Overview of Issues in Evaluating Remediation of a PCB-Polluted Waterbody

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Introduction

Polychlorinated biphenyls (PCBs) are among the most significant, commonly encountered hazardous chemicals in the environment, especially in urban and industrial areas, despite the banning of their use in the 1970s. As discussed in these comments based on Dr. Lee's more than 50 years of experience in conducting laboratory and field studies on the occurrence and impacts of PCBs on water quality and on the related professional literature, the technically reliable assessment and management of PCB pollution (impairment of beneficial use) of water, sediment, and aquatic organisms continue to be a challenge for regulatory agencies.

The primary concerns for PCBs in aquatic environments are their presence in edible aquatic organisms at levels that pose a threat to human health when the organisms are eaten, especially by subsistence fishers, and their potential toxicity to aquatic life and wildlife. Aquatic organisms absorb PCBs from their food as well as directly from water and accumulate them in their fatty tissues. Reliable measures by which PCBs in water, sediment, and aquatic organisms can be evaluated are critical for the meaningful assessment of their water quality impact and the need for PCB-remediation. They are likewise critical for the assessment of the efficacy and adequacy of remediation measures taken or natural processes for improving water quality/beneficial uses. However, there are no reliable cause/effect relationships between, or mathematical models relating, concentrations of PCBs in edible fish tissue and concentrations in sediment, water, or fish-food organisms. The lack of such relationships is understandable given the aqueous environmental chemistry of PCBs, but prevents the simple and reliable screening or targeting of sediments and water in need of remediation to assess or mitigate water quality impacts; site-specific evaluation and focus on concentrations in edible fish, the integrators of system functions, are necessary.

From the authors' experience over the past nearly five decades, assessments of the environmental significance of, the need for, and adequacy/success of remediation of PCB contamination often rely on spurious mathematical correlations (co-occurrence) or mathematical models employing scant data and tenuous assumptions about the uptake and availability of PCBs in and from water, sediment, and aquatic life, and impacts of PCBs on aquatic life and on people who consume PCB-contaminated fish. While it is administratively expedient to make remediation decisions on the basis of concentrations of PCBs in sediment or water, those measures cannot be reliably translated into body burdens in edible flesh of food organisms. As discussed herein, numeric concentrations, and co-occurrence-based assessments of concentrations of PCBs in sediment are

unreliable, and in fact misleading, indicators of potential public health impacts or of the need for, or adequacy of sediment "clean-up" efforts.

The concentration of PCBs in edible tissue of organisms used for human food, as well as the consumption rate of those organisms, is key to assessing public health implications of PCBs in an aquatic system. However, interpretation of the public health significance of concentrations of PCBs in edible aquatic organisms is often unreliably done. It is not uncommon for the body burdens of PCBs in fish to simply be compared with FDA (Food and Drug Administration) tolerance values; this is inappropriate for the potential public health significance of the contamination because of the economic and other, non-public-health-related factors that are considered in establishing the FDA values.

Assessing the public health and water quality significance of PCBs found in water and sediment, evaluating and prioritizing the need for "remediation" of contaminated sediments, and determining the sufficiency/success of remediation accomplished are fraught with conjecture and uncertainty. This is due not only to the unreliability and incompleteness of some of the information used, but also to regulatory desire for simplistic and inexpensive analysis irrespective of reliability.

This report provides guidance to sources of technical information important to the assessment of the significance of PCBs in waterbody sediments and fish. It is based on the authors' five decades of expertise and experience in making such evaluations, which is summarized at the close of this report.

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Water Quality Criteria and Other Guidance for PCBs

Dr. Lee has been involved in the development and use of water quality criteria, standards, and other guidance for chemical contaminants, including PCBs, in the environment since the 1960s. A discussion of his expertise and experience in water quality criteria/standards, and development and implementation of NPDES permits into permitted discharges, upon which these following comments is drawn, is available at http://www.gfredlee.com/exp/wqexp.htm; that expertise and experience is also highlighted in Appendix A. Among his overview reports and articles discussing issues that need to be considered in using the US EPA water quality criteria and state water quality standards based on these criteria are:

Lee, G. F., and Jones-Lee, A., "Clean Water Act, Water Quality Criteria/Standards, TMDLs, and Weight-of-Evidence Approach for Regulating Water Quality," Water Encyclopedia: Water Law and Economics, Wiley, Hoboken, NJ, pp 598-604 (2005).
http://www.gfredlee.com/SurfaceWQ/WileyCleanWaterAct.pdf

Lee, G. F. and Jones-Lee, A., "Appropriate Use of Numeric Chemical Water Quality Criteria," *Health and Ecological Risk Assessment*, **1**:5-11 (1995).
http://www.gfredlee.com/SurfaceWQ/chemcri.pdf

Described below are sources of information on the significance of PCBs in the water. As noted, some criteria and guidance in use by regulators and others have been subject to peer review, others have not. Some are technically sound concerning the public health aspects of PCBs, others incorporate technically invalid components and/or political, economic, and other considerations. It is important to consider the technical foundation and its reliability, limitations, and intended uses of concentration levels, models, and assessment approaches offered by agencies and others for assessing public health implications of PCBs.

