Stormwater Managers Beware of Snake-Oil BMPs For Water Quality Management

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ABSTRACT
The US EPA's recent reaffirmation of the requirements of ultimately having to meet water quality standards in the receiving waters for urban area and highway stormwater runoff requires that stormwater runoff water quality managers adopt a significantly different approach for selecting BMPs. The traditional stormwater runoff water quality "BMPs", such as detention basins, filters, etc., will not "treat" urban area and highway stormwater runoff to a sufficient degree so that the runoff does not cause violations of water quality standards in the receiving waters for the runoff. In order to achieve this degree of treatment, it will be necessary to use advanced wastewater treatment technology. This paper provides guidance on the approach that stormwater runoff water quality managers should follow in selecting, implementing and evaluating BMPs under current regulatory requirements. Particular attention is given to determining whether the stormwater runoff associated constituents cause real significant water quality use impairments of the receiving waters for the runoff. Also consideration is given to determining whether the exceedance of a water quality standard in the receiving waters represents a real use impairment of these waters or an administrative exceedance of the standards due to the overly protective nature of US EPA water quality criteria and state standards based on these criteria when applied to urban area and highway stormwater runoff.

KEYWORDS
stormwater, water quality, BMPs, water quality standards

INTRODUCTION

The US EPA (1990) as part of implementing the 1987 revisions of the Clean Water Act developed a national stormwater runoff management program that requires that NPDES-permitted urban area and highway stormwater dischargers will have to control the characteristics of the runoff/discharges so that it does not cause exceedance of water quality standards in the receiving waters for the discharge more than once every three years. While attempts were made to try to get the Agency to relax this requirement by urban stormwater dischargers, in January 1998 through testimony presented to the state of California Water Resources Control Board in connection with an appeal of the Orange County, California stormwater NPDES permit, the Agency reaffirmed that NPDES-permitted stormwater dischargers ultimately must not cause violations of water quality standards in the receiving waters for the stormwater runoff. This requirement is to be implemented through a BMP ratcheting down process where if a NPDES permitted stormwater runoff manager finds through the required stormwater runoff monitoring program that the concentrations of constituents in the discharge are such that they cause

violations of water quality standards in the receiving waters for the discharge, then the permittee must report this finding to the regulatory agency and modify the stormwater management plan so that the violations of the water quality standards are eliminated.

Some urban stormwater dischargers had been interpreting the US EPA's 1990 stormwater runoff water quality control regulations of controlling pollution due to NPDES-permitted stormwater runoff to the maximum extent practicable(MEP) using best management practices (BMPs) to mean that non-structural BMPs such as educational programs that inform the public not to dump wastes into streets or stormsewers, control of illegal connections and illicit discharges coupled with effective street sweeping would satisfy the BMP to the MEP regulatory requirements. Eventually, some traditional structural BMPs such as retention basins and grassy swales might be used, especially in new developments. However it is becoming increasingly clear that many of the conventional BMPs that are being installed in new developments, such as retention basins, filters, grassy swales, etc., will not treat urban area and highway stormwater runoff (UAHSR) so that it does not cause receiving water water quality standard violations. Expensive, structural BMPs based on advanced wastewater treatment practices will have to be retrofitted to existing urban area and highway stormwater runoff conveyance structures in order to achieve a stormwater discharge that does not cause violations of water quality standards in the receiving waters. In some locations where the regulatory agencies have not developed mixing zones for the stormwater runoff that could be used to dilute the stormwater runoff and still protect the designated beneficial uses of the waterbody, stormwater discharges will have to meet water quality standards in the stormwater discharge, i.e. end-of-the-pipe requirements.

This situation is further complicated by the fact that the US EPA water quality criteria and state standards based on these criteria are not appropriate goals for the BMP ratcheting-down process that is currently required under the US EPA stormwater management policy (Lee and Jones-Lee, 1997a). These criteria and standards were not designed to control chemical constituents that are largely in non-toxic, non-available forms such as those that occur in UAHSR. These criteria/standards are also not appropriate for regulating potentially toxic or bioaccumulatable chemicals under conditions where aquatic life are exposed to available forms of the chemical for short periods of time such as those typically associated with a stormwater runoff event. They were developed to control extended duration discharges containing largely toxic forms of chemical constituents, such as occurs with some domestic and industrial wastewater discharges.

