Monitoring Pollutants in Stormwater Runoff from Superfund Sites and Other Locations

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We have found that regulatory agencies often give inadequate attention to regulating pollutants in stormwater runoff from Superfund and other hazardous chemical sites, including brownfield redevelopment sites. We have developed summary reviews of our experience on deficiencies monitoring stormwater runoff from hazardous chemical sites as,

> Lee, G. F. and Jones-Lee, A., "Development of a Stormwater Runoff Water Quality Evaluation and Management Program for Hazardous Chemical Sites," (1997). [Published in condensed version as Lee, G.F. and Jones-Lee, A., "Stormwater Runoff Water Quality Evaluation and Management Program for Hazardous Chemical Sites: Development Issues," Superfund Risk Assessment in Soil Contamination Studies: Third Volume, ASTM STP 1338, American Society for Testing and Materials, pp. 84-98 (1998).] http://www.gfredlee.com/Runoff/stmhzpap.htm
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> Lee, G. F. and Jones-Lee, A., "Improving Public Health and Environmental Protection Resulting from Superfund Site Investigation/Remediation," Remediation 14(2):33-53, Spring (2004). http://www.gfredlee.com/HazChemSites/remediation-paper.pdf

As an example of significant deficiencies in stormwater runoff monitoring from hazardous chemical sites, since the mid-1990s the authors have served as Technical Assistance Grant (TAG) advisors to the public through the Davis South Campus Superfund Oversight Committee (DSCSOC–the organization that represents the public interests at the LEHR site) on the University of California Davis Department of Energy (UCD/DOE) Laboratory for Environmental Health Research (LEHR) National Priority List (NPL) Superfund site located on the University of California Davis Campus. As discussed in their reports to the DSCSOC there have been chronic problems with inadequate monitoring of the stormwater runoff from this site. These reports are available on the DSCSOC website at, http://www.gfredlee.com/DSCSOC/DSCSOC.htm. We have reviewed this situation at,

> Lee, G. F., "Comments on UCD/DOE LEHR Superfund Stormwater Runoff Water Quality Monitoring Program," Report of G. Fred Lee & Associates, El Macero, CA, March (2009). http://www.gfredlee.com/DSCSOC/2009/LEHRStormwaterMonComments.pdf

Presented herein is a review of the LEHR and other Superfund and hazardous chemical sites and other areas where inadequate stormwater runoff for potentially hazardous chemicals water quality monitoring is occurring.

Mention is made at various locations in this paper of the availability of additional discussion of a topic in one or more issues of our "Stormwater Runoff Water Quality Newsletter," identified by Number/Volume (NL) designations. These Newsletters, as well as an index to all newsletter topics and past newsletters are available on our website [www.gfredlee.com] in the "Stormwater Newsletter" section [http://www.gfredlee.com/newsindex.htm].

Constituents of Concern in Stormwater Runoff

The proper selection of the monitoring parameters is key to instituting a meaningful stormwater runoff monitoring/remediation program, especially for areas where potentially hazardous chemicals are present and can be in stormwater runoff. Traditionally, stormwater runoff monitoring at Superfund and hazardous chemical sites is limited scope; the US EPA regulates only some of the chemicals present in stormwater runoff from areas be monitored/controlled, that are hazardous and otherwise detrimental to water quality. A few classical pollutants, such as heavy metals and some of the priority pollutants, are generally selected for monitoring. These represent only a small portion of the potential pollutants that may be present at hazardous chemical sites. In general water quality monitoring programs focus on only a hundred or so of the millions of chemicals in commerce today and that can be introduced into the environment through their manufacture and use. Because of these limitations in monitored chemicals, "new" pollutants are periodically identified in the environment often in spite their having been present in waterbodies for many years; they simply have not been included in monitoring programs. (See discussion in Newsletters NL 7-3, 8-5, 9-3, 10-7, 11-7/8, 11-11, 12-6.)

Limited attention is also typically given in stormwater monitoring/remediation programs to monitoring for "toxicity" that could be caused by chemicals that are not measured; that are toxic at levels below analytical limits; that are not recognized or identified as pollutants; or that in combination with other chemicals can cause toxicity, to aquatic life in the watercolumn and/or sediments of the receiving water. Failing to adequately consider toxicity as a monitoring parameter can result in missing significant potential impacts of stormwater runoff on water quality.

An example of ramifications of these inadequacies in typical stormwater monitoring is seen in experience with organophosphorus and pyrethroid-based pesticides that are used in urban and/or agricultural areas. The widespread presence of organophosphorus and pyrethroid-based pesticides causes stormwater runoff from many areas to be toxic to some forms of aquatic life, especially zooplankton. This toxicity is a violation of the Clean Water Act requirements for the control of toxics in toxic amounts/ This issue is discussed in Stormwater Runoff Water Quality Newsletters NL 1-1, 2-1, 3-5, 3-6, 6-3, 6-4, 7-6/7, 8-1/2, 9-3, 9-4, 9-6, 9-7, 9-8, 10-3, 10-8, 10-12, 11-4, 11-7/8, and 12-4.

