REPORT ANNOUNCEMENT

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USE OF A CONSTRUCTED REEDBED WETLAND IN THE MITIGATION OF HIGHWAY RUNOFF ON THE GROUND-WATER QUALITY IN A CARBONATE ROCK AREA.

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Highway runoff pollutants can include sediment, trace metals, toxicants, hydrocarbons, nitrogen, and phosphorus that originate from atmospheric deposition, metal corrosion, material from worn brake linings and tires, organic matter, litter, and debris. These materials accumulate rapidly on impervious surfaces and are easily washed off by stormwater runoff into stormwater collection systems and other receiving waters. Highway runoff pollution, which is of special concern in areas with carbonate geology, can result in direct ground-water contamination through solution enlarged cracks and fissures in the bedrock.

Pollutants in stormwater can be removed by wetlands through a combination of several processes: (1) incorporation into or attachment to wetland sediments or biota; (2) degradation; or (3) exportation to the atmosphere or ground water. Both physical and chemical pollutant-removal mechanisms are thought to occur in wetlands. These mechanisms include sedimentation, absorption, adhesion, precipitation and dissolution, filtration, biochemical interactions, volatilization and aerosol formation, and infiltration. Because of the many interactions among physical, chemical, and biological processes in wetlands, these mechanisms are not independent.

The purpose of this report is to evaluate the feasibility of constructed wetlands to mitigate any adverse water quality effects due to highway runoff in areas of carbonate rock. Analysis of stormwater runoff chemical properties was conducted to assist in development of design criteria for a wetland treatment system. Runoff samples were collected at the entrance and exit of the wetland to determine pollution treatment efficiency.

This report includes sections on:

- Description of the study area
- Wetland design and construction
- Wetland vegetation
- Stormwater runoff monitoring facilities and sampling procedures
- Analysis of stormwater runoff chemistry
- Effectiveness of constructed wetland
- Possible explanations for project failure

Description of the Study Area

The study area is located in Dickinson Township, Cumberland County, Pennsylvania. A highway drainage site with carbonate geology, stormwater drainage, and ground-water pollution concerns was selected at the northbound rest area along Interstate 81 (Plainfield rest area), near the town of Newville. A high percentage of adjacent impervious surface indicated that the wetland would receive adequate runoff volumes, while the close proximity of the wetland to highway activities provided a substantial pollutant load.

Wetland Design and Construction

Stormwater runoff discharge was conveyed to the wetland through three stormwater collection pipes. At the wetland entrance, large boulders were positioned to dissipate energy and reduce erosion and scour during high discharge conditions. The constructed wetland is an excavated basin that is 50 feet wide and 70 feet long. The basin was filled with 62 cubic yards of sterile washed bar sand to form a 6-inch deep sand bed. The entire wetland was surrounded by a 3-foot embankment, which was constructed from the native soils removed during excavation.

Discharge from the wetland was determined by water depth within the wetland. Minor discharge volumes flowed through the wetland and exited through a slotted pipe that was positioned at the top of the sand bed. Moderate discharges were drained through a second slotted pipe that was positioned through the earth embankment. Large storm events would result in the stormwater runoff exiting the wetland over the emergency spillway.

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Wetland Vegetation

The goal of planting wetlands for stormwater treatment is to generate dense, diverse vegetation that is representative of a natural wetland. Abundant vegetation increases sedimentation and supports a variety of microorganisms. To maintain abundant and diverse vegetation, it is important to maintain a shallow water depth and ensure that sufficient soil moisture is maintained between rain events.

The constructed wetland at the Plainfield rest area was planted with over 7,000 herbaceous emergent plant plugs of eight different species. Wetland sedge seeds also were sowed to ensure an adequate seed bank for the following spring. This abundance and diversity was representative of natural wetlands of southern Pennsylvania. The embankment was sowed with a variety of upland plant seeds.

Stormwater Runoff Monitoring Facilities and Sampling Procedures

The wetland vegetation and hydrology were monitored, and highway runoff samples were collected to evaluate design performance and pollution treatment efficiency. A series of runoff samples, collected by automatic samplers positioned near the inlet and outlet structures, were used to determine pollution treatment efficiency. Temperature, conductivity, pH, color, various nutrients, metals, and semivolatile compounds were analyzed at the inlet and outlet sample points.

Periodic inspection and maintenance visits were conducted. During a site visit, the inlet area, auto-sampler intakes, and outlet pipe areas were freed of any debris. Vegetation type, growth characteristics and location, and the hydrologic condition of the wetland were documented. The 1997 growing season was characterized by short, infrequent storm events, which resulted in a drought watch declaration. The reduced precipitation frequency and durations limited sampling opportunities.

Analysis of Stormwater Runoff Chemistry

Highway runoff pollutants can include sediment, trace metals, toxicants, hydrocarbons, nitrogen, and phosphorus that may originate from atmospheric deposition, metal corrosion, material from worn brake linings and tires, organic matter, litter, and debris. Water chemistry analyses of stormwater runoff samples collected from the inlet and outlet sample points did not show significant pollution treatment. Review of these data suggests that the wetland did have the potential to remove nitrogen, most likely as nitrate-nitrogen.

Effectiveness of Constructed Wetland

Limited precipitation restricted analysis of hydrologic conditions in the wetland. No moderate or high discharge volumes occurred; therefore, the design criteria for the wetland and emergency spillway design could not be evaluated. The limited hydrologic field observations were inadequate to determine if the inundation period, duration and frequency were sufficient for planted hydrophytic vegetation.

As a result of these limiting factors, the effectiveness of the wetland treatment system is, at best, characterized as inconclusive. The limited number of storm events sampled, the inconsistency in the water quality parameters analyzed, and lack of vegetation growth and germination prohibited determining the wetland's potential to significantly reduce pollutant concentrations.

Possible Explanations for Project Failure

There are several possible explanations for the demise of wetland vegetation at the Plainfield rest area constructed reedbed. Drought conditions led to minimal inundation frequency and duration in the wetland, therefore stressing the environmental community. Vegetation species selection was less than optimal; three of the eight herbaceous emergent plant species and two of the three wetland seed species planted required regular or permanent inundation and winter deicing practices also were not considered. The use of sterile sand during construction and no application of a fertilizer resulted in an inadequate nutrient supply for plant growth and germination.

Additional studies during more optimal hydrological conditions will ultimately be needed to fully assess the viability of using constructed wetlands to reduce pollutants from stormwater runoff in carbonate rock areas.

This report is available on the Susquehanna River Basin Commission website at:
www.srbc.net/technicalreports.htm
It also is available on compact disc.
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