

**P-23 - DEVELOPMENT OF DELAWARE DEPARTMENT OF TRANSPORTATION
STORMWATER BEST MANAGEMENT PRACTICE INSPECTION PROGRAM**

Peter Mattejat, PE – KCI Technologies, Inc.; Laurel, Maryland
Bruce Thompson– KCI Technologies, Inc.; Newark, Delaware

A. INTRODUCTION

Municipalities and state transportation agencies throughout the Nation are contending with the challenge of inventorying and maintaining their existing stormwater Best Management Practices (BMPs). The management of BMPs is mandatory as part of their Phase I or II permits for National Pollutant Discharge Elimination system (NPDES) Municipal Separate Storm Sewer System (MS4) Program. Historically, BMPs are stormwater management (SWM) ponds or infiltration devices. However, BMP categories have recently diversified to include shallow wetland marshes, filtering devices, and low impact development techniques, to name a few. The task is becoming increasingly daunting due to the rise in the number of BMPs constructed combined with more complex BMP design and function. The Delaware Department of Transportation (DelDOT) is tackling this permit requirement head on.

B. BEST MANAGEMENT PRACTICES

DelDOT maintains more than 5500 total miles of roadway system throughout Delaware; road classifications range from interstate to local residential roads. In addition, the roadway system lies within the Delaware Bay and Chesapeake Bay watersheds, which are vital environmental and economic resources. DelDOT has a Phase I permit in New Castle County, and Phase II permits in Kent and Sussex Counties. The BMPs used to treat runoff from DelDOT roadways vary in type and size. Currently, DelDOT has 300+ BMPs statewide and another 100+ planned for future construction. The primary BMP categories are listed below; SWM Ponds account for almost half of the inventory.

DELDOT BMP CATEGORIES

SWM Ponds	Infiltration Devices
Open Channel Systems	Filtering Devices
Proprietary Site Devices	Others

C. INSPECTION METHODOLOGY

DelDOT’s NPDES permit requires annual BMP inspection. In 2007, DelDOT, assisted by KCI Technologies, Inc. (KCI), developed a statewide stormwater BMP inspection/maintenance program. This program provides a consistent protocol for inventorying, inspecting and maintaining BMPs. The inventory and inspection protocol is documented in DelDOT’s comprehensive *BMP Field Inspection Manual*. The manual was developed in early 2007 and field tested during the 2007 annual inspection of 309 BMPs. Inspection results were used to develop a long-term remediation strategy for sustaining original design BMP performance.

Inspection Parameters

There are four key components of a BMP inspection: Site Conditions, Water Quality, Embankment, and Outlet Structure. For each of these four components, specific parameters were developed to be evaluated during the inspection. Care was taken to consider the differences between BMP types in developing the parameters, and in some cases are not applicable to a specific BMP.

1. Site Conditions

This component relates to immediate surroundings within the BMP site that are not directly involved in SWM. If the parameters in this category have issues, they may impact DelDOT property or the public in general.

Access – assesses the ingress and egress into and around a BMP for inspection and construction activities. Consideration is given to key features, such as in-flow points, pre-treatment area, and outlet structures.

Fence – assesses the condition and functionality of a fence, and can focus on concerns such as ease of entry into the facility or restriction of public accessibility.

Invasive Vegetation – assesses foliage problems around the site and the need for vegetation management. This parameter covers the entire site with exception of embankments, since this covered by other parameters. This parameter is best evaluated during the growing season between May to October. A common issue is that of Phragmites and Cattails dominating BMP impoundment areas. Comments are used to track specific vegetation and areas needing maintenance.

Public Hazards – assesses the observed access to a BMP by non-authorized personnel. Signs of navigation or inhabitation (e.g. graffiti, foot paths, vandalism) should be documented.