Another example of ramifications of the narrow selection of parameters for stormwater monitoring/remediation is the situation being faced at the LEHR Superfund site. Soil at the LEHR site contains mercury that was apparently deposited there when nearby Putah Creek flooded its banks during periods of high creek flow; the mercury in the creek was apparently derived from historic mining activities in the Putah Creek watershed and inadequate management of mine waste. Present-day runoff from the LEHR site contains sufficient amounts of that deposited mercury to cause violation of water quality standards for mercury in the stormwater runoff.

The mercury in the LEHR site runoff cannot be tied to UCD or DOE activities at LEHR. According to Region 9 staff, pollutants in stormwater that are derived from site soil rather than from past waste disposal at the site, like the mercury at the LEHR site, are not regulated under CERCLA. The US EPA Region 9 staff has determined that mercury in stormwater runoff from the LEHR site is not a CERCLA Superfund site "constituent of concern" even though its concentration in the runoff is, at times, more than 10-times the water quality criteria/standard for mercury in the Putah Creek waters receiving the runoff. That assessment was made despite the fact that Putah Creek is classified as "water quality limited" due to excessive mercury in fish in Putah Creek. It is the US EPA Region 9 staff's position that the excessive mercury in LEHR site stormwater runoff will have to be addressed under the Clean Water Act TMDL for mercury that is scheduled to be developed by the Central Valley Regional Water Quality Control Board by 2015. While CERCLA apparently only addresses pollutants at a Superfund site that are associated with past waste disposal activities by the site's Principal Responsible Parties (PRPs), the Clean Water Act requires the control of pollutants at a site independent of their origin, including run-on to the site from upstream sources. Information on the LEHR site stormwater runoff mercury issues is available at,

> Lee, G. F., and Jones-Lee, A, "LEHR Superfund Stormwater Runoff and Putah Creek Mercury Issues," Journal Remediation, 19(2):123-134, Spring (2009).
> http://www.gfredlee.com/SJR-Delta/LEHRrunoffHgRemediation.pdf
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> Lee, G. F., and Jones-Lee, A., "Summary of Slides – Putah Creek Mercury Water Quality Issues," Report of G. Fred Lee & Associates, El Macero, CA, Presented to Delta Tributaries Mercury Council, December 2, (2008). http://www.gfredlee.com/SJR-Delta/PutahHgMineSummary.pdf
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> Lee, G. F., and Jones-Lee, A., "Runoff of Mercury from UCD/DOE LEHR Superfund Site – Putah Creek Mercury Issues," PowerPoint Slides for Presentation to Delta Mercury Tributaries Council, Sacramento River Watershed Program December 2 (2008). [http://www.sacriver.org/issues/mercury/dtmc/],
> http://www.gfredlee.com/SJR-Delta/PutahHgMinesli.pdf

The mercury that is presently in stormwater runoff from the UCD/DOE LEHR Superfund site is likely from both CERCLA- and non-CERCLA-regulated areas of the site. The CERCLA-regulated areas include former waste disposal areas such as landfills and septic tanks. It is likely that in the development of these waste management areas, surface soils contaminated with mercury derived from past Putah Creek upstream mercury mine waste disposal practices contaminated the CERCLA areas subject to remediation. Therefore, mercury-contaminated soils on the LEHR site should be part of the CERCLA remediation and mercury from these areas should be identified as a constituent of concern for surface water runoff from the site.

Analytical Methods

Analytical methods prescribed for monitoring the impacts of certain stormwater runoff-associated potential pollutants on receiving water quality at the LEHR Superfund site and other hazardous chemical sites are often inadequate. One inadequacy is their insufficient sensitivity in the concentration range of importance to water quality. This is of particular concern for chemicals that can bioaccumulate in edible tissue of aquatic life in the receiving water. Chemicals in this group include mercury, PCBs, and legacy organochlorine pesticides (e.g., DDT, dieldrin, and toxaphene). Concentrations of these chemicals in water at levels that are not believed to cause unaccepted human health impact or aquatic life toxicity, can bioaccumulate in aquatic organisms to levels that render the organisms unsuitable for use as food for people and hazardous to higher trophic-level organisms especially fish-eating birds and animals. Analytical methods that may reliably detect these chemicals at higher concentrations cannot necessarily document that the concentrations are not sufficiently high to bioaccumulate to excessive levels in receiving water organisms.

This problem with analytical detection is compounded by application of inappropriate criteria/standards for these chemicals in stormwater runoff.

For many years at the LEHR site, the regulatory agencies managers (RPMs) representing the federal and state regulatory agencies allowed UCD/DOE to use mercury analytical methods that were typically about four times higher than the water quality criteria/standard for the runoff.