This paper reviews some of the characteristics of urban stormwater runoff relative to the ability of various types of conventional stormwater runoff BMPs to achieve water quality standards in the BMP-treated runoff waters. It provides guidance on how UAHSR managers should evaluate, on a site-specific basis, whether their stormwater runoff is causing real water quality use impairments in the receiving waters for the runoff waters that require a structural BMP for control of chemical constituents in the runoff waters.

TRADITIONAL APPROACH FOR BMP DEVELOPMENT

The traditional approach for selecting an UAHSR BMP is for the stormwater water quality manager to work with a consulting engineering firm to select one of the traditional BMPs such as a detention basin or filter from one of the BMP manuals that will physically fit into the area available. The BMP is constructed and except for occasional maintenance such as removal of

accumulated sediment, it is largely forgotten. If an evaluation of the efficacy of the BMP is made, it is based on across the unit removal of the typical constituents of concern such as certain particulate heavy metals, TSS, particulate phosphorus, oil and grease, etc. The traditional approach for UAHSR water quality BMP selection meets the current regulatory requirement for the stormwater manager having to install a BMP. Until recently it was thought that this approach will keep the regulators off the stormwater managers' back for at least one or possibly two five-year NPDES permit cycles. The consulting engineer is pleased since the firm has been paid its consulting fees and has a satisfied client. The regulatory agency staff are satisfied in that stormwater is being "treated" to remove particulate heavy metals and phosphorus, TSS, etc. Even environmental activists are satisfied especially if they have been active in forcing the stormwater manager to install BMPs to"treat" the stormwater runoff. Basically there is little incentive to "rock the boat" by questioning whether the installed BMP is a real water quality BMP that is resulting in an improvement of the water quality related beneficial uses of the receiving waters for the BMP "treated" stormwater runoff, by significantly reducing or eliminating the pollution of the receiving waters for the stormwater runoff as required by current regulatory requirements.

Recently the Water Environment Federation (WEF)and the American Society of Civil Engineers (ASCE) published a "manual of practice," "Urban Runoff Quality Management" (WEF/ASCE,1998). This 259-page manual has been in development for about five years. While the manual contains significant contributions in many areas of urban stormwater runoff water quality management, it is significantly deficient in providing the guidance that stormwater quality managers need to develop technically valid, cost-effective, environmentally protective management of urban area and highway stormwater runoff. Pages 3 and 4 of this manual present a discussion of the scope of the manual where it is stated,

> *"Water quality parameters addressed most in this manual are total suspended solids (TSS) and nutrients (nitrogen and phosphorus); this reflects current common practice in BMP design. In fact, TSS and nutrients are the primary constituents of stormwater runoff that can be controlled by the passive BMPs considered in this manual. It is noted that focus on these parameters is not a complete oversight of other parameters, because most other constituents of concern (for example, metals, hydrophobic organics) are reduced by the processes used to remove TSS, and remove nutrients. Moreover, the two most widely documented effects of urban runoff on receiving waters are associated with sediment and nutrient enrichment.*
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> *"Benefits do accompany the removal of other substances, such as metals (for example, copper, zinc, iron, and lead) if they are primarily particulate, hydrophobic organics, detritus, and bacteria. However, it is difficult to develop design criteria to control these substances because their removal depends on the physiochemical factors that are intractable in design. All things considered, it is not unreasonable that present common practice focuses on particulate removal, and this approach is adopted in this manual.*
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> *"It is noted that water quality parameters described in this manual typically use the total mass per unit volume (total concentration) as a basis for discussion. This is because the reference quantity used in many water quality standards is the total concentration. It is nevertheless recognized that the ecological significance of total concentration is the subject of much debate."*

As a member of the WEF review panel for the several drafts of this manual, the junior author worked for over two years to try to get those responsible for the development of the manual and, in the final year, the WEF management to expand the scope of the manual to reflect what is well known today about the inadequacies of the conventional structural BMPs of the type described in this manual in controlling chemical constituents that are present in urban area and highway stormwater runoff at concentrations above water quality criteria/standards in the runoff waters. Also an effort was made to try to get those responsible for the development of this manual to address the adequacy of conventional BMPs of the type discussed in this manual to control constituents that are not now regulated by water quality criteria and standards, such as the organophosphate pesticides being used in urban areas, but are being found to cause potentially significant aquatic life toxicity in receiving waters for urban area stormwater runoff in many parts of the US and in other countries. Those responsible for the development of this manual refused to incorporate an appropriate discussion of the technical information needed to provide guidance to urban area and highway stormwater runoff water quality managers on how to select a true BMP to manage real water quality - use impairments in the receiving waters for urban area and highway stormwater runoff.

