Stormwater Runoff Management: The Need for a Different Approach

Lee, G. F. and Jones-Lee, A., "Stormwater Runoff Management: The Need for a Different Approach," WATER Engineering & Management. 142:36-39 (1995).

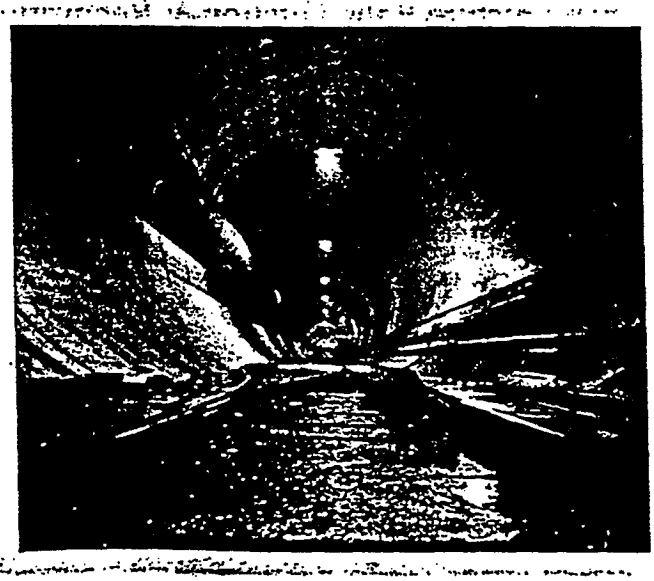
by Dr. G. Fred Lee and Dr. Anne Jones-Lee

This article is the first in a three-part series on the subject of urban stormwater runoff. Part I discusses the reasons why this category of stormwater runoff should be regulated differently than municipal and industrial wastewater.

The amended Clean Water Act, reauthorized by Congress in 1987, mandated that the U.S. Environmental Protection Agency develop a National Pollutant Discharge Elimination System (NPDES) permit program for urban stormwater runoff discharges. The initial phase of this program was to be devoted to urban areas with populations greater than 100,000. Further, industries and construction sites were required to obtain NPDES stormwater runoff discharge permits. The USEPA's current stormwater quality management program calls for stormwater-caused "pollution" to be controlled to the maximum extent practicable (MEP) through the use of best management practices (BMPs). However, this term, maximum extent practicable, has not yet been defined by Congress, the USEPA, or state or local agencies.

A wide range of views on what MEP means exists. Some people advocate that MEP means achieving water quality standards at the edge of the mixing zone for the stormwater runoff. Others maintain that good housekeeping at industrial sites and proper street sweeping and litter pick-up practices in urban areas are adequate BMPs to achieve MEP.

Over the years, based primarily on hydraulic considerations, a number of structural BMPs have been developed for allegedly controlling water pollution from urban stormwater runoff. Detention basins, grassy swales and other vegetative areas and infiltration areas are often promoted as BMPs for this runoff. However, as discussed later, a critical review of the potential effects of stormwater runoff-associated chemical constituents raises significant questions about whether a detention basin is, in fact, a treatment system for removal of pollutants in urban stormwater runoff. A number of the issues associated with developing technically-valid, cost-effective approaches to the evaluation and management of urban and industrial stormwater runoff-caused water



Like most of the older large cities in the United States, Milwaukee, Wisconsin, has many miles of sewerage which must collect stormwater along with domestic and industrial wastewater, and send the combination to treatment plants. The photograph shows a section of the 17-mile tunnel that has been constructed 300 ft below the city to act as both storage and conveyance for the massive volumes of mixed sewage and stormwater that collect after rain events. The system has been in use for almost two years and was designed to reduce by over 90 percent the number of combined sewer overflows which occur in the metropolitan region in the course of a year. It is heavily instrumented, a condition which will assist city staff in dealing with the various regulations that apply to water quality, including those intended to control the makeup of stormwater runoff from industrial, institutional and residential surface areas.

quality impairments are reviewed in this first article.

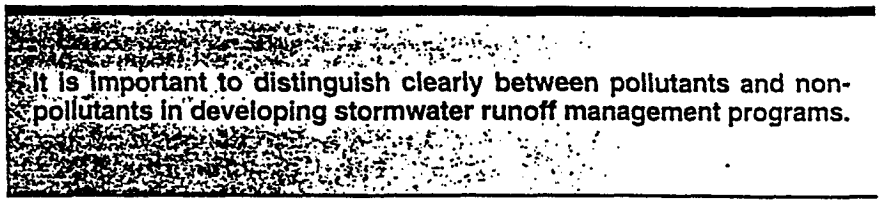
Stormwater Runoff Pollution

The USEPA's stormwater management regulations specifically delineate that urban stormwater runoff management programs control pollution of waters. Pollution is defined in these regulations as well as in the Clean Water Act and in many state regulations as the impairment of the designated beneficial uses of the waterbody receiving the stormwater runoff. In accord with the 1972 amendments to the federal regulations governing water pollution control in the US (PL 92-500), all waterbodies in the United States were to be classified with respect to their designated beneficial uses. Uses such as domestic water supplies, propagation of fish and aquatic life, recreation, agricultural and industrial water supplies, navigation, and waste heat dissipation, etc., are typically considered. The 1972 regulations established as a national goal that all waters of this country should be "fishable and swimmable." Normally, propagation of desirable fish and aquatic life and body contact recreation (wading and swimming), and of fresh water domestic supplies, require the highest quality.

PL 92-500 also established as a national goal zero pollutant discharge. This was supposed to be achieved by the mid 1980s. It is important to emphasize that this goal was not zero chemical constituent discharge, i.e., the equivalent of distilled water. Instead it focused on controlling those chemical constituents which in fact cause pollution. As discussed below, it is important to distinguish clearly between pollutants and non-pollutants in developing stormwater runoff management programs.

The 1972 federal regulations required the USEPA to develop water quality criteria which would serve as a basis for state water quality standards that when achieved will be protective of designated beneficial uses of water bodies.