Even meeting the current water quality criteria for mercury such as those adopted by the US EPA in the California Toxics Rule (CTR), http://www.epa.gov/waterscience/standards/rules/ctr/index.html is not protective against excessive bioaccumulation of mercury in edible fish. The 50 ng/L CTR criteria for total recoverable mercury is about a factor of ten times the concentration of mercury that in some waters will bioaccumulate to excessive levels in some edible fish. When the US EPA adopted the CTR criterion for total recoverable mercury it recognized that this was an interim value that was to be adjusted downward with further revision of the mercury criteria. However, the US EPA has failed to conduct the followup criteria adjustment to correct the error made in establishing the CTR criteria for mercury. These issues are discussed in,

> Lee, G. F., "Regulating Mercury in the Water Column and Sediments" Report to Dredge Tailings Workgroup, by G. Fred Lee & Associates, El Macero, CA (2003).
> http://www.gfredlee.com/SurfaceWQ/TotalMercuryandDissolvedMercuryStandards-rev.pdf

The net result of this situation is that mercury detection limits for mercury in stormwater runoff monitoring programs are not adequate to protect the public and higher trophic level organism from damage to their health by consuming fish and some other forms of aquatic life that are present in waters that receive stormwater runoff from hazardous chemical sites with mercury present in the area soils that can lead to stormwater runoff from the site with concentration of mercury above about 5 ng/L. Unless the stormwater runoff monitoring program includes mercury analytical methods that can reliably detect mercury at a few ng/L (nanograms/liter) the stormwater runoff can be contributing to excessive fish tissue mercury.

For some bioaccumulatable chemicals such as PCBs the concentrations in stormwater runoff water that can bioaccumulate to excessive concentrations in receiving water organism can be less than the water analytical methods detection limits. In order to address this issue. the concentration of the hazardous chemicals in receiving water aquatic life should be measured in the organism edible tissue. Several years ago the US EPA proposed to change the regulation of some bioaccumulatable chemicals such as mercury based on excessive fish tissue concentrations rather than the water column or runoff/discharge concentrations. This is a far more reliable way to identify water quality problems of bioaccumulable chemicals in receiving waters for runoff/discharges.

An example of this situation is the California Central Valley Regional Water Quality Board monitoring program for stormwater runoff from irrigated lands in the Central Valley. As discussed in,

> Lee, G. F., and Jones-Lee, A., "Issues in Regulating Water Quality Impacts from Irrigated Agricultural Runoff and Discharges in the Central Valley of California," Report of G. Fred Lee & Associates, El Macero, CA, February 4 (2009).
> http://www.gfredlee.com/SurfaceWQ/Impacts-Ag-Runoff.pdf

This monitoring program was primarily concerned with currently and previously used pesticides in stormwater runoff with particular concern about the legacy pesticides such as DDT. As reported in,

> Lee, G. F. and Jones-Lee, A., "Organochlorine Pesticide, PCB and Dioxin/Furan Excessive Bioaccumulation Management Guidance," California Water Institute Report TP 02-06 to the California Water Resources Control Board/Central Valley Regional Water Quality Control Board, 170 pp, California State University Fresno, Fresno, CA, December (2002).
> http://www.gfredlee.com/SurfaceWQ/OClTMDLRpt12-11-02.pdf

Many of the waterbodies in the California Central Valley have fish with excessive concentrations of DDT in edible tissue. Runoff from agriculture lands in Central Valley have been found to contain DDT at concentrations that can bioaccumulate to excessive concentrations in fish. The CVRWQCB Irrigated Lands runoff water quality monitoring program only requires the measurement of the DDT concentrations in a few grab samples of runoff waters each year. Since the analytical methods detection limits for DDT is above the concentrations that can bioaccumulate to excessive levels in edible fish means that an irrigated farm land can be contributing DDT to the receiving waters which is reported as DDT as non-detect is contributing to excessive DDT in receiving water fish. In situations such as this it essential to measure the concentrations of DDT in the fish of the receiving waters.

In order to determine if the runoff waters are still contributing DDT to the receiving waters it will be necessary to expose fish to runoff water and sediments to determine if the runoff waters are still contributing DDT to the receiving waters in sufficient amounts to contribute to excessive DDT in receiving waterbody fish.

Finding DDT in water samples above the US EPA water quality criterion,

> USEPA "National Recommended Water Quality Criteria" United States Office of Water Environmental Protection Office of Science and Technology 2006 Agency (4304T) Washington DC (2005). http://www.epa.gov/waterscience/criteria/wqctable/index.html

does not mean that it is in a form that can bioaccumulate to excessive levels in fish. Water column particulate forms of DDT and many other forms of potential pollutants are not available to be taken up in the water column by aquatic life. Much of the DDT and similar chemicals such as PCBs is taken up through the benthic organism food web which can be independent of water column concentrations. Further the total organic carbon content of water column and bedded sediments influences the amount of DDT et al. that is available to be bioaccumulated in the food web.

In order to determine if the PCBs and other bioaccumulatable chemicals in aquatic sediments is bioavailable it is necessary to use biouptake studies of the type conducted by the authors,

> Lee, G. F., Jones-Lee, A., and Ogle, R. S., "Preliminary Assessment of the Bioaccumulation of PCBs and Organochlorine Pesticides in *Lumbriculus variegatus* from City of Stockton Smith Canal Sediments, and Toxicity of City of Stockton Smith Canal Sediments to *Hyalella azteca*," Report to the DeltaKeeper and the Central Valley Regional Water Quality Control Board, G. Fred Lee & Associates, El Macero, CA, July (2002). http://www.gfredlee.com/HazChemSites/SmithCanalReport.pdf

Traditionally the regulated allowed concentrations of hazardous chemicals in edible fish and other aquatic life is based on a risk based assessment of the potential for the chemical to cause adverse impacts to humans who use the organisms as food. Recently the California Office of

Health Hazard Assessment (OEHHA) has changed its approach for establishing recommended safe consumption guidelines to consider not only the hazard of the chemical in fish but also the benefits of eating fish. This approach is discussed in, http://oehha.ca.gov/fish/general/99fish.html.