Those responsible for the development of the manual wish to maintain the status quo of having stormwater runoff water quality managers continue to assume that construction of detention basins, filters, and other conventional so-called stormwater runoff BMPs is the appropriate state of the science and engineering that exists today. While the management for the manual did include the above-quoted materials in the manual, they did not want the manual to reflect what has been well-known since the early 1990s and was adopted into regulatory practice in the mid-1990s-that removal of particulate forms of many constituents, such as heavy metals, does not address real water quality problems that reflect use impairments of the receiving waters for the stormwater runoff. As was pointed out to the manual development managers, the US EPA in the early l990s recommended and in 1995, officially adopted dissolved forms of heavy metals in ambient waters as the basis for regulating ambient water concentrations of many heavy metals, including those that are known to cause water quality standards exceedances in urban area and highway stormwater runoff (US EPA 1995).

With respect to the above-quoted statement on nutrients, those familiar with the elements of nutrient impacts and control know that the focus of nutrient control programs must be on available forms of nutrients, not total forms. It is also well known through extensive research (Lee et al. 1980) that the forms of nitrogen and phosphorus that are removed as particulates in conventional BMPs are largely in non-available forms. For the manual to state that the guidance provided in this manual is appropriate for developing BMPs for nutrient issues is a significant deficiency in this manual in providing reliable information on BMP selection and evaluation for stormwater runoff nutrient-related problems.

The statement, "However, it is difficult to develop design criteria to control these substances because their removal depends on the physiochemical factors that are intractable in design." reflects a lack of knowledge about conventional advanced wastewater treatment plant design. Contrary to this statement, this design is readily tractable and commonly practiced in the environmental engineering field. The physiochemical factors that govern removal of chemical constituents in UAHSR that are not TSS or nutrients are well understood. The basic problem is

not the intractability of the physiochemical factors in applying them to UAHSR, but it is the cost to the public of their construction, operation and maintenance. Consultants for several urban areas who are familiar with advanced wastewater treatment principles and practices have estimated that the cost of treating UAHSR so there is no more than one exceedance of a water quality standard every three years (current Clean Water Act requirements) is on the order of hundreds of millions to billions of dollars for various communities.

Those familiar with the current significant UAHSR water quality management issues know that the real issue that a guidance manual on BMP selection and evaluation must address is water quality criteria/standards exceedances that are occurring in UAHSR. While there are some situations where TSS is an issue in stormwater runoff associated with new construction, the real issues of concern to UAHSR water quality managers are the exceedances of the water quality standards for heavy metals, organics and pathogenic organism indicators.

One of the most significant impediments to developing a technically valid approach to cost-effective UAHSR BMPs is the general lack of knowledge of those in the field on the factors that influence the impact of chemical constituents on the beneficial uses of waterbodies. Typically stormwater managers and consulting firms have limited expertise and experience in the aquatic chemistry, aquatic toxicology/biology, public health and water quality that is needed to evaluate the water quality impacts and appropriately manage chemical constituents in UAHSR. If the stormwater runoff water quality field is to achieve technically valid, cost-effective development of stormwater runoff water quality management, it will be necessary that individuals with high levels of expertise and experience in the applied sciences and engineering that serve as the foundation of 1990 level water quality impact evaluation and management become active in the field.

INADEQUATE PERFORMANCE OF TRADITIONAL STORMWATER RUNOFF BMPs

Traditional BMPs such as detention basins which are based on particulate removal while appropriate for TSS removal, when considered from a basic aquatic chemistry/aquatic toxicology/biology and water quality perspectives, would not be expected to be effective in removal of chemical constituents that are of concern because of their impact on receiving water aquatic life-related beneficial uses. The non-toxic, non-available nature of particulate forms of chemical constituents that are potential pollutants in UAHSR has been known since the late 1960s (Jones-Lee and Lee, 1994). This information has been largely ignored by those who developed the BMP manuals that are now the source of BMPs that consultants and some environmental groups recommend to stormwater managers as appropriate for "treating" urban area and highway stormwater runoff.