Three types of constituents in urban and industrial stormwater runoff have the potential to cause water pollution, i.e., impairment of designated beneficial uses. One of these is the particulate matter present in stormwater runoff. Suspended and deposited sediments can affect water quality in ways not related to the chemical characteristics of the particulate matter, which can cause filling of the water body receiving the stormwater runoff. This, in turn, can interfere with navigation and change the characteristics of the water body. The settled particulate matter also can adversely impact fish and aquatic life through smothering of organisms and altering their habitat. Particulate can affect the optical properties of the waterbody by causing turbidity which can influence the aesthetic quality of a water body and the photosynthesis that may take place there.



The second major group of constituents of concern in urban stormwater runoff which may adversely affect designated beneficial uses is made up of pathogenic organisms, especially the enteric waterborne pathogens (bacteria, viruses or protozoans). These organisms are of concern because they can affect the quality of domestic water supplies, as well as the sanitary quality of water used for contact recreation. While typically in the past the sanitary quality of a water has focused on fecal coliforms, today increasing attention is given to the enteroviruses, especially the cyst-forming protozoans such as Cryptosporidium and Giardia. It is now well known that water meeting the coliform standard for contact recreation or domestic water supplies is not necessarily safe for consumption or contact recreation since the enteroviruses and the protozoan cysts are more difficult to control by chlorine disinfection than the coliforms.

Third on the list of concern in terms of potentially causing impaired use of receiving water bodies are the chemical constituents. Typically these receive the greatest attention in urban stormwater runoff quality management programs. Chemical constituents exist in aquatic systems in a variety of chemical forms, only some of which are toxic-available and therefore can be adverse to aquatic life and to other designated beneficial uses of a waterbody. With few exceptions, it is the dissolved forms that are toxic-available. While this has been known for over 25 years, the USEPA recently acknowledged this situation in its guidance for regulating heavy metals in ambient waters, where the Agency now recommends that the dissolved heavy metal concentration be used as an indicator rather than total heavy metals. The particulate forms such as those that may be removed in a stormwater detention basin normally are non-toxic and non-available. This same situation also applies to most other chemical constituents in stormwater runoff and other sources of chemical constituents. It is for this reason that stormwater detention basins are typically not effective in removing chemical pollutants. They, however, can be effective in removing suspended sediment. The impact of these particulates removed in a stormwater detention basin is not related to the chemical characteristics of the sediment.

Another factor to be considered in evaluating the potential water quality effects of chemical constituents in stormwater runoff is the duration of exposure that aquatic organisms can receive in the receiving waters for stormwater runoff. The shorter the duration of exposure, the greater the concentration of toxic-available forms that can be present without adversely impacting the designated beneficial uses of a waterbody. Because of the short-term, episodic nature of most stormwater runoff events, much higher concentrations of chemical

constituents can be present than the worst-case or near worst-case USEPA criteria and state water quality standards, and still protect the designated beneficial uses of the water body.

Unreliable Reporting of Water Quality Significance

Unfortunately the USEPA and state regulatory agencies responsible for conducting the National Water Quality Inventory in which urban stormwater runoff is ranked as the second most important cause of water quality impairment in the country have been providing unreliable information to Congress and the public on this issue. A critical review of how this ranking was developed shows that it was assumed that any parameter value outside a water quality standard in the receiving waters for an urban stormwater discharge represented a water quality use impairment. As discussed here, and as is well known, significant excursions beyond water quality standards of the type available today can and do occur without any impairment of the designated beneficial uses of the water bodies in which the excess occurs.

While typically in the past the sanitary quality of a water has focused on fecal coliforms, today increasing attention is given to the enteroviruses, especially the cyst-forming protozoans such as *Cryptosporidium* and *Giardia*.

Chemical Constituents vs. Pollutants

Significant problems exist today in the stormwater runoff water quality evaluation and management field due to the fact that many of the individuals working in this field do not distinguish or properly distinguish between inert chemical constituents (non-pollutants) and pollutants. For a chemical constituent in stormwater runoff to be a pollutant, it must be present in the water body receiving that runoff in sufficient concentrations of available forms for a sufficient time to be adverse to the designated beneficial uses. For aquatic life-related beneficial uses, the chemical constituent, either alone or in combination with other chemical compounds, must adversely affect the numbers, types and/or characteristics of desirable aquatic life.

Typically today, those working in the urban stormwater runoff water quality field inappropriately label as pollutants all chemical constituents in runoff that have been found to be pollutants in other situations. It is totally inappropriate to assert that a chemical constituent, such as copper present in highway or street runoff, adversely impacts the designated beneficial uses of the water body receiving this runoff because copper from a different source, such as in plating or mining wastes, is a pollutant in some other water body. This is technically invalid and can result in a massive waste of public and private funds assigned to control chemical constituents by various types of structural BMPs, e.g., stormwater detention basins, that will have little or no impact on the receiving water quality.

Beginning in the 1960s, several studies were conducted in various locations in the United States which demonstrated that urban stormwater runoff contained chemical constituents at significantly elevated concentrations compared to most ambient waters. In the late '70s and early '80s, the USEPA conducted a National Urban Runoff Program (NURP) in which studies were undertaken in several cities across the country that involved monitoring chemical constituent concentrations in stormwater runoff. It was known at the time the NURP studies were initiated (from the work done in the '60s), that chemical constituents in urban stormwater runoff typically were associated with particulate matter and were non-toxic and non-available. However, the Agency's NURP studies failed to determine the water quality effects of the elevated concentrations of chemical constituents present in the runoff samples investigated. This was a significant deficiency in the NURP studies which is still adversely influencing the cost effectiveness of stormwater runoff quality evaluation and management programs.