This "balancing" of adverse vs beneficial impact of eating fish with that is hazardous to humans in establishing allowed consumption rates is impacting the decisions on the need to regulate some bioaccumulatable chemicals such as DDT. The OHEHHA fish consumption guidelines did not impact the allowed PCB concentrations in edible fish.

A major problem exists in regulating the human health hazards of some chemicals such as arsenic, lead, and chromium. The US EPA water quality criteria for these chemicals is typically much lower than the US EPA drinking water maximum contaminate levels (MCL). Typically regulatory agencies regulate stormwater runoff with respect to protecting drinking water quality based on MCLs rather than the human health risk based criterion. The difference between two approaches for regulating hazardous chemicals in drinking water is that the US EPA in establishing drinking water MCLs considers not only the human health impacts but also the cost to remove the pollutant during drinking water treatment. This makes drinking the water with concentrations of some carcinogens such as arsenic and chromium at or even somewhat below the MCL a human health hazard.

Arsenic is a chemical where the drinking water MCL is much above the human health risk of arsenic in drinking water. While the US EPA MCL for arsenic is established at 10 µg/L yet the US EPA (2005) human health risk concentration is 0.018 µg/L for a risk based criteria for cancer risk of one cancer in one million people consuming 2 liters of water per day over lifetime (70 years). The 10 µg/L MCL represents a significant increase in acquiring cancer from drinking water with this level of arsenic.

The California Office of Environmental Hazard Assessment (OEHHA) has the responsibility of establishing the critical concentration of chemicals in drinking water. Recently OEHHA has reviewed the human health hazards of consuming chromium in drinking water. Chromium is another chemical where there is a significant difference between the drinking water MCL and the OEHHA recently proposed Public Health Goal (PHG) for hexavalent (VI) chromium in drinking water. The US EPA total chromium MCL is 100 µg/L. OEHHA has proposed to establish a PHG for hexavalent chromium of 0.06 µg/L based on its potential to cause cancer in those who drink water with this level of chromium VI.
http://oehha.ca.gov/public_info/facts/chrom6facts.html.
Regulating chromium in stormwater runoff to the US EPA drinking water MCL could increase the cancer risk for those who use the receiving waters as a source of drinking water.

We have been involved in reviewing the critical concentrations of PCBs in soils and wastes that can be considered safe in accord with some regulatory limits. In connection with the review of the US Gypsum/Port of Stockton, California draft environmental impact statement we submitted,

> Lee, G. F., and Jones-Lee, A., "Comments on 'US Gypsum Draft Environmental Impact Statement for the Development of the US Gypsum Proposed Wallboard Plant to be Located on Port of Stockton West Complex,'" Comments submitted to Lozeau/Drury, Alameda, CA by G. Fred Lee & Associates, El Macero, CA, December 15, (2008). http://www.gfredlee.com/HazChemSites/USGypsumDEIR.pdf

As discussed in this report,

> *"With respect to protecting aquatic life and human health from excessive bioaccumulation of PCBs in fish the USEPA (2005) has adopted Polychlorinated Biphenyls PCBs water quality criteria to protect aquatic life from PCB toxicity of 0.014 µg/L and 0.000064 µg/L to prevent excessive bioaccumulation of PCBs in fish that would cause the fish to be hazardous to consume for food."*

The lack of understanding of the extremely low concentrations of PCBs and some other hazardous bioaccumulatable chemicals is common place such as in the remediation of Sydney Nova Scotia Tar Ponds contaminated estuarine sediments. These sediments have high concentrations of PCBs and other hazardous chemicals. The inadequate approach that has been adopted by the Sydney Tar Pond Agency for remediation of these sediments is discussed in,

> Lee, G. F. and Jones-Lee, A., "Progress toward Remediation of the Sydney Tar Ponds: A Major Canadian PCB/PAH 'Superfund' Site," Journal Remediation 17(1):111-119 (2006). http://www.gfredlee.com/Landfills/STP-Remediation-pap.pdf

Concentrations of PCBs in stormwater runoff that result in PCB concentrations above the US EPA water quality criteria concentration in the receiving waters near the point of discharge can bioaccumulate to excessive levels in fish.

