Stormwater Treatment Demonstration Project
Oil Water/Grit Separator followed by a Sand Filter

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ABSTRACT

Under a three-year grant from EPA, this paper presents the results of a project that monitored the performance of a Vortechnics Oil/Grit separator followed by a sand filter. The system, built at a rest stop on Interstate Route 287 in New Jersey, was monitored from new using ISCO automated samplers. Samples of TPH, TSS, and TS were taken at three points for a number of storms. The first was the untreated water flowing from the parking area. The second point was the discharge from the oil/grit separator, and the third was the discharge from the sand filter. The results showed that the oil/grit separator removed on average 85% of the TPH, and the sand filter removed another 85% for a total removal of more than 95%. System performance over time was a key metric to be determined, however, since the system appears to have been over-designed, it has not needed maintenance to date. This approach to stormwater treatment may have extensive applicability to large paved areas in many areas.

INTRODUCTION

This paper describes a project that was designed to test the effectiveness of stormwater treatment technologies and Best Management Practices for a paved parking area at a rest stop on an Interstate Highway in New Jersey. The project was conducted under a USEPA grant administered by the New Jersey DEP. The implementing agency for the project was the Harding Township Environmental Commission, and Thonet Associates was retained to assist in data analysis and in the development of the BMP recommendations. Under the grant a stormwater treatment demonstration project was implemented for the Harding Rest Stop located on Interstate Highway Route 287 (I-287).

The project quantitatively evaluates the effectiveness of stormwater management facilities that were constructed at the Harding Rest Stop and recommends additional "best management practices" (BMPs) aimed at minimizing stormwater quality impacts associated with spill events. The stormwater treatment systems included a Vortechnic Oil/Grit separator followed by a custom built sand filter. These systems were sized to handle the anticipated 100 year storm flow from the paved area at the rest stop, which was about 3 acres. The objective of the project was to:

- Promote greater understanding the how stormwater runoff from rest stop areas degrades surface water quality;
- Encourage sound stormwater management practices for truck rest stops located along New Jersey's Interstate and other major highways;
- Serve as a model for a potential ordinance requiring stormwater treatment systems for paved areas in Harding Township
- Develop data on the relative effectiveness of oil/grit separators alone, and in conjunction with sand filters, and to estimate the required frequency that maintenance (clean outs) would be required.

Location and Description of the Project Area

The Harding Rest Stop is located off the northbound lane of I-287 in Harding Township. The rest stop consists of parking for approximately 22 trucks and 63 cars and includes other amenities such as vending machines, a picnic area, nine (9) outdoor pay phones and four (4) pay phones inside the building. The photographs that follow illustrate the general conditions at the rest stop.

Figure 1 View of Parking Upper Parking lot

Figure 2 View of Lower Parking lot

Stormwater from the rest stop is collected via a traditional stormwater collection and conveyance system that directs the site's stormwater to an onsite stormwater quality treatment system prior to discharge to a tributary to the Great Brook, one of the principal tributaries to Great Swamp National Wildlife

