GUIDELINES FOR STORMWATER BACTERIA REDUCTIONS THROUGH BMP IMPLEMENTATION NY/NJ HARBOR TMDL DEVELOPMENT

Elevated bacteria in stormwater runoff in urban areas are well documented by many researchers. Monitoring programs throughout the United States show that bacteria concentrations in stormwater runoff are typically elevated well above primary contact recreation standards, regardless of land use in the watershed (e.g. open space, residential, commercial, industry, or highway). Many communities and researchers have made efforts to identify the sources of bacteria in urban runoff. In some cases, human induced problems exist as a result of illicit connections of sanitary sewers to storm sewers, sanitary sewer overflows, and leaking sanitary sewers as a few examples. In other cases, nonanthropogenic sources of bacteria are dominant. In suburban and urban areas these would include pet waste and wildlife such as deer, raccoons, birds, and geese.

Polluted stormwater runoff is commonly transported through Municipal Separate Storm Sewer Systems (MS4s) from which it is often discharged untreated into local waterbodies. To prevent harmful pollutants from being washed or dumped into a MS4, operators must obtain a NPDES permit (Phase I, 1990 – medium and large cities or counties, Phase II, 1999 – small MS4s outside the urbanized area). Each regulated MS4 is required to prohibit illicit discharges and develop and implement a stormwater management plan (SWMP).

The MS4 program contains elements called *minimum control measures* designed to reduce pollutants discharged. These include the following:

- Public Education/Outreach and Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Control
- Post-Construction Runoff Control
- Pollution Prevention/Good Housekeeping

It is critical for this paper to address how these minimum controls impact the reduction of bacteria for the NY/NJ Harbor TMDL development. First, although the removal of illicit connections is critical for water quality, *the model baseline conditions already assumes illicit connections have been removed*; therefore no additional credit can be given for eliminating these connections. Second, the Construction Site controls are geared at reducing sedimentation and are not aimed at reducing bacteria levels. Post construction controls such as infiltration islands in parking lots are a means of reducing runoff of new developments and therefore, in most cases, are not reducing existing runoff but instead are mitigating new runoff.

Pollution Prevention/Good Housekeeping can be a very broad category; pollution prevention practices do not have quantifiable goal and therefore there is a great deal of flexibility in choosing exactly how to satisfy the minimum control measure requirements. In addition, most of the example guidance for fulfilling this requirement is related to debris and floatables control. Entities could certainly elect to develop more sophisticated BMPs; these will be addressed in the following sections. In most cases, the minimum controls will do little for reducing bacteria loads. However, reducing pet waste through education, street sweeping and any low level BMP that induces infiltration will have some impact on nonanthropogenic loadings but probably will be less than 2% of present loading conditions. It is also noted that routine septic system inspections and pump-outs is an excellent method for anthropogenic source control; however, septic sewer systems are not prevalent in the NY/NJ Harbor area.

BMP Effectiveness

The ability of structural BMP performance to reduce bacteria counts varies widely within BMP categories. As a result, stormwater managers should not assume that structural BMPs can meet numerical limits for bacteria for all storms and under all conditions. This is consistent with the 2006 findings from *Storm Water Panel Recommendations to the California State Water Resources Control Board* (CSWRCB 2006)

BMP reductions of bacteria loadings to the Harbor may be achieved through either direct BMP reduction in concentration levels between influent and effluent or through volume reduction. There are, for example, BMPs that have little bacteria removal but may have significant volume reduction which in effect will reduce the bacteria loadings. The following will address BMPs that reduce bacteria concentration and volumes. These will be on a site-specific basis. However, a key question is whether these BMPs can be practically implemented and to what degree these can be applied in the NY/NJ Harbor area. A preliminary assessment of the implementation of these BMPs will be addressed in this paper.

Boyer (Delaware Department of Natural Resources) summarized bacteria reductions for several types of BMPs. These reductions are shown on Table 1.