Based on the large amount of reliable information that has been developed, and the basic principles of aquatic chemistry, aquatic toxicology and water quality evaluation and management, it is more technically valid to assume that chemical constituents in urban stormwater runoff normally considered to be pollutants are, in fact, non-pollutants. While typical runoff from residential and commercial areas contains a wide variety of chemical constituents at concentrations above USEPA water quality criteria/state standards, it is rare that such examples result in significant impairment of the designated beneficial uses of the water bodies receiving the runoff. This situation arises from the fact that most of the chemical constituents in runoff from residential, street and highway, and commercial areas are in non-toxic, non-available forms. Further, because of the limited duration of exposure that desirable aquatic organisms can receive near points of runoff discharge, even the failure of such discharge to meet state standards for toxic-available forms in typical runoff will not result in a significant impairment.

Therefore, it is appropriate to regulate chemical constituents in urban stormwater runoff differently than the approach that has been used for municipal and industrial wastewaters. Failure to take the differences into account can result in large-scale waste of public and private funds applied to control chemicals in stormwater runoff that have little or no effect on the designated beneficial uses of the specific receiving waters.

While the focus here is on urban stormwater runoff, these same issues are equally applicable to rural and industrial stormwater runoff. To require, as is being done today, that runoff from industrial proper-

ties meet state water quality standards at the point where the runoff leaves the property represents gross over-regulation of its chemical constituents.

Taking a different approach for regulating urban, industrial and rural stormwater runoff chemical constituent control than has been used for end-of-pipe municipal and industrial wastewater discharges does not mean these discharges also are not in some instances being over-regulated today. The 1972 Amendments to the Water Pollution Control Act initially required that municipal and industrial dischargers achieve fixed degrees of treatment irrespective of the need to protect the designated beneficial uses of the receiving waters for the discharges, i.e., effluent standards. These discharges now are required to achieve water quality standards at the edge of a mixing zone in the receiving waters. The standards being applied to these discharges are designed to protect the designated beneficial uses under worst-case or near worst-case conditions. This means normally that municipal and industrial wastewaters treated to achieve water quality standards at the edge of a mixing zone in most instances receive more treatment than is necessary to protect designated beneficial uses, since the worst-case conditions the standards are designed to protect rarely occur in US waters.

Therefore, it is not that there is need to regulate urban industrial and rural stormwater runoff chemical constituents differently than the same constituents in municipal and industrial wastewater discharges. It is that in developing approaches for regulating urban stormwater runoff chemical constituents, the USEPA should not make the same mistake that it made in developing regulations for the classical point source discharges of municipal and industrial wastewaters.

Some regulatory agencies and environmental groups are attempting to define the MEP term to mean achieving state water quality standards at the edge of the mixing zone where the stormwater discharge enters the receiving water. While they acknowledge it is not possible to accomplish this today, they are attempting to develop regulations which establish these standards as goals defining MEP, and by which BMPs are to be evaluated. Such approaches are technically invalid and will grossly over-regulate stormwater runoff-associated chemical constituents.

Rather than trying to achieve inappropriately developed water quality standards for stormwater runoff discharge situations, the approach that should be followed is to first define on a site-specific basis what, if any, real water quality use impairment is occurring for a particular discharge. Where specific use impairments have been defined, then efforts should be made to determine their specific cause, i.e., the specific chemical constituents and forms that cause use impairment. When defined, efforts should be made to control these substances at the source. Only in situations where it is not possible to control at the source should structural BMPs be developed to treat the stormwater runoff for control purposes.

There is little doubt that the structural BMPs eventually needed to control real water quality problems associated with urban, street and highway, industrial, and rural stormwater runoff will be significantly different than the BMPs of the type being fostered today as appropriate for stormwater runoff pollution control.

The evaluation of the effectiveness of the BMPs in achieving MEP should be based on how well the BMP addresses/controls the water quality use impairment and not, as is typically done today, be based on the percent removal of a total chemical constituent across a structural BMP. Such an approach fails to recognize the aquatic chemistry and aquatic toxicology of chemical constituents in stormwater runoff as they may affect water quality. ■

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The second and third parts of this series will discuss approaches developed by California's Stormwater Quality Task Force for implementing urban stormwater runoff water quality evaluation and control.

For more information and a list of references on this subject, circle 901 on the reader service card.

Implementing Urban Stormwater Runoff Quality Management Regulations

Lee, G. F. and Jones-Lee, A., "Implementing Urban Stormwater Runoff Quality Management Regulations, "WATER Engineering & Management 142:38-41 (1995).

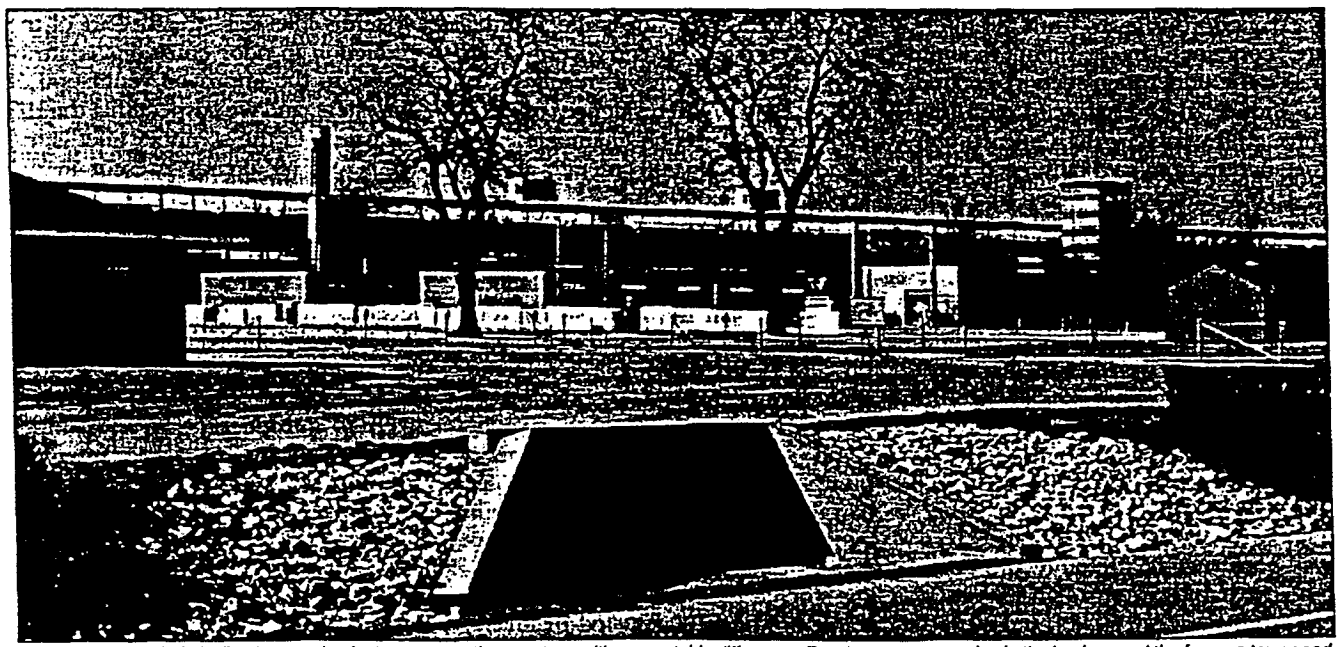
by Dr. G. Fred Lee and Dr. Anne Jones-Lee