US EPA Water Quality Criteria (WQC) for PCBs

The evolution of water quality criteria in the US through the mid-2000s is discussed in Appendix B and by Lee and Jones-Lee (2005) in:

Lee, G. F., and Jones-Lee, A., "Clean Water Act, Water Quality Criteria/Standards, TMDLs, and Weight-of-Evidence Approach for Regulating Water Quality," Water Encyclopedia: Water Law and Economics, Wiley, Hoboken, NJ, pp 598-604 (2005).
http://www.gfredlee.com/SurfaceWQ/WileyCleanWaterAct.pdf

In 2005 the US EPA released its "National Recommended Water Quality Criteria of 2005," http://www.epa.gov/waterscience/criteria/wqctable/. Water quality criteria for PCBs for aquatic life toxicity and specified as applicable to total PCBs (e.g., the sum of all congener or all isomer or homolog or Aroclor analyses), were given for:

- freshwater CCC (chronic): 0.014 ug/L
- saltwater CCC (chronic): 0.03 ug/L

In 1999 the US EPA released "Human Health Water Quality Criteria for Polychlorinated Biphenyls (PCBs) in the National Toxics Rule (NTR) Summary of Final Rule Revision," EPA-822-F-99-003; September 1999 [http://water.epa.gov/lawsregs/rulesregs/ntrfact.cfm], which stated:
"The U.S. Environmental Protection Agency is revising the human health water quality criteria for polychlorinated biphenyls (PCBs) in the National Toxics Rule. When the National Toxics Rule was adopted, human health criteria for PCBs were calculated using the cancer potency factor entered in the Agency's Integrated Risk Information System (IRIS). The Agency is revising the human health water quality criteria for PCBs in the NTR, based on the Agency's reassessment of the cancer potency of PCBs."

"EPA now adopts an approach that distinguishes among PCB mixtures by using information on environmental mixtures and different exposure pathways. Based on this reassessment, EPA derived the new human health criteria for PCBs by using a cancer potency factor of 2 per mg/kg-day. This potency factor is considered protective of children and adults who drink surface water and eat fish from water contaminated with PCBs. The revised NTR human health criteria for PCBs are both 0.00017 ug/L for protection of human health from consumption of aquatic organisms and water, and consumption of aquatic organisms only."

US Public Health Service PCB Drinking Water MCL
In 1970–1971 Dr. Lee served as a consultant to the US Public Health Service (PHS) on the significance of PCBs in drinking water and as chairman of its committee to address the development of drinking water Maximum Contaminant Levels (MCL) for PCBs. Dr. Lee concluded from that work that there was insufficient information available to establish an MCL for PCBs in drinking water. No MCL has been established for PCBs in the intervening years; the regulation of PCBs in surface waters is included in the water quality criteria for PCBs.

ATSDR PCB Human Health Evaluation
The Agency for Toxic Substances and Disease Registry (ATSDR) has developed peer-reviewed "toxicological profiles" [www.atsdr.cdc.gov/toxprofiles] that characterize the toxicological and adverse health effects information for hazardous substances, including PCBs. According to the ATSDR Toxic Substances Portal for PCBs [http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=142&tid=26]:

"Each peer-reviewed profile identifies and reviews the key literature that describes a hazardous substance's toxicologic properties. Other pertinent literature is also presented, but is described in less detail than the key studies."

The ATSDR "Toxicological Profile for Polychlorinated Biphenyls (PCBs)" is:

ATSDR (Agency for Toxic Substances and Disease Registry), "Toxicological Profiles for Polychlorinated Biphenyls (PCBs)," US Department of Health and Human Services, Public Health Service, ATSDR, November (2000). http://www.atsdr.cdc.gov/toxprofiles/tp17.pdf

US Army Corps of Engineers Dredged Sediment Disposal Regulations

Sediments tend to be sinks for PCBs in environmental systems; there is concern that they serve as a long-term source of PCBs for bio-uptake by fish and fish-food organisms. While sediments remain as a potential source of PCBs that can be measured and "remediated," the key, but difficult, aspect of assessing the significance of the PCBs in any particular sediment is defining the availability of those sediment-associated PCBs to aquatic organisms of concern, primarily edible fish. It has been known since the 1960s that total concentration of a contaminant such as PCBs in a sediment is not a reliable or valid predictor of contaminant availability to affect or be taken up by aquatic life. Approaches developed since then for "normalizing" or modeling sediment PCB concentrations to make them useful and reliable for screening and management have not proven reliable.

PCBs were among the organochlorine compounds included in Dr. Lee's $1-million coordinated laboratory and field investigation of the release and availability of sediment-associated pollutants during dredging and dredged sediment disposal in the 1970s under contract with the US Army Engineer Waterways Experiment Station as part of its Dredged Material Research Program (DMRP). That study, which examined the behavior of about 30 chemical parameters in sediments from about 100 different waterways across the US, was a key technical component of the development of the current dredged material disposal criteria. The data from the Lee et al. work were reported in the following two-part "Data Report:"

Lee, G. F., Jones, R. A., Saleh, F., Mariani, G., Homer, D., Butler, J., and Bandyopadhyay, P., "Evaluation of the Elutriate Test as a Method of Predicting Contaminant Release during Open-Water Disposal of Dredged Sediments and Environmental Impact of Open-Water Dredged Material Disposal; Volume II: Data Report Part 1" (Pages 1-611) Technical Report D-78-45, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. (1978). [Data Report Summary and Table of Contents only]
http://www.gfredlee.com/Sediment/DMRP_VolumeII_Data_Report_Part1_Summary.pdf