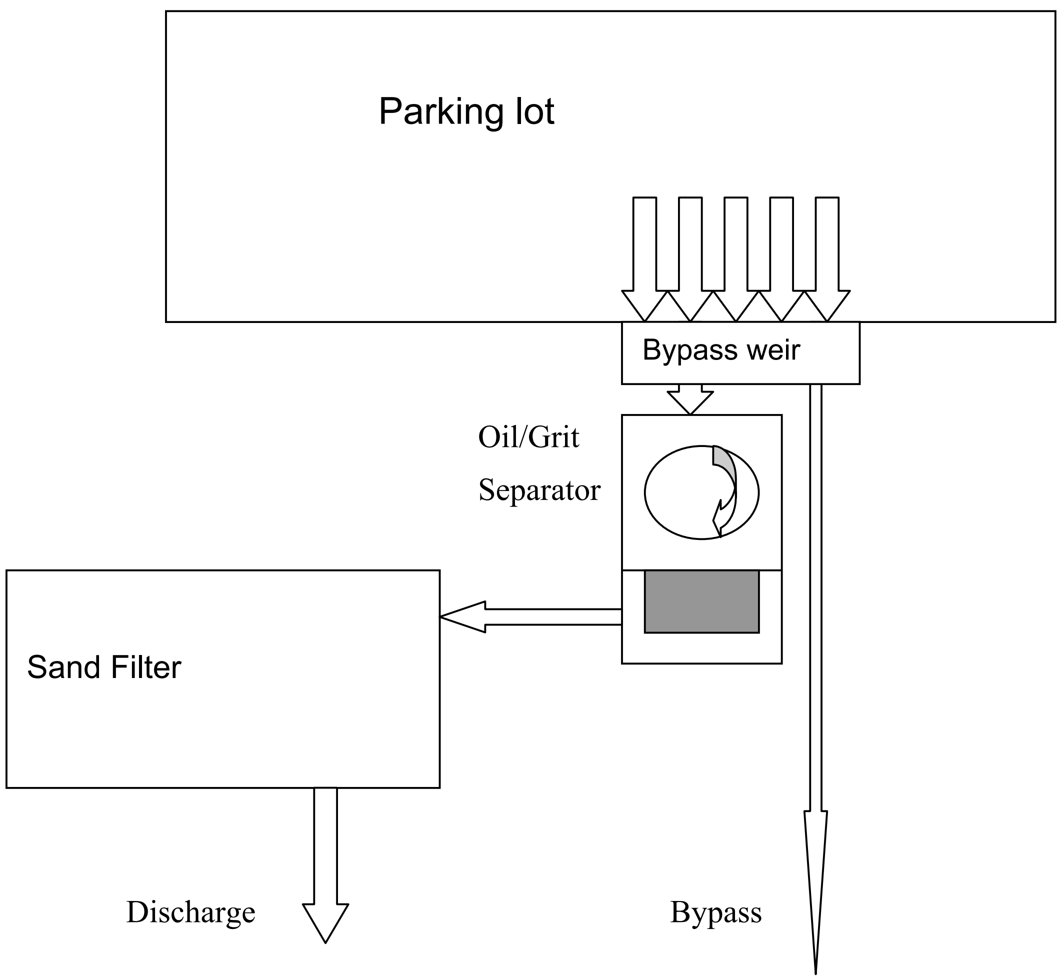
Refuge, a National Park with significant environmental resources.

The stormwater quality treatment system includes an oil/grit separator manufactured by Vortechnic Inc., known as a Vortechnic Stormwater Treatment System, followed by a horizontal sand filter. No other stormwater management BMPs are presently employed.

The Vortechnic Stormwater Treatment System combines swirl-concentrator technology and flow control to eliminate turbulence within the system and to promote the physical separation and capture of sediments and oils.

The sand filter is a filter constructed of sand that strains the runoff thru removing suspended sediments in that runoff and any other contaminants associated with the sediment. **Figure 3** illustrates the sand filter. The filter is also thought to aid in oil and total petroleum hydrocarbons (TPH) removal through filtering and possibly through biologic activity.

The arrangement of the system, in overview is as follows:



Investigations

The study's investigations included the following:

1. Collection and water quality analysis of stormwater samples.

The Environmental Commission study team members equipped the rest stop's stormwater management system with automatic stormwater samplers to collect stormwater samples from three locations:

- Point 1 – raw stormwater from the rest stop's parking area;
- Point 2 – stormwater discharging from the oil/grit separator, following treatment; and
- Point 3 – stormwater discharging from the sand filter, following this additional treatment.

Figure 3: The Sand Filter and rain gage.

The samplers were programmed and equipped with an automatic rain gauge that would trigger the sampling operation during rainfall events, taking samples at twenty-minute intervals during the storm event.

Figure 4

Figure 5

Figure 4 Illustrates the ISCO Automated Samplers

Figure 5 illustrates the "visual results" of the stormwater treatment system. The bottle on the left is the runoff from the parking lot, the middle is the discharge from the oil/grit separator, and the bottle on the right is the discharge from the sand filter.

The parameters tested included total petroleum hydrocarbons (TPH), total suspended solids (TSS), and total solids (TS). Samples were taken on May 10, 1999, November 2, 1999, March 11, 2000, June 2, 2000, and November 14, 2000.

Conclusions

During the five storm events sampled, the following pollutant removal efficiencies were achieved:

a. First Flush Removal Efficiencies:

   1) Total Petroleum Hydrocarbons(TPH) present in the raw stormwater were reduced by 78.57 percent by the oil/grit separator and by an additional 15.09 percent following treatment by the sand filter, resulting in a final removal efficiency of 93.66 percent.

   2) Total Suspended Solids(TSS) present in the raw stormwater were reduced by 94.52 percent by the oil/grit separator and by an additional 4.17 percent following treatment by the sand filter, resulting in a final removal efficiency of 98.69 percent.