Dioxins and furans are group of chemicals that are potent carcinogens that are rarely monitored in stormwater runoff from areas where they can be present such as from certain types of industrial facilities and areas where combustion residues are present. The US EPA Recommended National Water Quality Criteria of 2005 at,
http://www.epa.gov/waterscience/criteria/wqctable/index.html lists the water quality criteria for 2,3,7,8 TCDD (dioxin) as 5×10^{-9} µg/L to prevent bioaccumulation of dioxins in edible aquatic organisms. Fish taken from areas that are likely sources of dioxins should be monitored for dioxins. The US EPA has established a drinking water MCL for dioxin of 3×10^{-5} µg/L. Again there is a major difference between the US EPA drinking water MCL for dioxin and the US EPA risk based water quality criterion for dioxin that can bioaccumulate to excessive levels with a 10,000 fold difference.

A common error that is made in reviewing the concentration of potential pollutants in soils and solid wastes is to assume that if the concentration of the pollutant in the TCLP is less than the regulatory limit for this test that the pollutant will not be hazardous in the environment. We have discussed this situation in.

> Lee, G.F., and Jones-Lee, A., "TCLP Not Reliable for Evaluation of Potential Public Health and Environmental Hazards of PCBs or Other Chemicals in Wastes: Unreliability of Cement-Based Solidification/Stabilization of Wastes," Report of G. Fred Lee & Associates, El Macero, CA, September (2009). http://www.gfredlee.com/Landfills/TCLP_Solidification.pdf

The authors have also experienced inadequate stormwater runoff monitoring at the Lava Cap NPL Superfund site (a former gold mine) located near Nevada City, California. As TAG advisors to the public for this site we developed a series of reports on the inadequacy of site investigation/remediation as being conducted by the US EPA which is the lead agency for this site. These reports are located at http://www.gfredlee.com/phazchem2.htm#lava and include, Lee, G.F., and Jones-Lee, A., "Occurrence of Public Health and Environmental Hazards and Potential Remediation of Arsenic-Containing Soils, Sediments, Surface Water and Groundwater at the Lava Cap Mine NPL Superfund Site in Nevada County, California," Proc. Fifth International Conference on Arsenic Exposure and Health Effects, San Diego, CA, July 2002, Society for Environmental Geochemistry and Health, Elsevier Science, Inc., pp. 79-91 (2003). http://www.gfredlee.com/HazChemSites/arsenic_07-2002.pdf

A significant problem with the US EPA conducted monitoring of stormwater runoff from the Lava Cap NPL site is that the Agency did not require that total flow of the runoff event be measured. This resulted in an inability to assess the total arsenic loads in a runoff event thereby prevent an assessment of the effectiveness of stormwater runoff control measures.

We have also been involved in investigating the adequacy of stormwater runoff monitoring from existing and proposed municipal and hazardous waste landfill sites. The reports on our studies of landfills impacts are located at, http://www.gfredlee.com/plandfil2.htm#examples. A summary review of these issues is available as,

Lee, G. F., and Jones-Lee, A., "Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste," Report of G. Fred Lee & Associates, El Macero, CA, December (2004). Updated September (2009). http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf

As discussed in these site reports and in the summary report, regulatory agencies typically fail to require the landfill owners to adequately monitor stormwater runoff for releases during the active life (during waste receipt) and after closure during the postclosure period. One of the most significant deficiencies in the US EPA Subtitle D landfill regulations is failure to assure that postclosure funds will be available to monitoring stormwater runoff after the 30 years required postclosure funding period. This is another example of the inadequate regulation of hazardous chemicals and other chemicals in stormwater runoff from landfills.

Inadequate Monitoring Program

Another of the major problems in stormwater runoff water quality monitoring at Superfund and other hazardous chemical sites include inadequate frequency and duration of monitoring with no first flush monitoring. At several Superfund and hazardous chemical sites the monitoring frequency, duration etc allowed by the regulatory agencies is patterned after the typical stormwater monitoring program allowed for large urban municipalities (MS4) including only collecting a grab sample of runoff at some arbitrary time during the runoff event for two runoff events per year. This monitoring program is typically design to do some limited monitoring while keeping the cost of this monitoring low. This monitoring program is grossly inadequate to determine whether hazardous chemicals are present in stormwater runoff that can be adversely impacting receiving water water quality.

Another significant problem with the stormwater runoff water quality monitoring program at the LEHR Superfund site is that UCD has been allowed to only collect a single grab sample at some time during a couple of storms per year. Since the concentration of pollutants can vary greatly during a runoff event the results of this sampling program can be misleading with respect to the maximum concentration of a pollutant in a runoff event. Also the UCD allowed stormwater runoff monitoring program only requires samples be collected during the week day, i.e., no weekend or night sampling. As a result of this grossly inadequate sampling program is that in several years the first major storm runoff event of the fall is not sampled since the event occurred on the weekend and at night. This is particularly significant in that the first fall storm is the first runoff event for the period from about April through October. The pollutant concentrations in the first major fall runoff event could be a major source of pollutants for the receiving waters that is not properly addressed in the subsequent storm runoff events.

Typically the Superfund site stormwater runoff monitoring fails to collect sample of the first flush and throughout the runoff event for representative runoff events for each season of the year. It should not be assumed that one or two grab samples of runoff waters per year can adequately detect and quantify the concentration of hazardous chemicals in the runoff. The least that should be collected is four samples during runoff event at the beginning to collect first flush, and near the anticipated end of the runoff event and two other spaced about equally anticipated duration through the runoff event.