Lee, G. F., Jones, R. A., Saleh, F., Mariani, G., Homer, D., Butler, J., and Bandyopadhyay, P., "Evaluation of the Elutriate Test as a Method of Predicting Contaminant Release during Open-Water Disposal of Dredged Sediments and Environmental Impact of Open-Water Dredged Material Disposal; Volume II: Data Report Part 2" (Pages 612-1186 + appendix) Technical Report D-78-45, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. (1978) [NTIS No. AD A061 710]
http://www.gfredlee.com/Sediment/DMRP_VolumeII_Data_Report_Part2.pdf

A summary of and conclusions drawn from those studies were published as:

Jones, R. A., and Lee, G. F., "Evaluation of the Elutriate Test as a Method of Predicting Contaminant Release during Open-Water Disposal of Dredged Sediments and Environmental

Impact of Open-Water Dredged Material Disposal; Volume I: Discussion," Technical Report D-78-45, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS (1978). http://www.gfredlee.com/Sediment/DMRP_VolumeI_Discussion.pdf

Several of Lee's DMRP study sites were selected specifically to evaluate the occurrence in and release of PCBs from sediment during dredging and dredged sediment disposal. Those sites included: Texas Gulf Coast–Galveston Bay Entrance Channel, Texas City Channel, Huston Ship Channel; Upper Mississippi River near Minneapolis/St. Paul; Lake Michigan–Sheboygan River and harbor; Hudson River and Estuary and New York Bight; Seattle–Puget Sound/Duwamish River; James River, VA; Los Angeles Harbor; San Francisco Bay; Florida and Alabama Coastal waters–Apalachicola Bay and Mobile Bay; and New England–Long Island Sound, Stamford Harbor, and Newport, RI. Their findings concerning the significance of PCBs in dredged sediment were reported in:

Lee, G. F., and Jones, A., "Significance of PCB's in Dredged Sediments," Dredged Material Research Program Technical Report, Prepared for Office, Chief of Engineers, US Army, 64pp, August (1979). [Executive Summary available at: http://www.gfredlee.com/Sediment/Lee_Jones_PCBs_Dredged_Sediment.pdf

The studies in the New York Harbor/New York Bight area included detailed field studies of the chemicals released to the water column during open-water disposal of hydraulically dredged sediment via hopper dredge. The Bay Ridge Channel and Perth Amboy Anchorage dredged sediments evaluated in that study were some of the most polluted in the Harbor and had high PCB concentrations. Of the approximately 30 contaminants measured, ammonia was the only chemical released at the disposal site during disposal; no PCBs were detected in the water column during disposal. Follow-on studies of fish collected in the disposal area showed that the fish did not contain elevated PCBs even though the deposited dredged sediment at the site contained elevated PCBs.

The Seattle–Duwamish River study focused on sediments dredged from an area in the river at which an electrical transformer containing PCBs had been accidently dropped into the river and released large amounts of PCBs. Elevated concentrations of PCBs were present in the sediments mechanically dredged and dumped in Elliot Bay of Puget Sound during the study. While the dumped sediments contained elevated PCBs no release of the PCBs occurred during dumping.

Lee and Jones (1979) summarized the results of the DMRP PCB study thus:
"It is concluded that U.S. waterway sediments contain sufficient concentrations of PCB's to be of potential significance to water quality during dredging and dredged material disposal. At this time, however, there is insufficient information available to predict, based on sediment analyses or elutriate test results, whether the PCB's in sediments represent a potential water quality problem at the dredging and dredge material disposal site. Bulk sediment criteria obtained for the total PCB content of sediments do not serve as a valid basis for developing an assessment of the potential environmental hazard of PCB's, their release to the watercolumn during dredging and dredged material disposal, or the direct uptake of PCB's from sediments by benthic and epibenthic organisms. A case-by-case evaluation of the significance of PCB's associated with a particular dredging project must be made in which primary reliance must be given to examining

the PCB content of edible fish and shellfish of the region of dredge material disposal that has received similar sediments in the past, in order to ascertain whether these organisms contain excessive amounts of PCB's based on the FDA limit of 2 ppm in the flesh."

Assessing Significance of PCBs in Fish Tissue

The amount of PCBs in the edible flesh of food organisms, along with the pattern of consumption of those organisms, is the key measure of the need for and success/adequacy of remediation for the protection of human health from PCBs in the aquatic environment. Various agencies have worked toward providing guidance for interpreting the significance of measured concentrations of PCBs in edible fish and shellfish, and for suggesting limitations on the amounts of such organisms that consumers should consider in light of the health benefits offered by those organisms. This section provides an overview of guidelines for fish tissue concentrations of PCBs.

US EPA vs. FDA Human-Health-Related Fish Tissue PCB Levels

The US FDA (Food and Drug Administration) has established PCB tolerance levels for fish and shellfish that are shipped in interstate commerce. As discussed below, despite their use for other purposes by some regulatory agencies, those levels are not intended for, or appropriate for evaluating the need for sportsfishing advisories or sediment remediation, and/or the adequacy of sediment/pollution management practices.