   3) Total Solids(TS) present in the raw stormwater were reduced by 74.38 percent by the oil/grit separator After the sand filter treatment, the final removal efficiency of total solids dropped to 68.75 percent.

b. Average Removal Efficiencies:

   1) Total Petroleum Hydrocarbons(TPH) present in the raw stormwater were reduced by 67.01 percent by the oil/grit separator and by an additional 18.72 percent following treatment by the sand filter, resulting in a final removal efficiency of 85.73 percent.

2) Total Suspended Solids(TSS) present in the raw stormwater were reduced by 92.86 percent by the oil/grit separator and by an additional 5.26 percent following treatment by the sand filter, resulting in a final removal efficiency of 98.12 percent.
3) Total Solids(TS) present in the raw stormwater were reduced by 38.21 percent by the oil/grit separator After the sand filter treatment, the final removal efficiency of total solids dropped to 28.57 percent.

The storm sample results from June 2, 2000 showed an unexpected increase in TPH following treatment by the facility's sand filter. While the most likely explanation for this anomaly would be laboratory or sampling error, there was some speculation by the Environmental Commission that the sand filter may have been contaminated by an improper discharge of oil onto the sand filter. An on-site inspection dispelled the likelihood of that occurrence.

In addition, it was speculated that the increase in TPH could have been due to the accumulation of hydrocarbons in the sand filter overtime, thus resulting in the leaching of more hydrocarbons out of the sand filter than actually entered the filter.

In order to further investigate this potential explanation for the anomaly, an additional storm was sampled on November 14, 2000. That sample yielded similar removal rates to the samples taken on May 10, November 2, 1999 and March 11, 2000, thus dispelling the theory of a hydrocarbon build-up in the sand filter.

Accordingly, at this point in time, we have no explanation for this anomaly in the data other than possible laboratory or sampling error.

Table One Summarizes the performance of the systems:

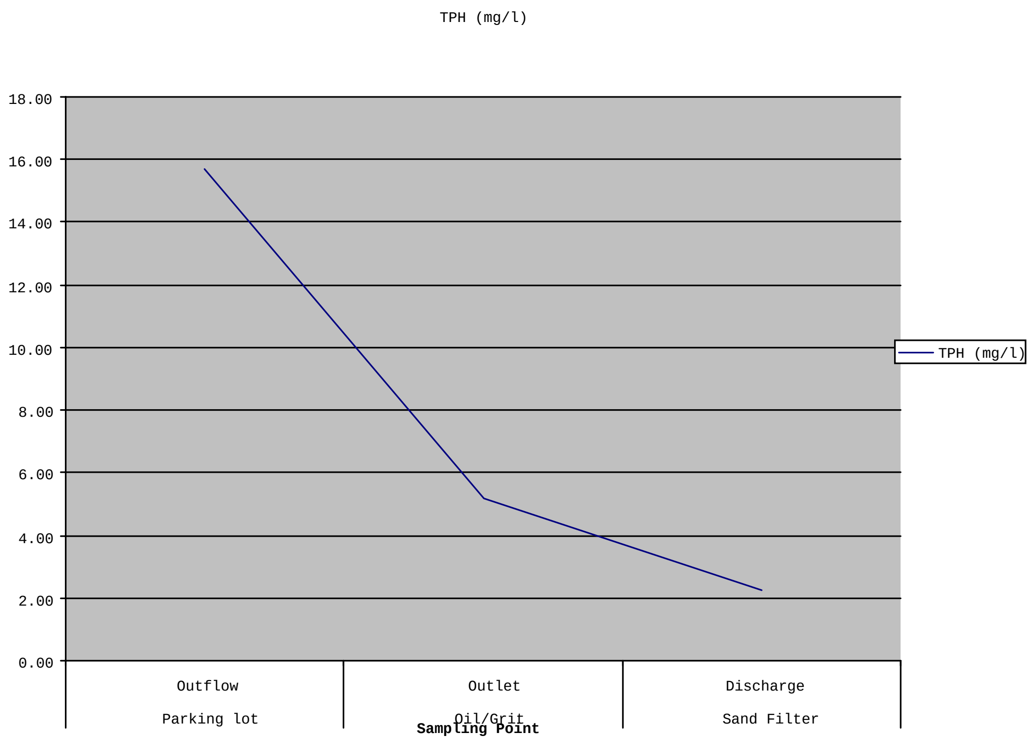
First Flush Analysis

Parameter	Parking lot Outflow	Oil/Grit Outlet	Sand Filter Discharge	Pollutant Removal Due to Oil/Grit Separator	Total Pollutant Removal After Sand Filter
TPH (mg/l)	31.54	6.76	2.00	78.57%	93.66%
TS (%)	0.16	0.04	0.05	74.38%	68.75%
TSS (mg/l)	1190.40	65.20	15.60	94.52%	98.69%