This is the second in a series of three articles on urban stormwater runoff. In the March issue of WEM, Part I discussed the 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 wastewater discharges. The second part focuses on some evolving concepts that recognize the need for different regulatory thinking. Also, attention is given to the regulation of chemical constituents in sediments associated with stormwater runoff.

The state of California is recognized as being among the leaders in the United States 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 (SWRCB) working with a number of stormwater quality management entities to develop a cooperative approach toward stormwater quality evaluation and management—an action promoted through the state's Stormwater Quality Task Force.

This task force consists of members of the SWRCB along with region... 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 California Highway Department, and various county highway departments and others interested in the urban stormwater issue. Participation in task force activities is open to anyone who is interested. The task force is organized through the California chapters of the American Public Works Association.

The group assisted the SWRCB in developing early NPDES permits for



This stormwater drain is like thousands of others across the country—with one notable difference. Readers may recognize in the background the famous tower and the stands along the finishing straightaway at the Indianapolis Speedway. Stormwater that enters this drain for most of the year probably is rather innocuous. But when the race cars are there during the spring, throngs of people and their vehicles visit the site for the events leading up to the big race, the race itself, and its aftermath. The runoff generated by a rainstorm in that period could contain significant concentrations of petroleum and other potentially harmful products.

urban stormwater dischargers with populations above 100,000, developed a best management practices guidance manual, which was active in formulating a consensus approach for reauthorization of the urban stormwater runoff quality management sections of the Clean Water Act, and assisted in the development of state regulations and implementation guidance for urban and industrial runoff monitoring and management practices. Through the leadership of the task force, California is recognized as being one to two years ahead of many other states in implementing the necessary programs. The cooperative consensus approach developed in California is becoming a pattern for similar programs in other states.

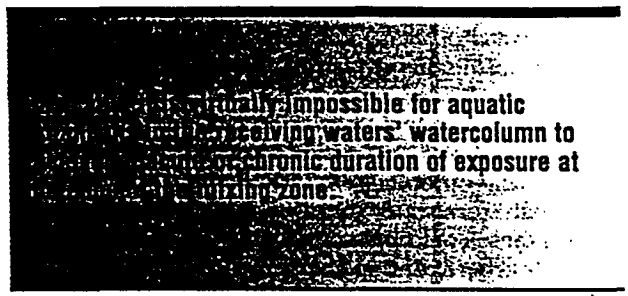
A review of the associated technical issues led the task force to conclude quite early in its deliberations that urban stormwater runoff effects must be evaluated and managed in a different way than has been employed for other point source discharges, such as municipal and industrial effluents. Initially, this was motivated by the finding that conventional treatment methods used for municipal and industrial wastewater discharges could not be applied to urban stormwater runoff because of the very high costs of treatment to achieve current water quality standards at the edge of the mixing zone in the receiving waters.

Technically Valid Approaches

Coincident with gaining an understanding of the very high costs associated with trying to follow the conventional wastewater management practices used to comply with ambient water quality standards, the task force members came to the realization that attempting to manage chemical constituents in urban stormwater runoff similarly would result in massive over-regulation of the chemical constituents in the runoff. This in turn would result in large-scale waste of public and private funds for treating this runoff to meet the quality standards. It has been known since the mid-1960s that many of the chemical constituents in urban stormwater runoff, as well as in the runoff from rural areas, were present in non-toxic, non-available forms. Therefore, as discussed in the first article in this series, excursions outside 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 out-of-limit quality situation 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 standards 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 runoff. This is because the exposure time of aquatic organisms in the receiving waters for the stormwater runoff is considerably shorter than the period which the water quality standards were designed to address. While the USEPA's water quality criteria have, since the mid-1980s, utilized a one-hour maximum and four-day average concentration for implementing requirements to control acute and chronic toxicity to aquatic life, it is well known that for essentially all chemical constituents these periods are grossly exaggerated in terms of protecting the designated beneficial uses of waterbodies from aquatic organisms of potential concern at the edge of a point or non-point source discharge mixing zone.

Basically, it is virtually impossible for aquatic organisms in the receiving waters' watercolumn to receive an acute or chronic duration of exposure at the edge of the mixing zone. The USEPA recently acknowledged this problem and is changing the exposure period against which the water quality criteria, and the state standards based on them, are implemented. The agency also is in the process of changing the allowed frequency of violations. 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 definitic is well known to be extremely over-protective since substantial violations of many water quality standards can occur on a routine basis without significantly adversely affecting the designated beneficial use of the waterbodies.