In the July 29, 1979 "Final Rule" for the reduction of PCB tolerances for fish and shellfish from 5 ppm to the current 2 ppm (and reiterated in subsequent Federal Register publications to the present), the FDA stated:
"*FDA's regulatory authority extends only to foods shipped in interstate commerce and clearly does not extend to fish caught and consumed by individual sport fishers."*

In setting the tolerance level, the FDA is required under section 408 of the FDC Act to take into account the nature and extent of "unavoidability" of PCB contamination of fish, the amount of PCB-contaminated fish that must be disposed of to reduce human exposure to a tolerable level, economic impacts, and the level at which the contaminant can be reliably measured for enforcement purposes. The July 29, 1979 "Final Rule" stated:
"Hence, in deciding the appropriate levels for PCB tolerances under section 408, FDA has had to make some extraordinarily difficult judgments. It has had to decide, in effect, where the proper balance lies between providing an adequate degree of public health protection and avoiding excessive losses of food to American consumers."

"Indeed, as one would expect, the risk assessment performed by the agency, and discussed above, indicates that the estimated risks that might be experienced by consumers of contaminated fish would be reduced even further by a reduction of the tolerance to 1 ppm. Based on the evidence now before it, however, the agency does not consider a reduction to 1 ppm necessary or appropriate in light of the policy of section 408 of the act [to consider factors other than public health in establishing the tolerances such as loss of food resources and economic impacts]."

"For these reasons, the agency concludes that at this time a 1 ppm tolerance would not strike the proper balance between protection of the public health and the need to avoid excessive loss of food.

Though FDA considers 2 ppm to be the appropriate tolerance level for PCB's in fish under the criteria imposed by section 406 of the act, the agency is concerned about the health of certain groups that may not be adequately protected by a 2 ppm, or even a 1 ppm, tolerance. As noted, sport fishers and others who consume abnormally large amounts of the more highly contaminated species may be at risk from PCB's regardless of any tolerance FDA establishes."

The July 29, 1979 "Final Rule" is available at:
[http://books.google.com/books?id=Zy32RCKKj40C&pg=PA126&lpg=PA126&dq=Reduction+of+Tolerances+FDA+Federal+Register&source=bl&ots=-1cE19SdsG&sig=skQ6DT6TlMvuxYjnGCfVFwhL1G8&hl=en&sa=X&ei=T4sHVJ3lMIXAigKQjYD4Dg&ved=0CB4Q6AEwAA#v=onepage&q=Reduction%20of%20Tolerances%20FDA%20Federal%20Register&f=false]

In summary, the FDA PCB tolerance level has been established for application to fish involved in interstate commerce; it is the result of the subjective bureaucratic balancing of not only human health considerations but also the impacts of fish tissue PCB concentration limitations on economics and on the potential loss of food products. While the FDA PCB tolerance level may suffice for its intended purpose, it cannot be presumed to be appropriate for assessing the wholesomeness of fish caught by recreational fishermen or subsistence fishers.

This finding was also discussed by Reinert and Stober (1993) who published a review of fish consumption advisories:

Reinert, R., and Stober, Q., "A Review of Past and Present Fish Consumption Advisories," Proc. 1993 Georgia Water Resources Conference, University of Georgia, Athens, April (1993).
https://smartech.gatech.edu/bitstream/handle/1853/33144/ReinertR-StoberQ-93.pdf;jsessionid=9A8D25D378F9456283192B5EE99868FF.smart1?sequence=1
They reported:
"Fish consumption advisories derived from the newer EPA risk-based-assessment approach generally give a much higher estimate of health risk for a given level of contaminant than those based on the FDA tolerance guidelines for several reasons. The two agencies use different risk assessment methodologies based on different assumptions (USEPA 1989), fish consumption rates vary in scope from national (FDA) to local (EPA). Also, FDA action levels are based not only on risk assessment but also on risk management considerations such as economic impacts likely to accrue to the commercial fishing industry (USEPA 1989). For example, the FDA clearly indicates that its rationale for the current 2 ppm action level for PCBs was a balance between public health protection and the economics involved in the loss of commercial fish to the consumer (USFDA 1984). In contrast, the EPA approach for fish consumption advisories gives full priority to protection of public health."

In both Volumes 1 and 2 of its "Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories," the US EPA discussed the use of fish tissue levels in establishing Fish

Advisories and the appropriateness of using FDA action levels (guidelines) or tolerances (regulatory requirements) to determine the need to issue an advisory.

US EPA, Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1-Fish Sampling and Analysis, Third Edition," EPA 823-B-00-007, US EPA, Office of Water, November (2000).
http://water.epa.gov/scitech/swguidance/fishshellfish/techguidance/risk/upload/2009_04_23_fish_advice_volume1_v1cover.pdf

US EPA, Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2 – Risk Assessment and Fish Consumption Limits, Third Edition," EPA 823-B-00-008, US EPA Office of Water, November (2000).
http://water.epa.gov/scitech/swguidance/fishshellfish/techguidance/risk/upload/2009_04_23_fish_advice_volume2_v2cover.pdf

The US EPA stated:
"FDA action levels and tolerances are indicators of chemical residue levels in fish and shellfish that should not be exceeded for the general population who consume fish and shellfish typically purchased in supermarkets or fish markets that sell products that are harvested from a wide geographic area, including imported fish and shellfish products. However, the underlying assumptions used in the FDA methodology were never intended to be protective of recreational, tribal, ethnic, and subsistence fishers who typically consume larger quantities of fish than the general population and often harvest the fish and shellfish they consume from the same local waterbodies repeatedly over many years. If these local fishing and harvesting areas contain fish and shellfish with elevated tissue levels of chemical contaminants, these individuals potentially could have increased health risks associated with their consumption of the contaminated fish and shellfish."