Full Storm Analysis

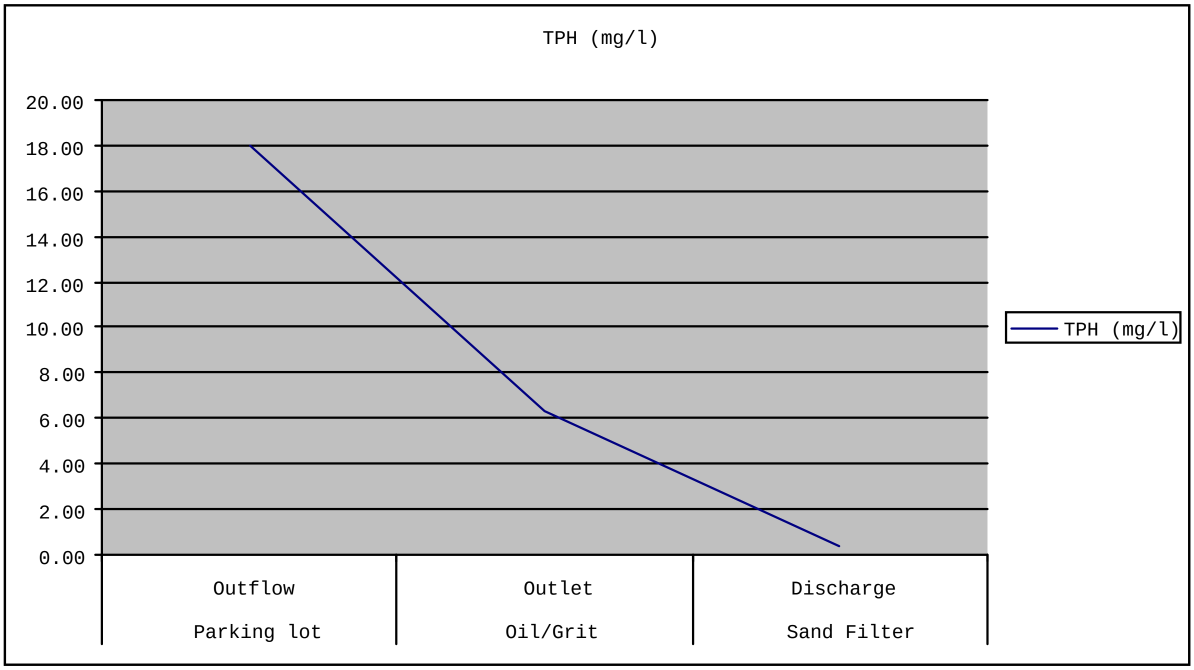
Parameter	Parking lot Outflow	Oil/Grit Outlet	Sand Filter Discharge	Pollutant Removal Due to Oil/Grit Separator	Total Pollutant Removal After Sand Filter

TPH (mg/l)	15.70	5.18	2.24	67.01%	85.73%
TS (%)	0.07	0.04	0.05	38.21%	28.57%
TSS (mg/l)	492.86	35.18	9.28	92.86%	98.12%



The chart above illustrates the effectiveness of the oil/grit separator and the added effectiveness of the sand filter. The sand filter is also thought to be a invaluable back-up treatment device in the event that the oil/grit separator passes oil or grit due to overdue cleanout.

Taking out the anomalous event of June 2, 2000 in which concentrations on TPH were higher after the sand filter, the overall performance of the system can be seen to be significantly better. The chart below shows the average performance over all events except for the June 2, 2000 storm. This data shows that the oil/grit separator removes 65% of the TPH leaving the parking lot, and the sand filter removes an additional 93% of the TPH leaving the oil/grit separator, for an overall removal of 97.67%. Clearly the sand filter adds an important additional treatment component as well as an important back up for the oil/grit separator.



