Stormwater Runoff Quality Evaluation and Management
Part II: Implementation of Urban Stormwater Runoff Quality Management Regulations

G. Fred Lee, PhD, PE, DEE and Anne Jones-Lee, PhD
G. Fred Lee & Associates
El Macero, CA

Part I of this paper [http://www.gfredlee.com/Runoff/stmwat_1.pdf] discussed the justified need to regulate urban, industrial and, for that matter, rural stormwater runoff quality differently than the approach that was and is being used for municipal and industrial wastewaters. Part II of this paper focuses on some of the approaches that are evolving that recognize the need for a different regulatory approach. Also attention is given to the approach that should be used for regulating chemical constituents in sediments associated with stormwater runoff.

California Stormwater Quality Task Force

The state of California is recognized as being among the leaders in the US in developing consensus approaches for implementing the federal and state stormwater runoff quality management regulations. This leadership role evolved out of the State Water Resources Control Board working with a number of stormwater quality management entities to develop a cooperative approach toward stormwater quality evaluation and management. This cooperative approach was promoted through the state's Stormwater Quality Task Force.

The state's Stormwater Quality Task Force consists of members of the State Water Resources Control Board and regional water quality control boards which regulate urban stormwater runoff within the state, municipal stormwater dischargers, representatives of various industrial and trade associations, environmental groups, consultants, academia, the state of California Highway Department and various county highway departments and others interested in urban stormwater runoff quality evaluation and management. Participation in Task Force activities is open to anyone who is interested. The Task Force is organized through the California chapter of the American Public Works Association.

This Task Force was instrumental in helping to work with the State Water Resources Control Board in developing early NPDES permits for urban stormwater dischargers with populations above 100,000, the development of a best management practices guidance manual, was highly active in formulating a consensus approach for reauthorization of the urban stormwater runoff quality management sections of the Clean Water Act, and in the development of state regulations and implementation guidance for urban and industrial stormwater runoff monitoring and management approaches. Through the leadership of the Task Force, the state of California is recognized as being about one to two years ahead of many other states in implementing urban stormwater runoff quality evaluation and management programs. The cooperative consensus approach for addressing urban stormwater runoff quality evaluation and management developed in California is becoming a pattern for development of similar approaches in other states.

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A review of the technical issues associated with urban stormwater runoff quality evaluation and management led this Task Force to conclude quite early in its deliberations that urban stormwater runoff impacts must be evaluated and managed differently than the approach that has been used for other point source discharges such as municipal and industrial wastewaters. Initially, this was motivated by the finding that conventional treatment approaches used for municipal and industrial wastewater discharges could not be applied to urban stormwater runoff because of the very high costs of trying to treat runoff where it would be collected and passed through a treatment plant that would remove chemical constituents and potential pathogenic organisms - waterborne pathogens to achieve current water quality standards at the edge of a mixing zone for the treated stormwater discharge.

Technically Valid Approaches

Coincident with gaining an understanding of the very high costs associated with trying to follow a conventional wastewater management approach for urban stormwater runoff, evolved the understanding among Task Force members that attempting to manage chemical constituents in urban stormwater runoff following the approach that is conventionally used for municipal and industrial wastewaters that results in achieving ambient water quality standards in the receiving waters for the stormwater runoff discharge would result in massive over-regulation of the chemical constituents in the stormwater runoff. This in turn would result in large-scale waste of public and private funds in treating this runoff to achieve ambient water quality standards. It has been known since the mid-1960's that many of the chemical constituents in urban stormwater runoff as well as stormwater runoff from rural areas were present in non-toxic, non-available forms. Therefore, as discussed in Part I of this paper, exceedance of a water quality standard based on total concentrations of chemical constituents at the edge of a mixing zone for the stormwater runoff, while causing an administrative exceedance of a water quality standard in the ambient receiving waters, does not necessarily cause a real designated use impairment of these waters.