"EPA and FDA have agreed that the use of FDA Action Levels for the purpose of making local advisory determinations is inappropriate. In letters to all states, guidance documents, and annual conferences, this practice has been discouraged by EPA and FDA in favor of EPA's risk-based approach to derive local fish consumption advisories."

Volume 1 states:
"EPA has provided this guidance [Table 1-3 the portion of which addresses PCBs is shown below] *to be especially protective of recreational fishers and subsistence fishers within the general U.S. population. EPA recognizes, however, that Native American subsistence fishers are a unique subsistence fisher population that needs to be considered separately."*

Table 1-3. Comparison of FDA Action Levels and Tolerances with EPA Screening Values [SV]

Chemical Contaminant[a]	*FDA Tolerance Level (ppm)*	*EPA SV for Recreational Fishers (ppm)*	*EPA SV for Subsistence Fishers (ppm)*
PCBs	*2.0*	*0.02*	*2.45×10^{-3}*

[a] *US FDA (1998)*

Volume 2 states with regard to the same table:
"As can be seen in Table 1-2, for the recreational fisher, the EPA-recommended values typically range from 2 to 120 times lower and thus are more protective than the corresponding FDA action or tolerance level. This difference is even more striking for subsistence fishers for whom the SVs are 20 to 977 times lower than the FDA values."

The FDA tolerance level for PCBs has narrow applicability and specific use clearly articulated from their inception; it incorporates factors other than public health concerns. The FDA, US EPA and others have issued clear admonitions against use of FDA levels for broader purpose. Nevertheless some regulatory agencies inappropriately continue to employ FDA fish tissue levels to evaluate the need for sportsfishing advisories and sediment remediation, and/or the adequacy of sediment/pollution management practices. It should not be done.

OEHHA Guidance
The California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) has made available on its website advisory tissue levels for PCBs and other chemical contaminants in fish [http://www.oehha.ca.gov/fish/gtlsv/crnr062708.html]. There it summarizes its work in this regard as follows:
"The California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) previously made available a draft report entitled, 'Development of Guidance Tissue Levels and Screening Values for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene.' OEHHA has revised the report in response to comments from the public and additional review of scientific knowledge in the subject area. As such, the report has been re-titled, "Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene." For each chemical, the toxicological literature was reviewed to establish acceptable toxicity values for cancer and non-cancer endpoints. Fish contaminant goals were then developed that can provide a starting point for OEHHA to assist other agencies in their efforts to develop fish tissue-based criteria with a goal toward pollution mitigation or elimination. The scientific literature on the benefits of fish and fish oil consumption was also reviewed. Finally, OEHHA developed advisory tissue levels, which balance risks and benefits and are one component of the complex process of data evaluation and interpretation used by OEHHA in the assessment and communication of fish consumption risks and development of advisories and safe eating guidelines."

In its final report:
OEHHA, "Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene," OEHHA (Office of Environmental Health Hazard Assessment), Oakland, CA, June (2008). http://oehha.ca.gov/fish/gtlsv/pdf/FCGsATLs27June2008.pdf

OEHHA provided the following guidance on the critical concentration of PCBs in fish that are a threat to human health through consumption of the fish:

Fish Contaminant Goals (FCGs) for PCBs Based on Cancer and Non-Cancer Risk* Using an 8-0unce Serving Size (Prior to Cooking) Consumption Rate (32 g/day)** (ppb, wet weight)	
Contaminant Cancer Slope Factor for Cancer Risk ($1x10^{-6}$)	Contaminant Reference Dose for Non-Cancer Risk
3.6	63
* The most health protective Fish Contaminant Goal (cancer slope factor – versus reference dose-derived) for each meal category is bolded. ** g/day represents the average amount of fish consumed daily, distributed over a 7-day period, using an 8-ounce serving size, prior to cooking	

Advisory Tissue Levels (ATLs) for PCBs Based on Non-Cancer Risk Using an 8-0unce Serving Size (Prior to Cooking) (ppb, wet weight)			
Three 8-ounce Servings* a Week	Two 8-ounce Servings* a Week	One 8-ounce Servings* a Week	No Consumption
<21	>21-42	>42-120	>120
*Serving sizes are based on an average 160 pound person. Individuals weighing less than 160 pounds should eat proportionately smaller amounts (for example, individuals weighing 80 pounds should eat one 4-ounce serving a week when the table recommends eating one 8-ounce serving a week).			