Failure to measure the stormwater runoff flow is a common problem at Superfund sites. Without continuous monitoring of stormwater runoff flow it is not possible to estimate the total load of hazardous chemicals discharged by the Superfund/hazardous chemical and other sites and the effectiveness of remediation efforts for the site.

Monitoring of stormwater runoff should be increased during the time that the site soils are disturbed such as part of remediation efforts to determine if the disturbance of the soil mobilizes pollutants for transport in stormwater runoff.

An issue that needs to be understood in stormwater runoff that sampling of the particulate associated pollutants in the runoff is not reliable to determine that total load of pollutants in runoff events. Grab samples as well as automatic monitoring systems do not quantitatively sample particulates in the runoff. In order to sample particulates in runoff events the sampling must be done using isokinetic (equal velocity) sampling where the flow of water into a sampling tube must be equal to the velocity of the water passing the sampling tube/device.

Also of concern is that appreciable amounts of pollutants in some runoff situations is associated with bedload transport. Sampling of bed load pollutant loads cannot be done quantitatively with normal sampling approaches.

Rather than establishing the stormwater runoff monitoring program to do the least possible to just gain some data without regard to the adequacy of the data to properly characterize the runoff pollution potential, the runoff monitoring program should be based on developing a comprehensive monitoring program that can, once several years of data is available, be reduced as the program is determined to be adequate to characterize the runoff.

Inadequate Regulatory Agency Stormwater Runoff Monitoring Guidance

The US EPA has developed "NPDES Stormwater Sampling Guidance Document (EPA/833/B-92/001)" for implementing the Agency NPDES stormwater management program. (http://yosemite.epa.gov/R10/WATER.NSF/NPDES+Permits/SW+guidance+&+fact+sheets+-+Region+10/). While this guidance provides considerable information on conventional NPDES stormwater runoff water quality monitoring, this guidance does not specifically address hazardous chemical site stormwater runoff monitoring for hazardous chemicals that are hazardous at very low concentrations.

Review of the current US EPA Superfund site investigation guidance shows that the Agency has failed to provide stormwater runoff monitoring guidance. Without this guidance the site regulatory agency staff allow the use of the urban stormwater runoff monitoring program guidance without evaluating the adequacy of this program to properly protect public health and the environment from the adverse impacts of runoff associated chemicals. Since typically the superfund/hazardous chemical site regulatory agency staff have limited expertise in developing water quality monitoring programs and in interpretation of water quality data for surface water impacts, the US EPA and state regulatory agencies need to develop detailed guidance on how stormwater runoff monitoring programs should be conducted to improve the adequacy and reliability of stormwater runoff monitoring/impact evaluation from these sites.

While the US EPA Superfund Site investigation guidance does not provide information that specifically addresses conducting appropriate stormwater runoff monitoring, the Agency stormwater runoff sampling guidance mentioned above can be used as guidance for sampling that the LEHR Superfund site RPMs adopt the approach advocated in the US EPA stormwater runoff monitoring guidance for industrial site be used as guidance for revision of the LEHR site stormwater runoff monitoring.

Interpretation of Stormwater Runoff Water Quality Data

Once adequate/reliable stormwater runoff water quality data has been collected, it is then necessary to properly interpret the data with respect to the receiving water beneficial use impairment. The typically followed approach of mechanically comparing the data to water quality criteria/standards can readily lead to over regulation of the sources of potential pollutants. This conclusion is based on gaining an understanding of how the US EPA water quality criteria are developed where they are designed to be worst case based national criteria that will be protective in all waters. This approach leads to overprotection in many waters where the characteristics of the potential pollutant in the discharge/receiving waters and/or constituents in the receiving waters cause the potential pollutant to be in non-toxic non-available forms. The authors have provided guidance on issues that need to be considered in properly evaluating the water quality significance of a concentration of a chemical in impairing the beneficial uses of a waterbody as,

> Lee, G. F. and Jones-Lee, A., "Issues in Developing a Water Quality Monitoring Program for Evaluation of the Water Quality - Beneficial Use Impacts of Stormwater Runoff and Irrigation Water Discharges from Irrigated Agriculture in the Central Valley, CA," California Water Institute Report TP 02-07 to the California Water Resources Control Board/ Central Valley Regional Water Quality Control Board, 157 pp, California State University Fresno, Fresno, CA, December (2002).
> http://www.gfredlee.com/SurfaceWQ/Agwaivemonitoring-dec.pdf

And in Stormwater Runoff Water Quality Newsletters,

> NL Volume 11 Number 6, July 16, 2008 Topic: Application of water quality criteria/standards to urban and highway stormwater runoff, and
> NL Volume 10 Number 3, April 16, 2007 Topic: Regulation of aquatic life toxicity in stormwater runoff from urban and agricultural areas

And in other newsletters with an index and newsletters at http://www.gfredlee.com/newsindex.htm.

