the most reproducible results. Each piezometer had at least two (2) tests completed on the standpipe until consistent readings were calculated (within 10%). All locations were within 10% (highest at PZ-3 was 7%) after the first replicate test.

Improper Construction

Basin construction is commonly considered perfunctory site work in the eyes of contractors and site managers. Further there is generally an assumption made that these facilities are non-structural improvements. These simple notions and ideals provide for a less than opportune environmental for the construction of these facilities.

The standard notes, such as (1) "heavy" equipment shall not be operated on the infiltrative surface, (2) no compaction equipment is to be operated on the bottom of the basin, and (3) infiltration level should

Illustration 1: Low Ground Pressure Tires

by protected from contamination and clogging by unsuitable soils; are commonly ignored or simply not complied with by site work personnel. Further, designers regularly do not provide a reasonable way to practically build the basins without operating equipment on the basin bottom.

Review of available design and construction documents revealed that this lack of coordination provided for a major impact on the proper operation of the basins (even prior to completion).

"Heavy" Equipment

The amount of equipment equipment contract pressure required to effectively seal off and compact soils is significantly less than most people realize. In the profession of turf farming it is not uncommon that during installation ground pressures be kept to 2 psi or less. While working on the turf (after

Illustration 2: Standard Rubber Tire Loader

placement) up to 4 psi might be allowable.

Referencing Illustration 2: Standard Rubber Tire Loader, this particular Caterpillar is considered a "small" unit, weighing in at the lightest weight of ± 28,000 lbs. This load is distributed over four tires with ± 29.5" wide tread and a contact length of ½ the width (15"); provides for a contact pressure of 12.5 psi. This would be 3 to 6 times greater than considered low ground pressure.

The impact of construction equipment on the the soil bulk density and permeability is nearly immediate, as the first pass of the equipment can provide up to 90% of the total compaction. This can lower a suitable soil (hydrologic group A or B) to an unsuitable material (almost) immediately.

There is also very poor, or no, definitions of what constituents "heavy" equipment. Low ground pressure tires are not what most people see on a typical project site.

Illustration 1: Low Ground Pressure Tires depicts what a low ground pressure tire looks like. Compared to the typical site equipment (depicted in Illustration 2: Standard Rubber Tire Loader) the differences are obvious.

Other ways to achieve low contact ground pressure is through the use of wide tracks. Low ground pressure tracks are typically made from plastic, not metal. Illustration 4: Low Ground Pressure Tracks depicts what a standard piece of constriction equipment looks like with low ground pressure tracks attached to it. A similar piece of equipment is provided in Illustration 3: Standard Track Mounted Equipment that is commonly used on site. Specifications provided by CAT Equipment reveals that even this small track mounted dozer provides more than 5 psi.

This could be considered double what a suitable ground contact pressure (to prevent infiltration clogging) should be for the bottom of these basins.

Illustration 3: Standard Track Mounted Equipment

Basin Maintenance Plans

Regular maintenance is critical to proper operation of any stormwater facility. NJDEP recommends that basins be inspected at least four (4) times annually or after every one (1) inch rain event (or greater) for clogging and debris (NJDEP 2004).

Reviews of the provided maintenance plans revealed inadequate maintenance schedules and enforcement. The basins observed during this investigation reveal that the extent of maintenance considered included mowing around the basin.
The most glaring example observed during the investigation was the basin designed to infiltrate into concrete structures. Visual inspections of the pits revealed the units completely silted-in and not allowing infiltration to occur.
Remediating the concrete basins with fabric lined rock wick-drains provided instant repair and infiltration of stormwater in the basin.

Nyrim Track Pads on
CAT 939C Loader

Illustration 4: Low Ground Pressure Tracks

Conclusion

Infiltration Stormwater facilities are difficult systems to install and operate properly. Long term use of these facilities will require the coordination and collaboration of all parties including: designers, constructors, and municipalities to provide enough guidance and support to allow proper operation and on-going maintenance.