Summary of Screening Values, Goals, Tolerance Levels for PCBs in Fish Tissue for Protection of Human Health

Lee and Jones-Lee (2014) prepared the following table of "Screening Values, Goals, Tolerance Levels for PCBs in Fish Tissue for Protection of Human Health:"

Source	PCBs in tissue (ng/g)
"Fish Contaminant Goals for Selected Fish Contaminants Based on Cancer and Non-Cancer Risk Using an 8-ounce/wk Consumption Rate" (Klasing and Broadberg, 2008)	3.6
US EPA (1999) Fish tissue concentrations associated with cancer health endpoint for one fish meal/wk	6 – 12
US EPA (2009) human health screening values for PCBs in fish	12
US FDA (1984) tolerance level for freshwater fish (edible flesh)*	2000
US EPA (1995) fish tissue screening value	10
OEHHA (1999) fish tissue screening value	20
US EPA (2000) EPA screening value for recreational fishers	20
US EPA (2000) EPA screening value for subsistence fishers	2.45

Table compiled by Lee and Jones-Lee (2014)

Table References:

Klasing, S., and Brodberg, R., "Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene," Report of Pesticide & Environmental Toxicology Branch, Office of Environmental Health Hazard Assessment (OEHHA), California Environmental Protection Agency, June (2008).

OEHHA, “Prevalence of Selected Target Chemical Contaminants in Sport Fish from Two California Lakes: Public Health Designed Screening Study,” Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, CA (1999). http://oehha.ca.gov/fish/pdf/Cx8258.pdf

US EPA, “Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories: Volume 1, Fish Sampling and Analysis.” Second Edition, EPA 823-R-93-002, US EPA, Washington, DC (1995).

US EPA, “Polychlorinated Biphenyls (PCBs) Update: Impact on Fish Advisories,” Fact Sheet, EPA-823-F-99-019, US EPA Office of Water, Washington, DC, September (1999).

US EPA, “Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1 Fish Sampling and Analysis, Third Edition,” EPA 823-B-00-007, US EPA Office of Water, Washington, DC, November (2000). http://water.epa.gov/scitech/swguidance/fishshellfish/techguidance/risk/upload/2009_04_23_fish_advice_volume1_v1cover.pdf

US EPA, “The National Study of Chemical Residues in Lake Fish Tissue, EPA-823-R-09-006, US EPA Office of Water, Washington, DC, September (2009). http://water.epa.gov/scitech/swguidance/fishstudies/upload/2009_9_28_fish_study_data_finalreport.pdf

US FDA, “Shellfish Sanitation Interpretation: Action Levels for Chemicals and Poisonous Substances.” U.S. Food and Drug Administration, Shellfish Sanitation Branch, Washington, DC (1984).

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Evaluating Aquatic Life Toxicity of PCBs in Sediment

The Corps of Engineers DMRP studies conducted by Dr. Lee and his graduate students discussed above included the measurement of PCBs and sediment toxicity to aquatic life. They found that in those tests that showed sediment toxicity the toxicity was due to ammonia and not to PCBs, DDT, heavy metals, or other of the contaminants measured. A summary report of the toxicity of the sediments was reported as

Lee, G. F., and Mariani, G., "Evaluation of the Significance of Waterway Sediment-Associated Contaminants on Water Quality at the Dredged Material Disposal Site," IN: Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, American Society for Testing and Materials, pp. 196-213 (1977). http://www.gfredlee.com/Sediment/Lee-Mariani-ASTM.pdf

Jones-Lee, A. and Lee, G. F., "Potential Significance of Ammonia as a Toxicant in Aquatic Sediments," In: Proceedings First International Specialized Conference on Contaminated Aquatic Sediments: Historical Records, Environmental Impact, and Remediation, IAWQ, June (1993). Available upon request as CS002 from gfredlee33@gmail.com

Jones, R. A., and Lee, G. F., “Toxicity of U.S. Waterway Sediments with Particular Reference to the New York Harbor Area,” Chemical and Biological Characterization of Sludges, Sediments, Dredge Spoils, and Drilling Muds, ASTM STP 976, Amer. Soc. Test. Mater., Philadelphia, pp. 403-417 (1988). http://www.gfredlee.com/Sediment/NYHarborSedimentToxicity.pdf

Assessing the Water Quality Significance of PCBs in Sediments and Soils

Unreliability of Co-Occurrence Approaches

The DMRP studies conducted by Dr. Lee and his graduate students, referenced above, included extensive laboratory and coordinated field studies at about 100 locations in US waterways on the release of specific chemical contaminants, including PCBs, from sediments. They designed their studies specifically to include assessment of relationships between sediment composition and the release of those contaminants. Their literature review and massive database clearly showed, as was expected based on aqueous environmental chemistry, that there is no relationship between concentrations of PCB and other potential pollutants in sediments, the release of those contaminants to the water, the impacts of those chemicals on aquatic life, or the bioaccumulation of those chemicals in aquatic life in the waterbody. Because the impacts of sediment-associated contaminants cannot be determined or estimated based on sediment concentrations, even as manipulated mathematically, aquatic organisms must be used to integrate and reveal the impacts and/or potential for bioaccumulation of those contaminants on a site-by-site basis. Lee and his students also developed and evaluated technically reliable approaches for assessing the water quality significance of chemical contaminants in sediments using toxicity testing and evaluation approaches with a variety of types of aquatic organisms. In his decades of involvement in the professional community, Lee was also active in the development and evaluation of such approaches.

In the 1990s a number of investigators including Long and Morgan undertook the compiling of data on total concentrations of certain chemicals in sediments and pairing them with subjective and varied indications that organisms in the sediments' waterbodies were in some manner compromised.