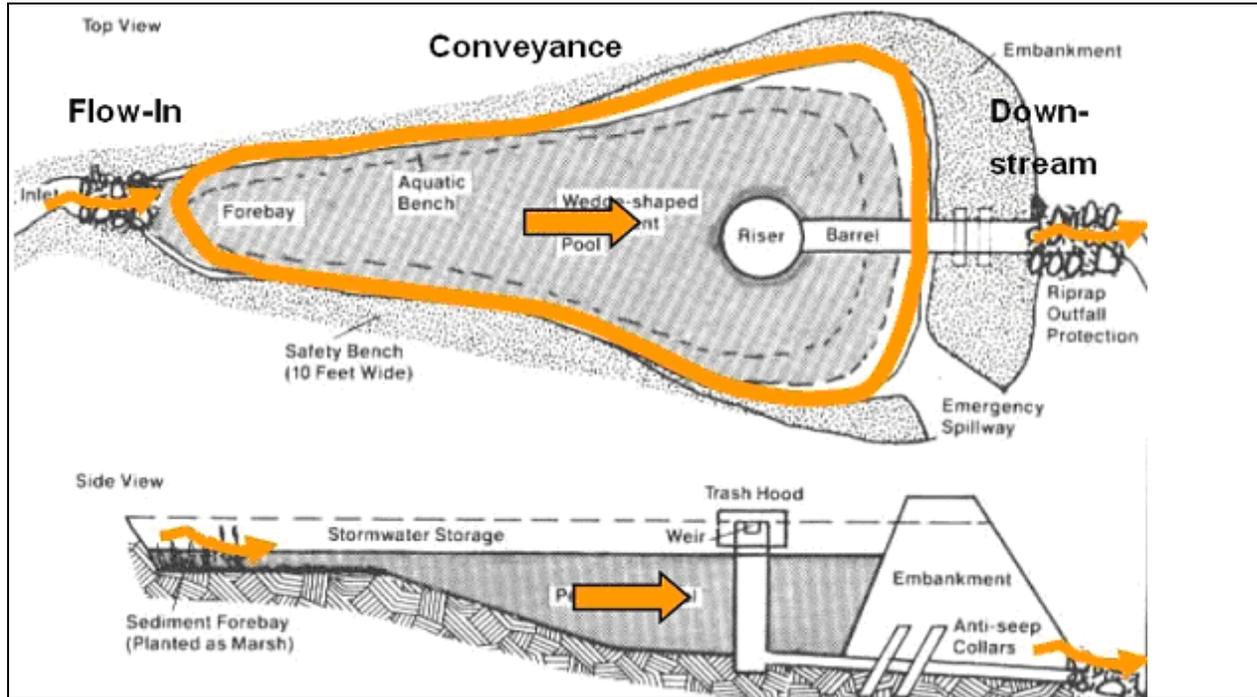
2. Water Quality

This component relates to stormwater management performance and related topics.

Inflow Condition – assesses the cumulative condition of the discharge point(s) into a BMP, such as sheet flow, conveyance swales, and storm drain outfalls. See **Figure 1**. This parameter considers their potential adverse effects to the BMP performance or stability.

Conveyance Condition – assesses the condition of conveyance of stormwater within a BMP. This begins after discharge into a BMP and ends at the outlet of the BMP, as seen in **Figure 1**. Features to consider are pilot channel, berms, check dams, etc. Sub-surface features to consider are underdrains, flow splitters, internal weirs, etc.

FIGURE 1 - Relationship of In-flow, Conveyance, and Downstream Conditions



Downstream Condition – assesses the overall downstream conditions starting at the outfall from a BMP. See **Figure 1**. This is applicable to open stream channel or connections to a storm-drain system.

Pre-Treatment – assesses the condition of the pre-treatment devices (e.g. forebay, filter strip) and the capacity to trap incoming sediment and debris.

Ponding – assesses the unwanted extended ponding of stormwater that reduces BMP performance or site stability. The evaluation is BMP type-specific. Typically there is evidence of ponding, such as high-water lines with accumulation of debris/garbage, or vegetation along the pond perimeter that appears to be distressed due to extended inundation. Inspection should be done 72 hours after a rain event; this allows time for the BMP to return to design water levels. The ponding in the facility above a design elevation should be recorded.

Water Quality Contamination – assesses the overall contamination within a BMP. The focus is on unwanted waste; such as organic debris, garbage, illicit contaminants, and excessive sediment. This evaluates on-site conditions as well as the consideration of sources beyond the BMP, but within the drainage area. If significant contamination is discovered it should be recorded.