The performance on solids is mixed. As the tables show, Total Solids removal is actually slightly higher after the sand filter than before. This may be a result of fine particles being discharged from the sand filter due to it's being newly filled with sand. This result, however was consistent, even with the last storm sampled. The reason for this result is possibly that the levels of TS are so low leaving the parking lot that the treatment systems do little to affect the discharge levels. It is also possible that some of the influent solids were trapped in the catch basins which are traditional square box-type basins with inverts above the bottom of the basins.

The performance on Total Suspended Solids was more consistent to the results for TPH. The Oil/grit separator removed 92.86% of the TSS, and the sand filter brought the total removal to 98.12%. In other words, the sand filter removed 74% of the TSS passing through the Oil/grit separator. For this parameter as well, the sand filter proves to be an important additional treatment system, as well as a back up should the oil/grit separator begin passing solids.

Maintenance Implications

An objective of the study was to estimate the required maintenance requirements. Due to the over-sizing of the oil/grit separator and the sand filter, neither reached a stage where maintenance (other than vegetative clearing of the sand filter) was required. It is anticipated that the oil/grit separator will need to be cleaned out, and we suggest for this installation, baring any change in utilization, once every two to three years. The oil/petroleum liquids would need to be disposed of as hazardous wastes, and the grit as regular waste, pending an analysis of its constituents. The sand filter will need to be scraped and a new layer of sand added on a two to three-year schedule. The old sand, like the grit would need to be disposed of as regular waste, but should be tested to be sure it does not need to be treated as a hazardous waste.

Best Management Practices Literature Review

The study also included the review of various documents pertaining to stormwater management BMPs:

a. Urban Stormwater Management and Technology - An Assessment, Metcalf and Eddy for the National Environmental Research Center, U.S. Environmental Protection Agency, 1974.

b. Urban Stormwater Management and Technology Update, Metcalf & Eddy for the U.S. Environmental Protection Agency, 1977.

c. Urban Stormwater Management and Technology: Case Histories, Metcalf & Eddy for the U.S. Environmental Protection Agency, 1980.

d. Handbook of Nonpoint Pollution, Novotny and Chesters, 1981.

e. A Handbook of Measures to Protect Water Resources in Land Development, Tourbier and Westmacott, 1981.

f. New Jersey Stormwater Quantity/Quality Management Manual, New Jersey Department of Environmental Protection/Division of Water Resources, February 1981.

g. A Guide to Stormwater Management Practices in New Jersey, New Jersey Department of Environmental Protection/Division of Water Resources, April 1986.

h. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Metropolitan Washington Council of Governments, July 1987.

i. Analysis of Urban BMP Performance and Longevity in Price George County, Maryland, Metropolitan Washington Council of Governments, August 1992.

j. A Current Assessment of Urban Best Management Practices, Metropolitan Washington Council of Governments, March 1992.

k. Stormwater and Nonpoint Source Pollution Control Best Management Practices Manual, New Jersey Department of Environmental Protection and New Jersey Department of Agriculture, December 1994.

l. Stormwater Management in the New Jersey Coastal Zone, Cahill Associates for the New Jersey Department of Environmental Protection, 1989.

2. A review of the above reference materials indicates that:

   a. Information is readily available regarding stormwater BMPs and the expected pollutant removal efficiencies of those BMPs for stormwater runoff collection and treatment, particularly regarding:

      1) Non-structural nonpoint source pollution BMPs: Source controls

a) Minimum disturbance/alternative landscaping;

b) Fertilizer management for urban/suburban landscaping;

c) Pesticide management in urban/suburban areas;

d) Roadway deicing: salt reduction; and

e) Roadway and parking lot sweeping.

All of the above non-structural NPS BMPs would be applicable to truck rest stops, though none of these BMP's are currently employed at the Harding Rest Stop.

2) Structural BMPs:

a) Detention Basins; wet and dry;

b) Infiltration basins;

c) Infiltration trenches;

d) Dry wells;

e) Vegetative swales;

f) Vegetative filter strips;

g) Porous pavement;

h) Multichamber catch basins (with sediment traps and oil/grease separators);

i) Artificial wetlands; and

j) Sand filters and sand/peat filters.

Some, but not all of the above structural BMPs would be applicable to truck rest stops. For example, due to the potential for spills and illegal dumping of waste at truck stops, the use of infiltration basins, infiltration trenches, dry wells, and porous pavement would not be recommended because of a concern for ground water contamination. In addition, artificial wetlands or wet detention basins might attract wildlife which, given the polluted nature of the stormwater, would not be advisable without substantial pre-treatment.