As discussed in these newsletters the interpretation of the water quality significance of exceedance of a water quality criterion/standard in the runoff waters being mechanically assumed to be an impairment of the beneficial uses of a receiving water water quality, the evaluation monitoring approach developed by the authors, as described in,

> Jones-Lee, A. and Lee, G.F., "Evaluation Monitoring as an Alternative to Conventional Water Quality Monitoring for Water Quality Characterization/Management," Proc. NWQMC National Conference Monitoring: Critical Foundations to Protect Our Waters, US Environmental Protection Agency, Washington, D.C., pp. 499-512 (1998).
> http://www.gfredlee.com/Runoff/wqchar_man.html

and

> Lee, G.F., and Jones-Lee, A., "Evaluation Monitoring vs Chemical-Constituent Monitoring: Chemical Concentrations vs Chemical Impacts," Keynote presentation at CA Water Environment Association Training Seminar, "Recent Advances in Receiving Water Monitoring," Anaheim, CA, February (1999). http://www.gfredlee.com/SurfaceWQ/concentrationvsimpact.pdf

Basically the evaluation monitoring approach focuses on evaluation of the water quality impacts of and exceedance of a water quality criterion/standard in the receiving waters, such as the toxicity of copper to aquatic life rather than trying to estimate the toxicity based on exceedance of the copper water quality criterion/standard. It is well established that there are many reasons why potentially toxic copper in many natural waters in not toxic in the waterbodies.

In addition for the mechanically using the US EPA water quality criteria and state standards to try to “evaluate” the water quality criteria/standards leading to overregulation of some runoff/discharges, there is need to understand that the way that the US EPA water quality criteria are developed is that the criterion values are estimated to be protective of about 90 % of aquatic life species. It is understood that there can be situations where there are aquatic species that are harmed at concentrations of a pollutant that are below the water quality criterion value. This situation appears to occur for the Sacramento Regional Sanitation Districts discharge of ammonia to the Sacramento San Joaquin Delta where some of the studies species such as Delta Smelt, are adversely impacted by ammonia concentrations below the US EPA water quality criterion. Information on this situation is available at,
http://www.science.calwater.ca.gov/events/workshops/workshop_ammonia.html

Controlling Runoff Pollutants

The key to controlling some particulate associated pollutants in stormwater runoff is to control erosion/transport of particulates in runoff waters. Under the current approach typically followed is the use of straw (fiber) bales, rolls and bags in the flow path of the stormwater runoff frequently just in front of the drop inlet for collection of the runoff. This so-called BMP approach is in the findings of the authors can be somewhat effective in reducing the total particulate load discharged from an area especially for large size particulate matter. However usually the most significant fraction of the pollutant load in stormwater runoff is so-called dissolved, colloidal and finely divided particles. An example of this type of situation that UCD is following in an attempt to control the exceedance of mercury in stormwater runoff from the LEHR site. UCD placed a several rows of fiber rolls in the flow path for stormwater runoff from the site. Examining the turbidity in downstream side of the straw rolls and in the final discharge is still highly turbid indicating that particulate matter from the site is being transported from the site and is likely transporting mercury in runoff.

It is highly important that adequate sampling of the discharge of the so-called BMP treated stormwater runoff to determine the actual effectiveness of the BMP. This sampling should include first flush, at several times during the runoff event and near the anticipated end of the runoff event. The approach that has been used at the LEHR site of a single grab sample taken at some time during the runoff event is not reliable to characterize the concentrations of pollutants in the runoff since various areas of the sampling point watershed will contribute pollutants to the sampling point at different times during the event.

As discussed in previous DSCSOC reports concerning LEHR Superfund site mercury issues, just meeting the 50 ng/L CTR criterion for mercury in the LEHR site stormwaters runoff does not prevent the LEHR site from contributing mercury to Putah Creek and adding to the total mercury in Putah Creek that is bioaccumulating to excessive concentrations in fish in the creek and the Delta. The concentration of total recoverable mercury in LEHR site stormwater runoff **at any time** during the runoff event would have to be less than about 5 ng/L to achieve that level of control.

The US EPA website contains "Fiber Rolls, Minimum Measure: Construction Site Stormwater Runoff Control Subcategory: Sediment Control" devoted to the use of Fiber Rolls as a BMP for controlling erosion runoff from areas states at,
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=121
"*The San Diego State University Soil Erosion Research Laboratory reported that the use of fiber roll products reduced offsite sediment delivery by 58 percent (International Erosion Control Association, 2005).*"

Dust/Erosion Control Chemicals as Pollutants
At some locations dust suppression and erosion control chemicals are used to control air and waterborne transport of particulate and pollutants from and area. Care must be given to properly evaluating the potential water quality impact of the dust/erosion chemicals. We have developed,

> Lee, G. F. and Jones-Lee, A., "Evaluation of the Potential Water Quality Impacts of Dust Suppressants," Report prepared for Expert Panel on the Potential Environmental Impacts of Dust Suppressants, organized by the University of Nevada, Las Vegas, Department of Civil Engineering, January (2004). http://www.gfredlee.com/HazChemSites/dust-suppress-guidance.pdf

that discusses problems with this approach and provides guidance on how to evaluate whether the dust/erosion control chemicals are having an adverse impact on receiving water quality for the runoff from the treated area. An issue of concern for landfill areas is that some landfill owners/operators use landfill leachate for dust control. Some of the pollutants in the leachate spread on the soil surface will be present in stormwater runoff from the landfill area. While this practice is no longer allowed by some states, it is still occurring at some landfills.