Table 1. Bacteria Concentration Reductions for Selected BMPs

BMP	Bacteria Reduction (%)
Buffer Strips	43 – 57
Constructed Wetlands	78 – 90
Sand Filters	36-83
Wet Ponds	44 - 99

Although these BMPs shows significant bacteria reductions, these BMPs may not be applicable to the NY/NJ area on a wide-scale basis. Buffer strips are vegetated sections of land that are essentially flat or low slopes. Typically, the wider the buffer, the more bacteria is reduced. These are usually applied to agricultural areas.

Planned or investigated wetlands development in the NY/NJ area are typically tidal wetlands that are not generally designed to reduce upstream stormwater discharges

Sand filters are generally considered appropriate in urban areas. However, there are several limitations of sand filters. First, sand filters cannot be used to treat large drainage basins but could be applicable for small areas. Secondly, surface sand filters are generally not aesthetically pleasing. Underground sand filters are not visible but are difficult to maintain.

The *Center for Neighborhood Technology* (CNT of Chicago) summarized the work of three centers of research based on monitoring and model performance results. These include the Portland Bureau of Environmental Services (PBES), the Milwaukee Metropolitan Sewerage District (MMSD), and the University Of New Hampshire (UNH). It is noted that the MMSD information is based solely on modeling results. The results reported here are for volume reductions since bacteria data were not reported. A summary of results are shown on Table 2.

Table 2. Reported Volume Reductions for Selected BMPs

BMP	PBES	MMSD	UNH
Bioretention	95	35 - 70	85
Green Roofs	60	35	NA
Porous Pavement	75	75	NA
Vegetated Swales	30	NA	NA
Surface Sand Filter	NA	NA	60
Retention Pond	NA	NA	85
Gravel Wetland	NA	NA	85

Again, an important aspect of this investigation is the practical applicability of BMPs to NY/NJ Harbor. One investigation that addresses this issue was performed by the New York City Department of Environmental Protection for the *Jamaica Bay Watershed Protection Plan.* The results of this study is summarized below.

Jamaica Bay Watershed Protection Plan

A comprehensive evaluation for the control of stormwater was conducted for the Jamaica Bay Watershed Protection Plan (JBWPP) by the New York City Department of Environmental Protection (NYCDEP). The analysis combines the knowledge of BMP performance, the applicability of BMPs for different land use types, GIS land use footprints, and uses calibrated InfoWorks models to simulate conditions of a typical yearly rainfall condition. In summary The JBWPP is one of the most comprehensive analyses available to estimate BMP impacts on a watershed basis. Also, arguably, the Jamaica Bay watershed is a reasonable representation on of NY/NJ Harbor as a whole; it has the characteristics of residential, urban, and commercial land use patterns that is also representative of the NY/NJ watershed. The analysis considers three levels of stormwater capture for existing developments and two levels of capture for new developments. It is noted that “new” developments in this context is either a major alteration to an existing development or taking an existing vacant area or lot with a high area of imperviousness and constructing a new infrastructure. A summary of the types of BMPs that are considered for various land use areas is shown on Table 3.

Table 3. Summary of BMPs Considered by Capture and Land Use
JBWPP

Land Use	Existing Development			New Development	
	Low Capture	Medium Capture	High Capture	Medium Capture	High Capture
Low Density Residential	Rain Barrels Rain Planter	Porous Paving Infiltration Basin	NA	NA	Porous Paving Infiltration Basin
Medium Density Residential	Rain Barrels Rain Planter	Porous Paving Infiltration Basin	Green Roof Rooftop Detention	Green Roof Rooftop Detention	Green Roof
High Density Residential	Rain Barrels Rain Planter	Porous Paving Infiltration Basin	Green Roof Rooftop Detention	Green Roof Rooftop Detention	Green Roof
Industrial and Public Facilities	Rain Gardens/Swales Porous Paving	Rain Gardens/Swales Porous Paving	Green Roof Rooftop Detention	Green Roof Rooftop Detention	Green Roof + Rain Gardens/Trees

The management plan assumed for existing development low and medium capture scenarios that 1% per year of existing development would install BMPs for a total 10% over a ten year period. For the high capture scenario, it was assumed that large rooftops over 5,000 square feet would install BMPs. New Development scenarios include both new developments and major alterations of existing development. It should be noted that rooftop detention is already required for new developments. Note also that for new developments, green roofs appear in both medium and high capture scenarios. However, the high capture scenario represents a more intensive green roof design.