Maxted and Shaver(1997) have conducted a study to evaluate the impact of retention basins in controlling constituents in new residential development runoff that could adversely impact the benthic invertebrate populations in receiving waters for the retention basin "treated" runoff. Maxted (1998) has reviewed these data and recently presented a paper, "The Effectiveness of Retention Basins in Protecting Stream Biota and Physical Habitat." These papers cover a two-year BMP effectiveness study that was conducted in Delaware where it was found that the installation of sedimentation basins (retention basins) for "treatment" of stormwater runoff from

residential developments did not impact the numbers and types of organisms present in the receiving waters for the stormwater runoff. This finding is expected based on the aquatic chemistry and toxicology of urban stormwater runoff-associated chemical constituents. Maxted pointed out that the primary impacts of urban area stormwater runoff are physical through changing flow and habitat characteristics; they are not related to the chemical characteristics of the runoff.

UNRELIABLE INFORMATION ON PHASE II MINIMUM CONTROL MEASURES TO ACHIEVE WATER QUALITY STANDARDS

US EPA representatives as part of presenting information on the proposed Phase II stormwater regulations (US EPA 1998) stated at the San Francisco March 6, 1998 hearing that it is the US EPA's position that the six "Minimum Control Measures" of:

1. Public education and outreach on stormwater impacts,
2. Public involvement/participation in developing stormwater management program,
3. Illicit discharge detection and elimination,
4. Construction site stormwater runoff control,
5. Post-construction of stormwater management in new development and re-development, and
6. Pollution prevention/good housekeeping for municipal operations,

set forth in these proposed regulations would enable Phase I and Phase II communities to achieve water quality standards in stormwater runoff with no more than one exceedance for a regulated constituent every three years. The US EPA representative indicated that this included meeting the narrative requirements for controlling toxicity, etc. It was learned that the Agency had not conducted a review of the information on the chemical characteristics of urban area stormwater runoff and the ability of the six Minimum Control Measures to impact the concentrations of constituents of concern that frequently cause exceedance of water quality standards in urban stormwater runoff in developing this position. Also, the US EPA did not conduct an economic analysis of what it would cost the Phase II communities to meet water quality standards in the stormwater discharge with no more than one exceedance every three years.

The US EPA representative at the March 6th hearing stated that it is the Agency's position that it will not be necessary to use conventional BMPs to achieve water quality standards in urban area stormwater runoff. However, if it is found that these six Minimum Control Measures do not control regulated constituents so that there are no exceedances of water quality standards, then structural BMPs would need to be used.

It is obvious to those who understand the characteristics of UAHSR and the ability of the six Minimum Control Measures, that UAHSR that is managed by the six Minimum Control Measures, will not meet water quality standards in the urban area stormwater runoff with no more than one exceedance of any regulated parameter every three years as required by the US EPA's current regulatory approach. The concentrations of fecal coliform organisms in UAHSR will violate sanitary quality standards for the protection of contact recreation, domestic water supplies and for marine waters, shellfish harvesting. In addition to the violation of NPDES permit conditions for regulated chemical-specific standards for several heavy metals such as copper, lead and zinc, urban area stormwater will be toxic to some forms of aquatic life due to

organophosphate pesticides such as diazinon and chlorpyrifos used on residential, commercial and industrial property for structural and lawn and garden pest control. There is substantial historical and current urban area stormwater runoff data that the US EPA could and should have used in evaluating the "ability" of the six Minimum Control Measures to enable regulated communities to meet water quality standards in the runoff waters.