Technically Valid Water Quality Standards for Stormwater Runoff

The California Stormwater Quality Task Force has adopted the position that urban stormwater runoff discharge requirements should not be based on meeting current wa quality standards at the edge of a mixing zone. The task force, in connection with its work on reauthorization of the Clean Water Act, joined with other groups in calling for the USEPA 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 proposed revisions of the Clean Water Act's stormwater quality management section, a consensus among various interested agencies and entities called for a ten-year moratorium in the application of water quality standards to urban stormwater runoff.

During the moratorium, the USEPA would be provided with $10 million per year, for a total of $100 million, to conduct research which would lead to development of an appropriate stormwater quality criteria, an an approach that could be used by the states to implement these criteria in the NPDES pe system governing stormw runoff. These criteria 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 would need to be consistent with wet weather standards, such that 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 period. This technically valid approach should be followed in developing regulatory approaches for controlling real water quality problems associated with urban stormwater runoff.

Also, these 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 over-the-limit excursions do not cause significant impairment of the designated beneficial uses of the waterbody. This is a technically appropriate approach that should be followed in developing regulatory means for controlling real water quality problems associated with urban runoff.

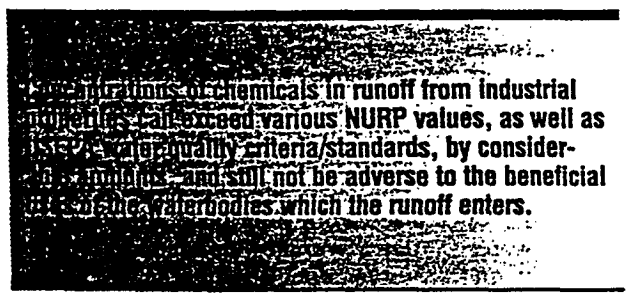
Industrial Stormwater Runoff

While there is widespread agreement that the current ambient water quality standards should not be applied to urban stormwater runoff, the USEPA and the states are applying these standards to industrial stormwater runoff at the edge of the property. This is not technically appropriate and results in over-regulation of the associated chemicals contained in the runoff. Similarly, significant over-regulation of stormwater discharges for industrial sites covered by the USEPA's multi-sector permit is occurring. The Agency's proposed idea of using benchmark values based on water quality criteria and its National Urban Runoff Program (NURP) studies also is technically invalid, and will result in significant over-regulation of many industrial stormwater discharges, and wasted funds devoted to inappropriate monitoring activities.

Concentrations of chemicals in runoff from industrial properties can exceed various NURP values, as well as USEPA water quality criteria/standards, by considerable amounts, and still not be adverse to the beneficial uses of the waterbodies 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 receiving waterbodies without wasting funds on ineffective or inappropriate control programs.

Water Quality Significance of Chemical Compounds in Sediments

Referring again to the previous article in this series (April *WEM*), we 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 to the particle surfaces. Chemical compounds associated with particulates are typically non-toxic and non-available and, therefore, should not be regulated in terms of the receiving waters' quality standards. These standards are applicable to the water column. They do not consider the potential effects of contained chemical constituents on suspended sediments in stormwater runoff that become part of the deposited (bedded) sediments.



It is well known that while most chemicals in sediments are detoxified, i.e. non-toxic, non-available, there are situations where the detoxification capacity of the sediment 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 a desire to regulate in terms of the chemicals associated with deposited sediments through water quality criteria and standards, such an approach is not appropriate and fails to recognize the aquatic chemistry and toxicology of sediment-associated contaminants.

Two principal water quality concerns are associated with chemicals in sediments. One is the potential for toxicity effects on benthic and epibenthic organisms within or upon the sediments. The second is the potential for some sediment-borne chemicals 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, PCBs 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-1970s the USEPA and the US Army Corps of Engineers have been regulating contaminated sediments associated with navigational dredging of US waterways. Based on the results of the Corps' Dredged Materials Research Program in the 1970s, where it was found that concentrations of chemicals in sediments were not reliable indicators of water quality, the Agency and the Corps developed biological effects-based contaminated sediment evaluation criteria. Rather than trying to estimate sediment toxicity based on chemical characteristics (an unreliable method), direct measurements with toxicity tests are used.

Assessing the potential for bioaccumulation of sediment-bound chemical compounds in higher trophic level organisms requires measurement of actual accumulations that occur in the tissues of

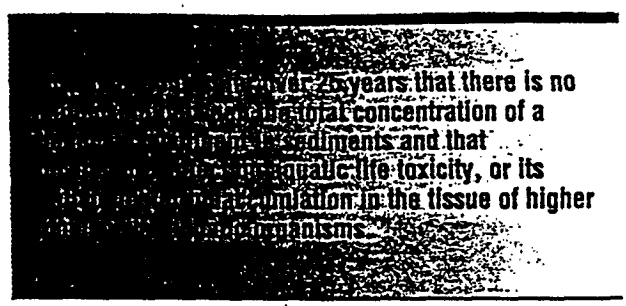
desirable organisms in the waterbody of concern. There is no reliable approach available today to predict, based on sediment concentrations, whether a particular constituent, such as mercury, will bioaccumulate in aquatic organisms that may be a source of food for man to a sufficient degree to be potentially harmful if consumed.

To determine if there is a need to control the chemical constituents of runoff sediments, it is necessary to conduct site-specific investigations of how the bedded sediment contaminants are affecting the designated beneficial uses of the associated waterbody. There is no reliable way at this time, and none is foreseen in the near future, to predict, based on concentrations of sediment-associated constituents in stormwater runoff, the potential effects these compounds would have on the receiving water's quality when the suspended sediment of concern becomes part of the bedded sediments.

Santa Monica Bay Restoration Project

Recently, the Santa Monica Bay, California, 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 best management practices (BMPs) for the control of selected chemical constituents. Examples are 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 heavy metals (e.g. copper, zinc, cadmium, nickel, lead, chromium, silver), and that some of these accumulate in Santa Monica Bay sediments to concentrations that exceed the arbitrarily established Long and Morgan ER-M values. This component of the Bay restoration plan focuses on the presence of chemicals in the area's stormwater runoff and in Bay sediments at elevated concentrations, irrespective of whether these concentrations are adverse to the designated beneficial uses.