Further, the short-term episodic nature of most urban stormwater runoff events means that the conventional water quality standards that are used to regulate municipal and industrial wastewater discharges based on their acute and chronic toxicity to aquatic life would over-regulate the toxic - available forms of chemical constituents in typical urban stormwater runoff since the extent of exposure of aquatic organisms in the receiving waters for the stormwater runoff was considerably shorter than the period of time which the water quality standards were designed to address. While the US EPA water quality criteria have since the mid-1980's utilized a one-hour maximum and four-day average concentration for implementing requirements designed to control acute and chronic toxicity to aquatic life, it is well-known that for essentially all chemical constituents that these periods of time are grossly over-protective of what is needed to protect the designated beneficial uses of waterbodies for aquatic organisms of potential concern at the edge of a mixing zone for a point or non-point source discharge.

Basically, it is virtually impossible for aquatic organisms in the receiving waters' watercolumn to receive an acute or chronic duration of exposure to aquatic life at the edge of the mixing zone for the stormwater discharge. The US EPA has recently acknowledged this

problem and is in the process of changing the exposure period to which the water quality criteria and state standards based on these criteria are implemented. The agency is also in the process of changing the allowed frequency of violation of water quality standards. Today, a violation of a water quality standard by any amount for more than once in three years represents a violation of the NPDES permit and is subject to regulatory action. This approach is well known to be grossly overprotective since significant violations of many water quality standards can occur on a routine basis without significantly adversely impacting the designated beneficial use of the waterbodies

Development of Technically Valid Water Criteria
and Standards for Stormwater Runoff

The state of California Stormwater Quality Task Force has adopted the position that urban stormwater runoff discharge requirements should not be based on meeting current water quality standards at the edge of a mixing zone. The Task Force, as part of work on reauthorization of the Clean Water Act, joined with other groups in calling for the US EPA to develop technically valid water quality criteria and state standards that could be used to control real water quality problems associated with urban stormwater runoff. In the latest version of the proposed revisions of the Clean Water Act stormwater quality management section, a consensus among various agencies and entities interested in this topic area was developed where a ten-year moratorium in the application of water quality standards for urban stormwater runoff would be permitted. During the moratorium, the US EPA would be provided with $10,000,000 per year, for a total of $100,000,000, to develop water quality criteria applicable to wet weather conditions and an implementation approach that could be used by the states to implement these criteria into state standards that could be used in the NPDES permit system governing stormwater runoff. These criteria/standards would be designed to protect designated beneficial uses of receiving waters from impairment by chemical constituents in urban stormwater runoff without significant unnecessary expenditures for chemical constituent control in this runoff.

These criteria/standards could be wet weather standards where during the period of a runoff event the concentrations of chemical constituents in the runoff would be allowed to exceed current ambient water quality standards near the point of discharge provided that such exceedance does not cause a significant impairment of the designated beneficial uses of the waterbody. This is the technically valid approach that should be followed in developing regulatory approaches for controlling real water quality problems associated with urban stormwater runoff.

Industrial Stormwater Runoff

While there is widespread agreement that the current ambient water quality standards should not be applied to urban stormwater runoff, the US EPA and states are applying these standards to industrial stormwater runoff at the edge of the property. This is a technically invalid approach which results in gross over-regulation of chemical constituents in stormwater runoff from industrial properties. Similarly, significant over-regulation of industrial stormwater discharges for those industries covered by the US EPA's multi-sector permit is occurring. The Agency's proposed approach of using benchmark values based on water quality criteria and the US EPA's National Urban Runoff Program (NURP) studies is technically invalid and will result in

significant over-regulation of many industrial stormwater discharges and a waste of funds devoted to inappropriately-based stormwater monitoring.

Concentrations of chemical constituents in stormwater runoff from industrial properties can exceed various NURP values as well as US EPA water quality criteria/standards by considerable amounts and still not be adverse to the beneficial uses of the waterbodies in which the runoff enters. A significantly different approach needs to be developed at the federal and state levels to protect surface and groundwater quality associated with industrial stormwater runoff that will protect the designated beneficial uses of waterbodies without wasting funds implementing control programs that will have no impact on the designated beneficial uses of the waterbodies receiving the industrial stormwater runoff.