In order to meet current water quality standards for protection of aquatic life, contact recreation, shellfish beds sanitary quality and domestic water supply raw water quality, it will be necessary to use advanced wastewater treatment technology to treat the stormwater runoff. The advanced wastewater and water treatment processes that will likely have to be used to treat stormwater runoff to achieve water quality standards include: trace element co-precipitation with iron hydroxide, sorption on activated carbon powder or columns, various types of ion exchange, microfiltration, and reverse osmosis. The actual treatment process(s) to treat any particular stormwater runoff will depend on the mix of potential pollutants that are present in the runoff. While several consultants have estimated that it will be necessary to use R/O to treat the runoff to achieve standards, for some situations it may be possible to use less expensive methods. As has been pointed out by Dr. R. Hale of Alameda County, one of the largest cost items will be the acquisition of land and the construction of the collection and especially the construction of the storage facilities to store the runoff prior to treatment. He estimates that it will take storage facilities equivalent to 50 Oakland Coliseums constructed on the shore of San Francisco Bay to store storm runoff from a one-day, two-inch storm. This type of storage will be needed in some areas to store runoff prior to treatment to avoid violating water quality standards no more than once in three years.

The cost of this treatment will be on the order of 10s to 100s of millions to billions of dollars to retrofit urban area and highway stormwater runoff conveyance structures with real water quality BMPs that will treat stormwater runoff to meet current Clean Water Act requirements for compliance with water quality standards. It is for this reason that increasing attention is being given by urban stormwater managers and some regulatory agencies to developing approaches for regulating urban area stormwater runoff that will protect the designated beneficial uses of waters receiving UAHSR without significant unnecessary expenditure of public and private funds for chemical constituent control. Of particular concern is the worst-case nature of the US EPA water quality criteria when mechanically adopted as state water quality standards for regulating UAHSR associated constituents. As discussed by Lee and Jones-Lee (1995a), many of these standards can be significantly relaxed and still protect the beneficial uses of waterbodies for protection of aquatic life and public health.

AREAS THAT NEED SPECIAL ATTENTION

As part of developing a more appropriate regulatory approach for UAHSR, there is need for urban area and highway stormwater dischargers to conduct site-specific studies to determine the real water quality use impairments due to chemical constituents and pathogenic organism indicators in the runoff waters. The overall objective of the needed UAHSR water quality impact studies should be to:

- examine the water quality use impairments caused by stormwater runoff-associated constituents,

- determine the water quality significance, i.e. real pollution, associated with the exceedance of a water quality standard/objective in highway stormwater runoff, and
- evaluate the water quality benefits that would accrue through controlling stormwater runoff-associated constituent concentrations in runoff waters on the designated beneficial uses of the waterbody of interest.

From this type of information, it will be possible to develop overall guidance that can be used by regulatory agencies, stormwater dischargers and others to establish site-specific discharge limits for pollutants in NPDES-permitted stormwater runoff to protect various types of waterbodies' designated beneficial uses in a cost-effective manner. Ultimately this type of information will be instrumental in serving as a technical base for revisions of the Clean Water Act so that the over-regulation of regulated constituents and the under- regulation of the non- or under-regulated constituents in urban area and highway stormwater runoff is minimized.

While there are some environmental activist groups, consultants, and public works directors that are opposed to conducting receiving water studies to determine the real significant water quality use impairments that are caused by UAHSR-associated chemical constituents, the very high costs of ultimately having to achieve water quality standards in the discharge/receiving waters for the runoff mandates that these studies be conducted to ensure that public funds are used wisely in stormwater runoff water quality management. Those who advocate maintaining the status quo of mechanically assuming that traditional stormwater runoff BMPs should be installed without evaluating their efficacy in water quality control are advocating approaches that are strongly contrary to the public's interests. The limited funds available for stormwater runoff water quality management must be used to address real significant water quality use impairments of concern to the public who must pay for the program.

EVALUATION MONITORING FOR WATER QUALITY IMPACT EVALUATION

There is growing recognition that traditional stormwater runoff monitoring in which a suite of chemical constituents are measured in samples collected at the end-of-the-pipe/edge-of-the-pavement for several stormwater runoff events per year is inadequate and often unreliable in detecting the water quality impacts of UAHSR. Lee and Jones-Lee(1995b, 1996a) and Urbonas and Torno (1995) have discussed that the current stormwater runoff monitoring is of limited value and largely a waste of funds in defining the water quality impacts of chemical constituents in runoff as they impact the beneficial uses of the receiving waters for the runoff. The basic problem is that it is not possible to translate runoff concentrations of potential pollutants to receiving water impacts without extensive site-specific studies since chemicals impact aquatic life through the concentrations of available/toxic forms - duration of exposure relationships. Lee and Jones (1991) suggested an approach for assessing the water quality impacts of chemical constituents in UAHSR that utilize the current, readily available science and engineering needed to properly evaluate how a chemical constituent in a discharge/runoff impacts the beneficial uses of receiving waters for the runoff.