The Long and Morgan ER-M co-occurence-based values are considered by many to be unreliable indicators for establishing the toxicity of heavy metals and other constituents of aquatic sediments. The ER-M values are based on total concentrations. It has been known for over 25 years that there is no relationship between the total concentration of a chemical constituent in sediments and that constituent's effect on aquatic life toxicity, or its availability for bioaccumulation in the tissue of higher trophic level aquatic organisms.



Managers of the Santa Monica Bay Restoration Project assumed that since heavy metals in some wastewater sources were toxic to aquatic life, the heavy metals in urban stormwater runoff from streets and highways in the local watershed also had to be significantly toxic to aquatic life if they were present in the Bay's sediments. Even though the project team, the Water Resources Control Board and the USEPA's Region IX staff were made aware of the unreliability of the test method used to establish the need to control certain heavy metals, 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. The ER-M values are easy to use, but they are not technically appropriate for this situation.

The development of the expensive Santa Monica Bay Restoration Project's Plan of Action to establish chemical contaminant control using structural BMPs without first finding a real stormwater runoff quality problem is becoming recognized as an example of how sediment data should not be used to evaluate the potential effect of contained heavy metals. Obviously before a waterbody restoration plan is developed, a real water quality/use impairment should be determined by site-specific studies, in this case of the Santa Monica Bay area.

If the issue of concern is heavy metal toxicity in aquatic sediments, then measurements of toxicity should be made. If the sediments are in fact toxic, then TIE studies should be conducted to determine if the source is chemical contamination in the stormwater runoff before any large expenditure of public funds is committed. Further, before structural BMPs are adopted in a Bay restoration plan based on contamination control, identification of specific causes of sediment toxicity should be accomplish
Subsequently, source control of t
offending constituents should be implemented. If it is then established that source control is not sufficient to avoid impairment of the designated beneficial uses of Santa Monica Bay waters, treatment of the stormwater runoff can be adopted as an appropriate method for restoring the Bay. ■

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For more information on this subject, circle 874 on the reader service card.

To conclude the series on urban stormwater runoff management, a third article will be published in the May issue of WEM. *It will focus on stormwater monitoring and modeling, the importance of aquatic plant nutrients that cause w quality impairment in receiving waters, and on sediments that accumulate as hazardous wastes in, for instance, detention basins.*

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Issues in Managing Urban Stormwater Runoff Quality

by Dr. G. Fred Lee and Dr. Anne Jones-Lee

The third and final article in a series addressing urban stormwater runoff deals with such issues as monitoring and modeling, highway runoff, classification of stormwater sediments as hazardous wastes, and the significance of aquatic plant nutrients and aquatic life toxicity testing. The first two articles, which appeared in the March and April issues of WEM, *discussed a number of the technical issues to be be considered in developing a stormwater runoff water quality management program.*

Aquatic Plant Nutrients

The aquatic plant nutrients, nitrogen (N) and phosphorus (P) compounds, are of potential concern in urban stormwater runoff due to their ability to stimulate excessive growth of aquatic plants in receiving waters. The eutrophication (fertilization) of a waterbody can be significantly detrimental to water quality-related beneficial uses. It was found in the 1970s that urban stormwater runoff contains about 100 times the total concentrations of phosphorus that are typically derived from stormwater runoff from forested areas, and about 10 times the amounts contributed from many agricultural areas. It was also found then that substantial portions of the nitrogen and phosphorus components are in particulate forms that are not available to support aquatic plant growth.

As with most other chemical constituents in urban stormwater runoff, the total concentrations of a constituent, such as nitrogen or phosphorus, is an unreliable indicator of potential water quality problems. Sufficient work has been done, however, on the available forms of phosphorus found in this runoff to be able to estimate the quantities of algal-available P in a runoff water. Normally, this is equal to the soluble orthophosphate plus about 20 percent of the particulate phosphorus.

Some groups are calling for a ban on the use of lawn fertilizers in urban areas in an effort to try to reduce the phosphorus content of urban stormwater runoff. As in the case of other chemical constituents in such runoff, site-specific studies have to be conducted to determine whether controlling the phosphorus to a certain extent will have a significant effect on the water quality-related beneficial uses of the receiving water. It has been found that to change the degree of eutrophication of a waterbody to a perceptible amount, it is necessary to reduce the quantity of algal-available P entering the waterbody by about 25 percent. It is unlikely that curtailing the use of lawn fertilizers will have a significant impact on most waterbodies since such fertilizers represent a small part of the total phosphorus load in urban runoff. Further, except for some urban lakes which essentially receive only this type of runoff, it will be unlikely that reducing the amounts of nitrogen and phosphorus will significantly improve the eutrophication-related quality of waterbodies.

Stormwater Runoff Monitoring

Primary emphasis in stormwater runoff quality management programs today is being given to monitoring for selected parameters. A critical review of the typical program, however, shows that the extent and degree of monitoring being done provides essentially no useful information on the potential effects of the associated chemical constituents on receiving water quality. Grabbing a few samples of runoff from a few storms over a year and analyzing them for a few indicator parameters does not properly characterize the concentrations of total chemical constituents of potential concern, much less the concentrations of toxic-available chemical constituents that could be adverse to the designated beneficial uses of the receiving waters.

About all that can be said for the current urban stormwater runoff quality monitoring program is that it confirms what is already known. Based on total constituent analysis, there are chemicals in runoff from urban areas at concentrations that exceed the USEPA's water quality criteria, and state standards based on these. However, as discussed in Part I, exceeding a state water quality standard for a contained chemical in a runoff does not mean that a designated beneficial use impairment will occur in the receiving waters. To make that assessment, it is necessary to conduct site-specific evaluations of the effect of runoff-associated constituents on the beneficial uses.