Results of ten year model runs (InfoWorks) are shown on Table 4 with the estimated costs for the various scenarios. The percent reduction shown on Table 4 is the volume reduction calculated for total untreated discharge to Jamaica Bay. For this analysis, it is also assumed that the volume reduction calculated would be directly proportional to bacteria load reductions. The ranges in the percent capture represents the ranges over four sewer districts in the Jamaica Bay Watershed.

Table 4. Estimated BMP Volume Reductions and Costs

	Existing Development			New Development	
	Low Capture	Medium Capture	High Capture	Medium Capture	High Capture
Percent Volume Reduction	2.8% (1.4 – 4.9)	5.7% (3.2 – 9.2)	7.9% (5.0 – 29)	4.8% (2.9 – 20.7)	15.5% (10.2 – 29.1)
Cost	$230 Million	$350 Million	$470 M (rooftop detention) to $3 billion	$ 0 (rooftop detention) to $1.7 Billion	$2.4 Billion

The costs shown in the table are given here to give an idea of the relative magnitude of capture scenarios. It appears the high capture scenario assumed for Jamaica Bay is about ten times the cost of the medium capture scenario. Actual costs for other areas of the Harbor would, of course, be dependent on the area being evaluated.

Summary

The purpose of this paper is to research BMP performance and applicability for the control of stormwater and ultimately the reduction of bacteria loadings. Based on the literature that has been reviewed, the following conclusions and recommendations are presented.

Three levels of stormwater control are presented as guidance for assuming what levels of stormwater control are achievable. These include MS4 minimum control requirements, medium level of BMP implementation, and a high level of BMP implementation. These levels are predominantly based on the work of NYCDEP for Jamaica Bay and based on engineering judgment by the author. The applicability of BMPs are very much dependent on the characteristics of small scale land use patterns. Detailed analysis of site-specific areas would be required with regard land use and regional planning to assess the possibilities of BMP effectiveness. In addition, the applicability of BMPs should also be evaluated in a detailed cost-benefit analysis that considers both the reduction of bacteria loadings *and* the resulting impact on water quality. The recommended guidelines for assuming BMP stormwater reductions are given in Table 5. These guidelines should be viewed only as a preliminary global assessment; these guidelines may vary significantly from area to area. These guidelines should be critically reviewed and assessed by regional stormwater managers.

Table 5. Recommended Stormwater Reductions
For NY/NJ Harbor TMDL Evaluations

Level of Reduction	Estimated Level of Reduction Level (Range)
MS4 Reductions	3% (1 – 4)
Medium Level BMP	10% (5-15)
High Level BMP(1)	25% (15 – 40)
(1) May not be practical due to cost	

The basic minimum control requirements of the MS4 program does not appear to do much for bacteria reduction; most of the minimum controls focuses on reduction of floatables and possible sediment discharge reductions. However, the minimum control of the MS4 program does require a stormwater management (SWMP) to be developed and implemented – but the goals are not well defined and there is a great deal of flexibility to satisfy this requirement. Therefore, it is assumed for this paper that the MS4 minimum control requirements will achieve stormwater reductions that are similar to the reduction levels calculated for the Low Capture – Existing Development reported in the JBWPP. The 3% percent reduction shown in the table for MS4 reductions does have a cost associated with it; therefore, the level of reduction may be optimistic for some areas.

The cost of the medium reduction level seems to be about 1.5 to 2.0 times the cost of the MS4 program assumed in this analysis. Therefore, in this paper, the medium level of BMP control is assumed to be potentially a reachable goal.

The high level BMP control is presented as control measures that are technically feasible. It should also be noted that an analysis by the *Charles River Watershed Association* developed a comprehensive high level stormwater management plan for the Boston area. The proposed plan, evaluated using the Win-Slamm Model calculated volume reductions of 32%; the cost of this plan was not immediately available. However, the high level of control may not be economically feasible (based on JBWPP) since it appears that high levels controls may be about ten times more expensive than the medium level of BMP control. Again, these BMPs would need to be assessed on a site to site basis with a detailed cost-benefit analysis.

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