Rather than measuring the concentrations/loads of a few "constituents of concern" in the runoff waters, there is general agreement that the funds available for monitoring should be used to assess the impacts of the stormwater runoff-associated constituents on the beneficial uses of the receiving waters for the runoff. As discussed by Lee and Jones-Lee (1996a,1997b), the

monitoring program should not be simply shifted to measuring a suite of chemicals and organism types in the receiving waters for the runoff on an arbitrary frequency such as once a month at a few selected stations over a year or so and then try to elucidate the water quality impacts of the runoff-associated constituents. While generating large amounts of "water quality" data, this type of monitoring program will also often fail to define the impact of stormwater-associated chemical constituents on the beneficial uses of the receiving waters for the runoff. Rather than the shotgun approach, the monitoring should be specifically focused on detecting the use impairments that are occurring in the receiving waters for the runoff that are due to runoff-derived constituents Lee and Jones-Lee (1996b, 1998) have developed an Evaluation Monitoring approach which focuses monitoring efforts on developing a stakeholder consensus on the water quality use impairments in the waterbody that receives the stormwater runoff. If there are use impairments in the waterbody of concern then their significance is evaluated, and the cause and source of the constituents responsible for the use impairment is determined. Also the relative significance of the stormwater runoff versus other sources of the pollutant is determined. The Evaluation Monitoring approach can readily lead to the development of technically valid, cost effective, site-specific BMPs to manage the water quality use impairment in accord with current regulatory requirements.

SELECTING BMPs BASED ON WATER QUALITY CONSIDERATIONS

The recent reaffirmation by the US EPA and the state of California Water Resources Control Board that NPDES permitted UAHSR must ultimately be treated to meet water quality standards in the runoff/receiving waters requires that a significantly different approach be followed in developing BMPs. The traditional hydraulic-based BMP design which focuses on removal of particulates will no longer be appropriate since it is becoming increasingly recognized that particulate forms of heavy metals and other constituents in UAHSR are in non-toxic, non-available forms and therefore their removal will not improve receiving water quality-beneficial uses. The valid approach for selecting an appropriate BMP for controlling real significant water quality use impairment involves the following components.

Review Existing Water Quality Characteristic Data for the Stormwater Runoff and Receiving Waters

- Determine if there is an exceedance of a receiving water water quality standard that is caused or contributed to by the stormwater runoff.
- Determine if a real water quality use impairment (pollution) of the receiving water is occurring in the receiving waters for the stormwater runoff that is due to constituents in the stormwater runoff. The purpose of this effort is to determine if the stormwater runoff is causing or significantly contributing to real pollution of the receiving waters for the stormwater runoff.
- If an inadequate database exists to determine if a violation of a water quality standard or a receiving water use impairment is occurring, then initiate a water quality monitoring/evaluation program designed to evaluate whether a real significant water quality use impairment is occurring in the stormwater runoff's receiving waters. Use the Evaluation Monitoring approach in evaluating whether a real significant water quality problem exists in the receiving waters for the runoff.

Evaluate Whether Administrative Exceedance of Water Quality Standards Is Occurring

- If a water quality standard violation occurs without a significant use impairment of the receiving waters, then petition the regulatory agencies for a variance from having to meet water quality standards in the runoff/receiving waters based on there being no use impairment occurring in the receiving waters due to the stormwater runoff associated constituents. This effort will enable stormwater runoff water quality managers to reveal and appropriately address the over-regulation of UAHSR that arises from the US EPA's Independent Applicability Policy. This variance should include the opportunity to adjust the receiving water standards/stormwater discharge limits and/or the designated uses of the receiving waters to protect the designated beneficial uses of receiving waters for the stormwater runoff without significant expenditures for chemical constituent or pathogenic indicator organism control. These adjustments should be based on appropriately conducted receiving water studies that focus on assessing chemical impacts, rather than the traditional approach of measuring chemical concentrations and loads.