The California Stormwater Quality Task Force has been working toward modifying the monitoring program requirements so that a number of stormwater management agencies could pool their monitoring resources to develop a fund that could be used to conduct site-specific evaluations. Rather than collecting additional stormwater quality data on the concentrations of selected chemicals, it is more technically appropriate and cost-effective to use

the monitoring funds to define whether real water quality use impairments are, in fact, occurring in receiving waters.

Highway Runoff Effects

Several years ago, the Federal Highway Administration (FHA) sponsored a number of studies devoted to evaluating the water quality significance of chemical constituents in highway runoff. It has been known since the 1960s that runoff from urban streets and highways contains high concentrations of chemicals that, if in toxic-available forms, could have significant adverse effects on beneficial uses of receiving waterbodies. However, the work done in the 1960s showed that many of the chemicals from streets and highways were in non-toxic, non-available forms. This meant it was not possible to relate the analytically-measured concentrations of these compounds to water quality.

Unfortunately, those responsible for conducting the mid-1980s studies for the FHA did not properly evaluate whether the elevated concentrations of chemicals in highway runoff were in forms that could adversely affect the receiving water quality. The authors of these studies labeled all constituents as pollutants, without finding a case of water pollution (use impairment) in their studies.

The inappropriate labeling of these materials as pollutants is contributing to significant problems for federal and state highway departments. Environmental groups are filing suit against them to have the courts force them to control "pollution" from highway runoff arising from the elevated concentrations of alleged "pollutants." Experience shows it would be rare where highway and street runoff-associated chemicals would have any significant adverse impact on designated beneficial uses. The fact that heavy metals and other runoff chemicals are in non-toxic forms, coupled with the short-term episodic nature of runoff events, suggests it is rare that these compounds are real pollutants that should be controlled using best management practices (BMPs).

Highway litter, however, can cause significant impairment if it finds its way into receiving waterbodies. This litter also can contribute to flooding by blocking stormwater inlet structures. At this time emphasis in implementing BMPs for highways should be based on litter control and the control of erosion associated with new highway construction. There is no technical justification to assume that constructing detention basins, grassy swales, etc., for "treatment" of highway runoff is in fact controlling pollutants that are significantly detrimental to beneficial uses. Before any structural BMPs are constructed to treat runoff, site-specific investigations should be conducted that demonstrate that there is a real water quality use-impairment associated with the current runoff. Where such problems are found, then efforts should be made to try to control them through controlling the specific causes of the use impairment. It is unlikely that conventional structural BMPs will be effective in addressing these types of situations.

Stormwater Quality Modeling

A substantial literature has accumulated on the subject of stormwater quality modeling. Sophisticated computer models have been developed which are said to provide information pertinent to urban stormwater quality impact evaluation and management. However, a critical review of these models shows they are simply chemical constituent models that can describe to some extent the total concentrations of selected chemical constituents at some location in the stormwater runoff system. To be able to relate the concentrations predicted based on such models, it is necessary to conduct site-specific evaluations of the relationships between the total concentrations of the constituents of potential concern and the toxic-available forms in stormwater runoff from a particular area.

Further, there is need to relate the concentration of toxic-available forms in stormwater runoff to site-specific use impairments in the receiving waters. The current models do not provide this type of information. To be true stormwater quality models, they must incorporate basic information from aquatic chemistry and aquatic toxicology as they relate to the true water quality effects of stormwater-derived chemical constituents. It could be many years before such models will be available that can reliably assess stormwater quality effects.

Some have asserted that equilibrium-based water chemistry models such as the USEPA's MINTEQ model can be used to predict the concentrations of toxic-available forms of chemical constituents in urban stormwater runoff. Such assertions are technically invalid since many of the particulate forms of chemicals found in urban runoff have unknown chemical characteristics and for which there are no thermodynamic equilibrium data. At this time, the only reliable approach for assessing whether a particular runoff water will be toxic to aquatic life is through the direct measurement of toxicity. This cannot be accomplished with chemical measurements.

Because of the variable concentrations of chemical constituents in urban stormwater runoff, various investigators have attempted to characterize the concentrations found in a runoff event through the use of what is called an event mean concentration. While such an approach makes modeling of an event for total constituents easier to achieve, it fails to properly address how chemical constituents in urban, highway and other stormwater runoff sources influence aquatic life-related beneficial uses of waterbodies. It has been known since the 1960s that aquatic organisms respond to the concentration of available form/duration of exposure relationship that they experience. The event mean concentration for a stormwater runoff event is not a reliable approach for assessing the potential effects of chemical constituents on aquatic life, and should be abandoned.

Runoff Toxicity

Since it is not possible to reliably predict, using chemical measurements, whether a chemical constituent in stormwater runoff is toxic to aquatic life in receiving waters, the use of aquatic life toxicity tests is beginning to be more widely practiced. These tests can be used to determine whether the regulated as well as the unregulated chemicals in runoff present a potentially significant threat to aquatic life due to toxicity. Caution, however, must be exercised in the interpretation of results. The toxicity tests typically used significantly overestimate the

actual toxicity since their duration provides longer exposure to aquatic organisms than they normally are exposed to in receiving waters. Ordinarily, the runoff is rapidly diluted, with an associated loss of toxicity. The aquatic life toxicity tests of the type available today should only be used as a screen for potential toxicity. They should not be used as a direct regulatory limit. If toxicity is found, then site specific investigations should be conducted to confirm the information.

Stormwater Runoff Sediments as Hazardous Waste

Increasing concern is evolving about the potential for stormwater runoff sediments that accumulate in detention basins, highway drop inlets, grassy swales, etc., being classified as a hazardous waste because of excessive concentrations of chemical constituents. Classification of a stormwater detention basin sediment as a hazardous waste can represent a significant increase in the cost of managing the sediments. Often managing a hazardous waste costs about 10 to 50 times more than using them as fill or placing them in municipal solid waste landfills. The USEPA, as part of implementing RCRA, has developed various procedures for classifying materials such as soils and sediments as hazardous waste. While there is potential concern about stormwater sediments from certain types of industrial properties being classified as a hazardous waste based on the origin of the sediment (the Derived-From Rule), the greatest concern for urban stormwater sediments collected in structural BMPs is the leaching characteristics under the Toxicity Characteristics Leaching Procedure (TCLP) test.