Water Quality Significance of Chemical Constituents Associated with Sediments

Part I of this paper discussed the potential significance of particulate matter in stormwater runoff on receiving water quality. There are two principal areas of concern. One is the particulates themselves, irrespective of their chemical characteristics. The other is the chemicals of concern associated with the sediments as precipitates and attached - sorbed on particle surfaces. As discussed, chemical constituents associated with particulates are typically non-toxic, non-available and therefore, should not be regulated as part of achieving water quality standards in the receiving waters for stormwater runoff. These standards are applicable to the water column. They do not consider the potential impacts of the chemical constituents on suspended sediments in stormwater runoff that become part of the deposited (bedded) sediments. It is well-known that while most chemical constituents in sediments are detoxified, i.e. non-toxic, non-available, there are situations where the detoxification capacity of the sediment which is basically controlled by the sediment matrix is exceeded with the result that chemical constituents in aquatic sediments can be toxic or otherwise available to adversely affect the designated beneficial uses of the waterbody in which the sediments are located. While there may be some who try to regulate water quality impacts of chemicals associated with deposited sediments through water quality criteria and standards, such an approach is technically invalid and fails to recognize the aquatic chemistry and aquatic toxicology of sediment-associated contaminants.

There are two principal areas of water quality concern associated with chemical constituents in sediments. One is the potential for sediment-associated chemical constituents to cause toxicity to benthic and epibenthic organisms present within or upon the sediments. The other area of concern is the potential for some chemical constituents in sediments to be sufficiently available to accumulate to excessive levels in benthic and epibenthic organisms that can serve as food for higher trophic level organisms, such as other aquatic life, man and terrestrial wildlife. The accumulation of chlorinated hydrocarbon pesticides, PCB's and mercury in fish flesh, causing the fish to be considered unsuitable for use as human food is an example of this type of problem.

Since the mid-1970's the US EPA and the US Army Corps of Engineers (US COE) have been regulating contaminated sediments associated with navigational dredging of US waterways. Based on the results of the US COE's Dredged Materials Research Program in the 1970's, where it was found that chemical concentrations of constituents in sediments were not reliable

indicators of water quality impacts, the Agency and the Corps developed biological effects-based contaminated sediment evaluation criteria. Rather than trying to estimate sediment toxicity based on chemical characteristics, which is well-known to be unreliable, direct measurement of sediment toxicity using sediment toxicity tests are used.

In order to assess the potential for bioaccumulation of chemical constituents in sediments in higher trophic level organisms, it is necessary to make measurements of the actual accumulation that occurs within desirable organisms tissue in the waterbody of concern. There is no reliable approach available today to predict, based on sediment concentrations, whether a particular constituent, such as mercury, present in the sediments will bioaccumulate in aquatic organisms that can serve as a source of food for man to a sufficient degree to be potentially harmful to those who consume the organisms.

In order to determine whether there is need to control the chemical constituents associated with sediments in stormwater runoff, it is necessary to conduct site-specific investigations of the water quality impacts that the bedded sediment-associated contaminants are having on the designated beneficial uses of the waterbody in which the sediment is located. There is no reliable way at this time, nor will such an approach be developed in the near future, to predict, based on concentrations of sediment-associated constituents in stormwater runoff, the potential impact that these constituents would have on the receiving water's water quality when the suspended sediment of concern becomes part of the bedded sediments in these waters.

Santa Monica Bay Restoration Project

Recently, the Santa Monica Bay, CA Restoration Project has adopted a restoration plan that calls for the expenditure of $42 million over a five year period for the development of structural BMP's for the control of selected chemical constituents such as several heavy metals in urban stormwater runoff in the Santa Monica Bay watershed. Review of the technical basis for development of this restoration plan shows that it was based on the finding that since urban stormwater runoff typically has elevated concentrations of certain heavy metals such as Cu, Zn, Cd, Ni, Pb, Cr, Ag, etc. and that some of these heavy metals accumulate in Santa Monica Bay sediments causing concentrations that exceed the arbitrarily established Long and Morgan ER-M values. Basically this component of the Bay restoration plan focuses on the presence of chemical constituents in urban stormwater runoff and in Santa Monica Bay sediments at elevated concentrations irrespective of whether these elevated concentrations are adverse to the designated beneficial uses of Santa Monica Bay.