Determining the Cause of the Pollution and the Source of the Pollutant

- If a water quality use impairment is found in the receiving waters for the stormwater runoff, determine the specific causes of the use impairment and through forensic studies, whether the toxic/available form of the specific constituent(s) responsible for the use impairment is derived from the stormwater runoff of concern. Also determine the relative significance of the stormwater runoff versus other sources of the specific constituents responsible for the use impairment as a cause of the use impairment. The relative contribution information is needed to evaluate the potential improvement in the receiving water water quality as a result of implementation of the proposed BMPs.

Selection and Economic Evaluation of BMPs

- Select a BMP(s) to control the specific constituents responsible for the use impairment. The BMP selection should be based on the specific chemical species that cause a water quality use impairment in the receiving waters rather than the total concentrations of the constituent. For example, focus the BMP on removing those forms of dissolved copper that are significantly adverse to beneficial uses in the receiving waters for the runoff.
- Determine if the total cost of construction, operation and maintenance of stormwater runoff BMPs exceeds 1% to 2% of the median household income of the community. If these costs exceed this value, then file a petition for a variance from having to meet water quality standards/designated beneficial uses based on economic factors of excessive costs which would represent a significant economic burden to the community responsible for the stormwater runoff water quality management.

Evaluate Cost Effectiveness of a BMP(s) in Controlling Significant Pollution

- If the development and operation of the proposed BMP appears to be economically feasible, then estimate the potential improvement in the designated beneficial uses that will occur relative to the unregulated or under regulated sources of the same pollutant(s) responsible for the use impairment. If the development of the BMPs will not significantly improve the water quality - use impairment, then a variance from having to develop BMPs until all sources of the pollutants are under regulation and control programs are being developed for these sources should be filed.

- If the potential improvements in the receiving water's designated beneficial uses is limited compared to projected costs to eliminate the use impairment, then the community leaders, regulatory agencies, environmental groups and public groups that are interested in appropriate use of public funds should be consulted to evaluate if the expenditures for stormwater runoff chemical constituent/pathogenic organism control is the best use of the funds potentially available to meet societal needs.

Evaluate the Efficacy of the BMP

- Evaluate the efficacy of the BMP in controlling existing use impairments as well as preventing new use impairments. The traditional approach of measuring the removal of a chemical constituent(s) across a structural BMP such as a filter, detention basin, etc. obviously does not evaluate whether the BMP has caused an improvement in the receiving water's impaired uses. BMP efficacy evaluations must be based on evaluating the improvements that the BMP causes or, for new developments, is expected to cause in the receiving water beneficial uses.

Detection of Future Stormwater Runoff Water Quality Problems

- Develop an ongoing monitoring/evaluation program to search for subtle and new water quality use impairment. An important component of a properly developed and implemented stormwater runoff water quality management program is the funding of a stakeholder consensus-based monitoring/evaluation program to detect subtle water quality problems that were not detected in the initial search for real significant water quality use impairments. This program should be designed to detect new water quality use impairments that arise from the use of new or expanded-use chemicals that become part of UAHSR. The search for undetected and new problems should be repeated every five years to coincide with the NPDES permit cycle.

Watershed-Based Approach

- This BMP selection and implementation program should be formulated on a watershed-based water quality management program in which the stakeholders for the management of the stormwater runoff water quality and the beneficial uses of the receiving waters and downstream waters for the stormwater runoff that could be impacted by the runoff, work together in a consensus-based approach to formulate, implement and evaluate the stormwater runoff water quality management program.

SUMMARY

The BMP development approach recommended herein is designed to transform the development of stormwater runoff BMPs from the current obviously technically invalid, non-cost effective traditional approach to one that incorporates mid-1990s science and engineering information into UAHSR water quality management. Adoption of this approach will enable stormwater runoff water quality managers to select, implement and properly evaluate the efficacy of stormwater runoff water quality BMPs that will cost-effectively address real water quality use impairments in the receiving waters for the runoff in a technically valid manner. It will also enable those responsible for managing public funds to do so in a technically valid, cost-effective manner.

ADDITIONAL INFORMATION

Additional information on these issues is available in the references listed below as well as in papers and reports developed by the authors that are available as downloadable files at the authors' web site, http://www.gfredlee.com. These papers and reports contain extensive references to the work of others that is pertinent to developing appropriate BMPs for UAHSR.

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