3. Embankment

Component specific to structural elements (e.g. embankments, berms) relating to impoundments. These parameters are critical to SWM ponds with embankments designed under federal, state, or local regulations.

Upstream Embankment Cover – assesses the vegetative cover of the upstream embankment. Cover should be stable and void of areas without vegetation, and there should be no woody vegetation. Parameter also addresses uneven settlement, horizontal or longitudinal cracking, sloughing or rutting, and rodent infestation.

Downstream Embankment Cover – assesses the vegetative cover of the downstream embankment similar to the upstream embankment listed above.

Seepage – assesses signs of seepage that may lead to embankment failure. Indicators are saturated soil conditions, direct discharge, surficial erosion, sediment build-up at toe, sloughing, and changes in vegetative characteristics (e.g. isolated hydrophytic vegetation).

4. Outlet Structure

This component assesses structural elements specific to outlet structures. These parameters are critical to SWM ponds with embankments designed under federal, state, or local regulations.

Riser-Opening – assesses the top of a riser structure (including trashrack), which may be a closed structure, weir, or headwall. This evaluates the presence of materials (e.g. vegetation, woody debris, sediment, garbage) that may affect routing flows out of the BMP.

Riser –Low Flow – assesses the opening of the low flow orifice that routes stormwater out of a BMP over a prescribed period.

Riser-Structure – assesses the structural integrity of the riser structure, and evaluates deficiencies, degradation, and instability.

Principle Spillway – assesses the condition of the principle spillway, including problems such as blockage and structural integrity.

Spillway Outfall – assesses the condition at the principle spillway outfall.

Emergency Spillway – assesses the stability of the side slopes and bottom of an emergency spillway.

Scoring Schema

A scoring schema was developed to provide for consistent inspection results. Parameters are evaluated on a scale of 1 to 5 to reflect their relative condition, and are rated from good to poor. A “0” is used in cases where the parameter can not be evaluated, or is not part of a BMP. In general, the scoring of individual parameters reflects:

- 1 – Performing as designed.
- 2 – Functional, but minor problem(s) exist, but no performance issues observed.
- 3 – Operational, but moderate problems exist that may impact performance.
- 4 – Performance is compromised, and major problem(s) exist.
- 5 – Non-Functional, and there is potential for failure or hazardous conditions.

An inspection rating schema was also developed that provides an overall assessment of the BMP performance, and is useful in developing remedial actions. This is selected after all inspection parameters are evaluated. In general, the rating reflects:

- A – BMP is performing as designed, no issues identified.
- B – BMP is functioning, minor problems observed; routine maintenance is recommended.
- C – BMP is functioning, moderate problems observed; routine maintenance is needed.
- D – BMP is not functioning; minor retrofit(s) of BMP component(s) are needed.
- E – BMP is not functioning; major retrofit of BMP, reconstruction or redesign, is needed.

D. FIELD INSPECTION PILOT STUDY

A pilot study was conducted in 2007 that tested the parameters and the methods to perform inspections on 309 BMPs. A variety of BMP types were inspected to allow for a comprehensive test of the inspection protocol. The approach included three phases: Pre-Field Investigation, Field Inspection, and Data Management. These are described in the following.

1. Pre-Field Investigation

The objective is to prepare for the field investigation. The inspector should research and review all relevant documentation, such as construction plans, GIS mapping, topography, inspection records, etc. Field mapping should be prepared to show existing BMPs and storm drains as well as existing land uses, roadways, hydrology, etc. The mapping should be reviewed to identify potential safety issues such as road access, road hazards, and BMP site conditions. As part of planning for the field inspection, the proper equipment *must* be identified to ensure comprehensive field inspections are performed. The equipment list should include both field inspection equipment as well as health and safety equipment.

2. Field Inspection

The inspector is required each field day to track daily information and site-specific data. Inspection field forms were developed and used to log the inspection parameter scores, pertinent measurements, comments, and overall rating. Digital field photos are taken to document the overall site and key features (e.g. inflows, control structures, outfall). In addition, photos are taken to record defects identified by select parameters, and will be used to support inspection results and supplement work orders.