Long E.R., L.G. Morgan, "The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program," NOAA Technical Memorandum NOS OMA 52, National Oceanic and Atmospheric Administration, Seattle, Washington (1990).

Out of those compilations of co-occurrences, mathematical "correlations" were developed between sediment concentration of particular chemicals and some level of "impact" associated with that sediment, without any determination, or reason to believe, that the particular chemical was the cause of the observed or presumed effect on aquatic life. To the contrary, this approach presumed that each measured contaminant included in the compilation was independently responsible for the "effect" reported. Rather than establishing a cause-and-effect relationship, the correlations simply demonstrated the co-occurrence of the conditions. In fact, a substantial portion of their "correlations" was based on the misuse of Lee et al. DMRP sediment chemical and toxicity data; they did not address fact that the Lee et al. work demonstrated a lack of causal relationship between concentration and impact; the co-occurrence compilations ignored the clear conclusion of a lack of causal relationship between sediment concentration and aquatic life toxicity. Furthermore, some of the well-recognized causes for sediment toxicity and impact, including low dissolved oxygen and ammonia, are not considered in the co-occurrence approaches. Thus, co-occurrence approaches not only ignore recognized and common causes of impact, but also implicate other contaminants that are either unavailable or not causing the noted impact.

Despite the absence of causal relationships, the "co-occurrence" relationships were used as the basis for sediment toxicity guidelines, "effects range low" (ERL) and "effects range median" (ERM) values, for characterizing the significance of sediment-associated contaminants. Those statistical manipulations have been used by Long and Morgan and subsequently by MacDonald and many others to conclude that if the concentration of a chemical in a sediment exceeded the co-occurrence-based sediment guideline, the sediment is to be considered toxic. This was done despite the lack of causality in those relationships.

While the lack of technical validity of the Long and Morgan and MacDonald co-occurrence-based sediment quality guidelines was clear, some regulatory agencies began using them as guidelines for assessing the need for remediation of sediments containing PCBs and other chemicals. For example, California's Los Angeles Regional Water Quality Control Board used them to conclude that the Colorado Lagoon sediments required remediation since the PCB concentration in the sediments exceeded the co-occurrence-based sediment guideline. The unreliability of that action was discussed by Lee and Jones-Lee in:

Lee, G. F., and Jones-Lee, A., "PCBs as an Unlikely Cause of Urban Aquatic Sediment Toxicity: Colorado Lagoon Sediment TMDL," Report of G. Fred Lee & Associates, El Macero, CA, December 3 (2010). http://www.gfredlee.com/Sediment/PCBs-SedToxicity.pdf

The US EPA Region 9 in San Francisco, CA also adopted the co-occurrence-based so-called sediment quality guidelines as a regulatory tool for assessing the need for sediment remediation. Lee responded to the US EPA's call for technical comment concerning that approach in:

Lee, G. F., "Comments on US EPA Region 9's Response to DSCSOC's Request for Technical Review of the Reliability of Using Co-Occurrence-Based SQGs in a LEHR Site Ecological Risk Assessment," Report submitted by G. Fred Lee & Associates to DSCSOC, February (2005). http://www.gfredlee.com/Sediment/ComUSEPAReg9SQG.pdf

Thus, while there are publications that describe co-occurrence approaches for assessing sediment-associated contaminants, including the following, they are unreliable and misleading for assessing impacts of chemicals in sediments:

MacDonald, D., Ingersoll, C., and Berger, T., "Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems," Arch. Environ. Contam. Toxicol. 39:20-31 (2000).
http://www.swrcb.ca.gov/water_issues/programs/tmdl/docs/303d_policydocs/241.pdf

As discussed by Lee and Jones-Lee in numerous publications including those cited below, as well as by others, such co-occurrence "relationships" are not only of no use in assessing and managing sediment-associated contaminants, they serve to misdirect and misinform regulators and the public about which sediments are of potential concern and which are not. The technical foundation for those conclusions, as well as more reliable approaches, have been discussed by Lee and Jones-Lee in a variety of professional publications including:

Lee, G. F. and Jones-Lee, A., "'Co-Occurrence' in Sediment Quality Assessment," Report of G. Fred Lee & Associates, El Macero, CA, February (1996).
http://www.gfredlee.com/Sediment/COOCCUR2PAP.pdf

Lee, G. F., and Jones-Lee, A. "Unreliability of Sediment Co-Occurrence-Based Approaches for Evaluating Aquatic Sediment Quality," Excerpts from 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, updated August (2003).
http://www.gfredlee.com/Sediment/UnrelSedCooccur.pdf

Jones-Lee, A. and Lee, G. F., "Unreliability of Co-Occurrence-Based Sediment Quality Guidelines for Contaminated Sediment Quality Evaluation at Superfund/Hazardous Chemical Sites," Journ. Remediation 15(2):19-34 (2005).
http://www.gfredlee.com/Sediment/SQGSuperfund2.pdf

Lee, G. F., and Jones-Lee, A., "Comments on 'Draft Staff Report Substitute Environmental Document Proposed Amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality for the Protection of Fish and Wildlife' Report of State Water Resources Control Board Division of Water Quality, January 28, 2011," Submitted to State Water Resources Control Board, Report of G. Fred Lee & Associates, El Macero, CA, March 14 (2011). http://www.gfredlee.com/Sediment/SedQualDraftSubCom.pdf