This test was developed as an administrative test to be used to determine whether a solid waste should be placed in a hazardous waste landfill or in a municipal landfill. The Agency was not trying to reliably delineate whether a material in a sediment or soil is hazardous. Rather, it was trying to limit the size of the hazardous waste stream that had to be managed as hazardous waste where the focus of the resources available would be on those wastes that represent the greatest hazard. Unfortunately, this test is being used for a variety of other purposes for which it is inappropriate and was not intended. A sediment or soil that passes the TCLP test can be hazardous to public health and the environment depending on how it is managed.

Another common mistake made in using the TCLP test is to assume that a material classified as hazardous according to TCLP also would be hazardous to aquatic life. TCLP classification is based on the leaching of selected chemicals from solid material under certain conditions which mimic to some extent the environment present in a municipal solid waste landfill, where the concern is that the leached constituents would become part of a groundwater-based domestic water supply. This approach has no relationship to whether the material is hazardous to aquatic or terrestrial life. The TCLP test focuses primarily on the potential for chemical constituents to cause cancer in people who are exposed over their lifetime through drinking water. These constituents are primarily Priority Pollutants. The critical concentrations for many of these regulated through the TCLP test have no relationship to the critical concentrations for the same constituents to aquatic life. In some cases aquatic life is more sensitive, and in others less sensitive than the TCLP values.

Detention basin sediments classified as hazardous waste is an even more complicated issue in some states. California has developed its own set of hazardous waste classification values. It uses a somewhat different leaching test and also has a set of total concentrations of chemical constituents in sediments or soil which define the sediment or soil as hazardous. A detention basin sediment that passes the TCLP test may fail California's Title 22 hazardous waste classification and would have to be managed as a hazardous waste. However, independent of the arbitrariness of these classification values, they are regulatory requirements that must be considered in the management of stormwater detention basin sediments.

Lead is of great concern if it is contained in detention basin sediments. Urban soils and soils near highways often contain lead at concentrations of at least 500 and frequently 1,000-1,500 mg/kg. Ordinarily, this lead, originally derived from its additive use in leaded gasoline, does not leach sufficiently in the TCLP test to exceed the USEPA's arbitrary 5 mg/l hazardous waste classification limit. It does frequently cause sediments to exceed the California Title 22 limit of 1,000 mg/kg for classification as hazardous waste.

The approach that should be used to evaluate potential public health and environmental effects of chemical compounds present in sediments which collect in stormwater treatment structures installed as BMPs is to make a site-specific evaluation of the hazards that these chemicals represent at the various locations where the sediments accumulate. Those who are concerned with stormwater runoff quality and regulations on a daily basis should work with federal and state agencies to eliminate the use of the arbitrary approaches that are in effect today for classification of stormwater-derived sediments as hazardous waste.

An Overall View

The implementation of the 1987 Clean Water Act requirement for controlling pollution of the nation's waters by urban and industrial stormwater runoff is challenged by a number of complex technical issues. They need to be resolved before their can be cost-effective management of the real water quality problems associated with stormwater runoff. Much remains to be done to develop specific approaches that can be used to control stormwater runoff-caused pollution to the maximum extent practicable. The key issue in developing an effective management program is whether current stormwater runoff quality is in fact having significant adverse effects on designated beneficial uses of receiving bodies of water. Failing to properly define th real pollution problems of stormwater runoff could result in excessive waste of public and private funds in the regulatory effort. ■

For more information on this subject as well as a list of references which provide additional discussion of these issues, circle 851 on the reader service card.

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Stormwater Runoff Quality and Related Studies Conducted by G. Fred Lee

30 years of university teaching and research with extensive research on toxic-available forms of chemical constituents in non-point source runoff

1960's

- Impact of urban stormwater runoff on Madison, WI and other WI lakes; US-Canadian Great Lakes and in Rochester, NY
- Evaluate nitrogen and phosphorus loads from urban areas and their water quality impacts
- Develop approaches for assessing available forms of chemical constituents in runoff waters
- Evaluate chemical constituent loads from atmospheric sources and the potential impacts on water quality
- Impact of wetlands on water quality
- Impact of development of recreational lakes on water quality

1970's

- Dallas, TX -- Lake Ray Hubbard watershed runoff impacts
- Western Europe and North America OECD eutrophication studies of about 200 lakes, reservoirs and several estuaries
- Developed nutrient export coefficients from various types of land use
- North Adriatic Coast of Italy -- evaluate causes of excessive fertilization of nearshore waters

1980's

- City and County of Denver, CO -- urban lakes and rivers
- Fort Collins, CO -- Spring Creek and several urban lakes
- City of Lubbock, TX -- chain of lakes, sanitary quality and chemical quality
- State of Florida -- Impact of wetlands on the Kissimmee River system downstream water quality
- NY Harbor, NJ Shore sanitary quality, urban lakes - watershed runoff on water quality
- USSR, Argentina, Dominican Republic, Jordan, Israel, Japan, South Africa -- reservoirs

1990's

- Lake Tahoe, CA -- evaluate the impact of development on water quality
- City of Hammond, IN -- impact of CSO's on sediment quality
- San Francisco Bay -- evaluate water quality significance of copper
- Santa Monica Bay -- evaluate impact of urban stormwater runoff-associated heavy metals on Bay water quality
- San Diego Bay -- evaluate impact of copper ore spill on water quality
- Rocketdyne - Canoga Park, CA -- review NPDES permit for stormwater runoff
- Participant in CA Storm Water Quality Task Force
- Developed BMP's to manage stormwater runoff from new highway in Orange County, CA.

Numerous professional papers and reports were developed on these studies. A list is available upon request. Additional information on these activities is also available upon request.