Phosphorus in Stormwater Runoff Impacts

The discharge of phosphorus to surface waters can cause a number of water quality problems including excessive growths of aquatic plants that are adverse to domestic water supply water quality, interfere with recreational use of waterbodies and can cause aquatic life toxicity through algae and other aquatic plant death and decay leading to low DO and an accumulation of oxygen demanding materials. A review of these issues, sources of phosphorus, relationship between phosphorus loads to waterbodies and excessive fertilization of waterbodies is available on the author's website, www.gfredlee.com in the Excessive Fertilization section at, http://www.gfredlee.com/pexfert2.htm.

A key issue that needs to be reviewed in connection with stormwater runoff phosphorus sources is the availability of inorganic phosphorus to support excessive fertilization of waterbodies. While the US EPA, without support evidence, has adopted the position that all forms of phosphorus is available or becomes available to support aquatic plant growth, there is substantial documentation that particulate inorganic phosphorus such as derived from agricultural and urban runoff is essentially unavailable to support aquatic plant growth and does not convert to available forms. These issues are reviewed in Newsletters NL 1-2, 1-3, 1-5, 4-3/4, 5-1, 6-1, 6-2, 7-6/7, 9-1/2, 9-7, 9-8, 9-10, 10-1, 10-2, 10-4, 10-5, 10-6, 10-7, 10-13, 11-2, 11-5, 11-7/8, 11-9, 11-10, 12-3, 12-5, and 12-6. While particulate organic phosphorus compounds such as algal cells and other plant materials can be converted to algal available forms of P, as discussed focusing phosphorus control in stormwater runoff from erosion of inorganic phosphorus in agricultural land runoff can result in very large expenditures for control of particulate removal and have limited impact on excessive fertilization of waterbodies receiving the runoff.

Authors' Background

G. Fred Lee earned a BA degree in sanitary science/public health from San Jose State College in San Jose, CA in 1955; a Master of Science in Public Health degree (with focus on water quality issues) from the University of North Carolina School of Public Health in Chapel Hill, NC in 1957; and a PhD degree in environmental engineering (with emphasis on water chemistry and public health) from Harvard University in 1960. For 30 years he held faculty positions in graduate programs at several major US universities. In that capacity he taught environmental engineering/science courses in water supply water quality, water and wastewater treatment, water pollution control, and solid and hazardous waste impact investigation/management; he conducted more than $5-million in research and published about 500 professional papers and reports on his studies.

Anne Jones-Lee earned a BS degree in biology from Southern Methodist University in 1973, and a PhD degree in environmental sciences (with emphasis on aquatic chemistry/toxicology) from the University of Texas at Dallas in 1978. For 11 years she held faculty teaching and research positions at several major US universities. She and Dr. Lee have worked as a team on water quality investigations since the late 1970s.

In 1989 Dr. Lee retired from university teaching and research, and with Dr. Jones-Lee expanded their part-time consulting in water quality and solid and hazardous waste site investigation and remediation into a full-time endeavor. Through their firm G. Fred Lee & Associates, they serve a wide variety of clients including water utilities, governmental agencies, industry, and members of the public, in addressing a broad array of problems and concerns associated with the sources, impacts, fate, and control of chemical contaminants in surface and groundwaters. Their website (www.gfredlee.com) describes their areas of expertise, discusses their experience, and makes available many of the more than 1100 papers and reports they have written on their studies.

Dr. Lee also has considerable expertise and experience in the development and appropriate use of water quality criteria. He served as an invited peer-reviewer for the National Academies of Science and Engineering "Blue Book" – Water Quality Criteria of 1972 – as well as an invited peer-reviewer to the US EPA on the "Gold Book" of Water Quality Criteria of 1987. At the request of the US Public Health Service, he took the lead in evaluating the need to develop a drinking water MCL for PCBs.

Through his academic education and subsequent experience, Dr. Lee has considerable expertise in the development and proper utilization of analytical methods for chemical pollutants in water and wastes. He has been serving as a peer-review member of the APHA et al. "Standard Methods for Examination of Water and Wastes" for more than 40 years. He also served as a US EPA peer-reviewer for documents addressing the adequacy of proposed screening methods for chemical threats associated with a terrorist attack.

For the past 12 years Drs. Lee and Jones-Lee have written and published the "Stormwater Runoff Water Quality Newsletter," an approximately monthly, no-cost newsletter that is emailed to more than 10,500 subscribers. That newsletter is an extension of the substantial professional service/education work they began during their university careers. Past issues of the Newsletter and a topic index are available on their website at http://www.gfredlee.com/newsindex.htm. As noted in the discussion presented above, a number of past issues of the newsletters provide additional information on the topics addressed herein.

Additional information on the authors' expertise and experience is available on their website at http://www.gfredlee.com/gflinfo.htm. It is with this background that these comments are offered.