The Long and Morgan ER-M cooccurance based values are widely recognized as an unreliable approach for establishing the toxicity of heavy metals and other constituents for which ER-M values have been established in aquatic sediments. The ER-M values are based on total concentrations of the constituent in the sediments. It has been known for over 25 years that there is no relationship between the total concentration of a chemical constituent in sediments and the constituent's effect on aquatic life toxicity or the availability of the constituent for bioaccumlation in the tissue of higher trophic level aquatic organisms.

The management of the Santa Monica Bay Restoration Project assumed that since heavy metals in some waste water sources were toxic to aquatic life that the heavy metals in urban stormwater runoff from streets and highways in the Santa Monica Bay watershed must be significantly toxic to aquatic life when present in the Santa Monica Bay sediments. Even though the Santa Monica Bay Restoration Project management team, the Water Resources Control Board and the US EPA Region IX was made aware of the unreliability of the approach that was used to establish the need to control certain heavy metals in stormwater runoff from the Santa Monica Bay watershed, these agencies choose to ignore the large amount of information in the aquatic chemistry and aquatic toxicology literature that shows that ER-M values should not be used as a basis for establishing regulatory programs. About all that can be said for ER-M values is that they are easy to use; they are obviously technically invalid.

The development of the Santa Monica Bay Restoration Project Restoration Plan of Action involving the expenditure of $42 million dollars for stormwater chemical constituent control by structural BMP's without first finding a real stormwater runoff quality problem associated with current stormwater runoff to the Bay is becoming recognized as an example of how sediment chemical constituent data should not be used to evaluate the potential impact of sediment associated heavy metals. Obviously before a waterbody restoration plan is developed, a real water quality - use impairment should be found by site specific studies of the geographic area of concern, i.e., Santa Monica Bay.

If the issue of concern is the potential heavy metal toxicity in aquatic sediments, then measurement of sediment toxicity should be made. If the sediments are in fact toxic, then TIE studies should be conducted to determine if this toxicity is due to chemical constituents in the stormwater runoff before a large scale expenditure of public funds is developed. Further before structural BMP's are adopted in a bay restoration plan based on control of stormwater associated chemical constituents, identification of the specific cause of the sediment toxicity should be made and attempts should be made to try to control the specific constituent(s) of concern by control at the source. Only when it is clear after careful study that it is not possible to control the impairment of the designated beneficial uses of Santa Monica Bay waters by source control, should treatment of the stormwater runoff be adopted as the approach that is developed for Restoration of the Bay. This is the technically valid and cost effective approach for development of stormwater runoff associated chemical constituents.

Part III of this paper [http://www.gfredlee.com/Runoff/stmwat_3.pdf] focuses on stormwater monitoring and modeling. Also a discussion is presented on the potential importance of aquatic plant nutrients present in urban stormwater runoff in causing water quality impairment in receiving waters. Part III also discusses some of the issues that are evolving on the classification of urban stormwater runoff associated sediments that accumulate in structural BMP's such as detention basins as hazardous wastes.

Lee, G. F. and Jones-Lee, A., "Stormwater Runoff Management: The Need for a Different Approach," Water/Engineering & Management 142(3):36-39 (1995).
http://www.gfredlee.com/Runoff/stmwat_1.pdf

Lee, G. F. and Jones-Lee, A., "Implementing Urban Stormwater Runoff Quality Management Regulations," Water/Engineering & Management 142(4):38-41 (1995).
http://www.gfredlee.com/Runoff/stmwat_2.pdf

Lee, G. F. and Jones-Lee, A., "Issues in Managing Urban Stormwater Runoff Quality," Water/Engineering Management 142(5):51-53 (1995)
http://www.gfredlee.com/Runoff/stmwat_3.pdf