A dry stormwater detention basin would be an appropriate stormwater BMP for truck stops for removal of sediments and pollutants associated with sediments. Detention basins however would be relatively ineffective with regard to the removal of floatables, including floating oil and hence should be combined with other BMPs more effective in the removal of oil and grease.

Specialized catch basins for removing oil and sediment, and sand filters also would be appropriate stormwater BMPs for truck rest stops for removing sediment, pollutants associated with sediment, and oil and grease. Sand filters would also be appropriate. The literature tends to indicate that sand filters are effective BMP's with moderate maintenance requirements and that multichamber catch basins that trap sediment and separate oil and grease provide limited pollutant removal efficiencies and are generally not cleaned and maintained.

In this case, an oil/grit separator manufactured by Vortechnic Inc. was utilized, followed by a horizontal sand filter. The combined removal efficiency for TPH and TSS were excellent, about 86 percent and 98 percent respectively. Interestingly, the Vortechnics system removed nearly 78 percent of TPH and 92 percent of TSS, thus indicating that the Vortechnic system is more effective than the systems in the literature above. The sand filter provides important additional treatment, bringing overall system performance to exceptional levels and providing an important back up for the oil/grit separator.

b. Little guidance is currently available from reviewed published sources of information specific to stormwater BMPs for spills occurring at rest stops. We would expect however, that dry detention basins, specialized catch basins such as the Vortechnic System utilized in this study, and sand filters would be effective in minimizing the impact of spills.

   In addition, on-site emergency procedures should be established and spill supplies made available to minimize impacts of spills.

3. As part of Best Management Practices for the rest stop, the following are absorbent materials that should be located on site in a locked storage facility in the event of a spill:

   a. Sausage Boom - This material can soak and retain up to five times its volume with any type of contaminant. In addition, this material can be stacked, forming a berm that is effective against any downstream flow of contaminants.

   b. Oil-Snare (Pom-Pom) - This material can be tied to a rope and lowered into a stormwater inlet in order to absorb contaminants that may have entered it. This material is extremely effective at cleanup of contaminated inlets.

   c. Speed Dry (Kitty Litter) Clay Absorbent - This material absorbs any type of liquid contaminant. This product can be poured above the contaminant and it begins absorbing upon contact.

   d. Blanket (Rolls) - This material is placed on top of liquid contaminant that has already drained into a pond or lake that has created sheen on the water surface. The blanket absorbs the contaminant off of the water surface into its fibers.

The key to the locked shed should be available from the local police department and "Notice" should be posted at the rest stop advising drivers of the procedure to follow to minimize the impact of spills.

1. Conclusions and Recommendations

Based on the above investigations and findings we conclude that:

1. The treatment of stormwater through a first phase oil/grit separator followed by filtration through a horizontal sand filter provides a very effective method of removing total petroleum hydrocarbons (TPH's) and total suspended solids, as evidenced by the above test results.

2. Truck stops also should be equipped with an *Emergency Spill Supply Shed* that would contain emergency tools and materials to be utilized by the police department as a first line of defense, limiting the extent of spill contamination area as well as absorbing contaminants until professionals arrive with more sophisticated equipment to remediate the spill area.

The emergency spill storage shed should be located to prevent unauthorized removal of the emergency materials and equipment stored there. The key to the shed should be available from the nearest local police headquarters and there should be a telephone posted on the shed advising anyone witnessing a spill to immediately notify the police and request assistance.

Finally, the instructions should be posted on the shed advising the police of the standard spill prevention and cleanup procedures to be followed to minimize the impact of the spill.

3. The systems performed well, without any maintenance. It was noted that the oil/grit separator had not collected enough oil or grit to require cleaning out even after 18 months of use. The sand filter, however, being of an open design, did develop a growth of vegetation that required weeding or mowing. It is possible that a sand filter design that includes planned vegetation growth could even further improve treatment effectiveness through biologic activity.

We hope this paper will promote a greater understanding of the water quality impacts of stormwater runoff from truck rest stops and other similar parking areas and the stormwater management practices available to mitigate those impacts. The results of this study provide a scientific basis for recommending stormwater treatment systems for truck rest stops and similar parking areas.

Acknowledgments

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References

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Key Words

Stormwater

Stormwater Treatment

Oil/Grit Separators

Automated Stormwater Samplers

Best Management Practices