3. Data Management

Managing the results from office review and field inspections is vital in developing and maintaining an accurate BMP database. Inspection data is comprised of inspection results and field photos. A geodatabase provides a repository to store vital information such as inventory data, inspection results, a catalog of field photos and design plan scans, and the geospatial location of a BMP.

E. REMEDIATION

After completion of the 2007 BMP, DeIDOT and KCI reviewed the inspection results to define the remedial action for each BMP, and to develop a long-term strategy for remedial actions. A key aspect of this exercise was the review of DeIDOT's operations, such as the availability of DeIDOT maintenance staff and current contractors for specific needs. As a result, three general categories for remediation were created: Maintenance Work Orders, Invasive Vegetation Spray List, and Retrofit Recommendations.

1. Maintenance Work Orders

Maintenance Work Order (MWO) issues are defined as those actions considered routine and able to be handled by field staff within DeIDOT's four maintenance districts. Beginning with the 2008 BMP inspections, routine maintenance issues identified by KCI will be entered into DeIDOT's MWO system. KCI will clearly identify and photograph the issue and submit the MWO to the appropriated geographical DeIDOT maintenance district. Each district has an assigned staff to receive BMP work orders and schedule the work based on type of work, location of work, and severity of the issue. For instance, a vacuum truck may be scheduled to handle removing all accumulated sediment from several BMPs, or a general labor crew will be scheduled to handle all MWOs at several BMPs located in the same area. The most common issue identified in the 2007 inspection that required routine maintenance was sediment and vegetation build-up that was impeding the conveyance into, through and out of the BMP.

2. Invasive Vegetation Spray List

DeIDOT annually maintains an inventory of invasive species types and approximate square footage at each BMP and hires a contractor to eradicate invasive species surrounding their BMPs. During the BMP inspections, KCI identifies the presence and square footage of the invasive species, and evaluates the need for eradication. For instance, DeIDOT has identified

Canadian Thistle as a species that needs to be eradicated regardless of the amount observed. For Phragmites and Cattails, DelDOT is interested in eradicating these species only when there is a significant concentrated band. The Invasive Species Spray List allows DelDOT to direct the appropriate level of annual funding for this issue and allows the contractor to schedule the appropriate timing of the work and the appropriate level of man-power needed to efficiently complete the work.

3. Retrofit Recommendations

Retrofit remedial actions are considered beyond the scope of DelDOT's maintenance districts. Remediation at this level may require engineering analyses to bring the BMP back to original design specifications or require engineering consideration of a different type of BMP for the particular stormwater treatment need. In the 2007 BMP inspections, KCI identified two levels of Retrofit actions, Minor Retrofit and Major Retrofit. The Minor Retrofit was defined as a component of a BMP that needed repair or reconstruction. Examples included swales with rock check dams, where the check dam needed to be repaired, or a sediment forebay of a pond that needed to be cleaned or reconstructed. An example of a Major Retrofit would be a BMP that has totally failed and needs to be reconstructed to original or new design.

F. SUMMARY

DelDOT's NPDES permit requires annual inspections of DelDOT-owned BMPs. In 2007, DelDOT, assisted by KCI Technologies, Inc., developed an inspection protocol to allow for consistent inspections that would additionally assist DelDOT in identifying specific levels of remediation. After completion of the revised inspection methodology in early 2007, KCI used and tested this methodology during DelDOT's 2007 inspections at 309 DelDOT BMPs. The methodology was based on specific features of a BMP categorized into four key areas: Site Conditions, Water Quality, Embankment, and Outlet Structure. After the 2007 inspections, DelDOT and KCI reviewed the results and developed a long-term strategy for remediation of DelDOT's BMPs, taking into account current DelDOT maintenance processes. Three general categories for remediation were created: Maintenance Work Orders, Invasive Vegetation Spray List, and Retrofit Recommendations. Maintenance Work Order issues were defined as those actions considered routine that could be handled by field staff within DelDOT's four maintenance districts. The Invasive Vegetation Spray List allowed DelDOT to approximate the scope of work and funding needed to eradicate invasive species surrounding their BMPs. And finally, Retrofit Recommendations were those actions requiring engineering analysis to correct serious issues with a specific BMP component and/or the entire BMP.