Bioavailability of PCBs in Sediments

While the PCBs in aquatic sediments are typically not toxic to aquatic life, sediment-associated PCBs have the potential to bioaccumulate to excessive concentrations in fish through the food web. It has been known since the late 1960s, however, that only some of the sediment associated PCBs are available to bioaccumulate. This was discussed, for example, in:

Veith, G. D. (coordinator), Carver, T. C., Jr., Fetterolf, C. M., Lee, G. F., Swanson, D. L., Willford, W. A., and Zeeman, M. G., "Polychlorinated Biphenyls," In: A Review of the EPA Red Book: Quality Criteria for Water, American Fisheries Society, Bethesda, MD, pp 239-246 (1979). http://www.gfredlee.com/SurfaceWQ/AFS_PCB_RedBookReview.pdf

In the Lee et al. DMRP dredged sediment studies of Houston Ship Channel, Texas City Channel, and nearshore Galveston Bay Entrance Channel cited earlier demonstrated that factors other than total concentration of PCBs controlled release of sediment-associated PCBs. The PCBs associated with the sandy, low-organic-content Galveston Bay Entrance Channel sediments were loosely bound to the sediments; when the sediments were suspended in disposal site water, PCBs were released. However PCBs associated with the more highly contaminated Texas City Channel sediments that were oily and of high organic carbon content were not released when suspended in water. There was not a quantifiable relationship among PCB concentration and measures of sediment character and release of PCBs.

The tight binding of some PCBs to sediment particles makes it impossible to reliably predict the potential for sediment-associated PCBs to be released to the water column or their tendency to bioaccumulate to excessive levels in fish to pose a threat to human health.

The US EPA has developed guidance on estimating the potential for sediment associated PCBs to bioaccumulate through the aquatic food web:

US EPA, "Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates," Second Edition, US Environmental Protection Agency, EPA/600/R-99/064, Washington, D.C. (2000a).

US EPA, "Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment: Status and Needs," U.S. Environmental Protection Agency, EPA-823-R-00-001, Washington, D.C. February (2000b).

Lee et al. used the US EPA recommended approach to evaluate the bioavailability of PCBs in sediments of Smith Canal in Stockton, CA. It was found that only a portion of the PCBs in the Smith Canal sediments were bioavailable. Their findings were discussed in:

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

Sediment Quality Criteria (SQOs)
Various regulatory agencies and investigators have developed and used numeric "sediment quality criteria" to assess and regulate the impact of chemicals in aquatic sediments. While promoted and used in some areas, such approaches (such as those proposed by Long and Morgan, MacDonald, the California Regional Water Quality Control Board - Los Angeles Region, and others) either rely on or incorporate data on the "co-occurrence" of concentrations of particular chemicals in or characteristics of sediments with a reporting or presumption of some "impact." As discussed above, however, such approaches are not only unreliable, but also misleading because of the absence of reliable cause-and-effect foundation that is essential for the approach to have any technical validity for evaluation or regulatory use. Not only is there no causal foundation to those approaches, but also it has been well-documented that such cause-and-effect relationships do not, and would not be expected to, occur. Indeed, as noted above, some of the data upon which co-occurrence relationships have been developed were extracted from studies that demonstrated the lack of cause-and-effect relationship between sediment concentration and impacts. Despite their unreliability, co-occurrence approaches are administratively expedient.

An effort has been underway for several years by the California Water Resources Control Board (SWRCB) to develop sediment quality criteria/objectives; several million dollars have been devoted to this effort. (See "Bay Protection and Toxic Cleanup Program (BPTCP)" Sediment

Quality Objectives (SQO) at:
http://www.swrcb.ca.gov/water_issues/programs/bptcp/sediment.shtml).

The SWRCB evaluated the co-occurrence approach for evaluating sediment quality and concluded that the ERM/ERL criteria were unreliable.

Reliance on or incorporation of chemical concentration-based approaches for assessing potential impact or need for remediation of sediments, as has been done by some of the California Regional Water Quality Boards' staff, can readily lead to incorrect classification of the water quality significance of chemicals in sediments and to disregard of actual causes of impact.

By far the most important problem with the SWRCB sediment quality objectives (SQOs) is the approach suggested for determining the chemical(s) responsible for, and adverse impacts of, sediment. Lee and Jones-Lee have published several reviews on technical strengths and weakness of the SWRCB SQOs and similar approaches. Their publications on the issues, including the following, are available in the "Contaminated Sediment" section of their website [http://www.gfredlee.com/psedqual2.html#criteria].

Lee, G. F., and Jones-Lee, A., "Comments on 'Draft Staff Report Substitute Environmental Document Proposed Amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality for the Protection of Fish and Wildlife' Report of State Water Resources Control Board Division of Water Quality, January 28, 2011," Submitted to State Water Resources Control Board, Report of G. Fred Lee & Associates, El Macero, CA, March 14 (2011). http://www.gfredlee.com/Sediment/SedQualDraftSubCom.pdf.

Lee, G. F., and Jones-Lee, A., "Comments on 'Draft Staff Report, Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1. Sediment Quality Developed by State Water Resources Control Board, California Environmental Protection Agency July 18, 2008'" and Answers to SWRCB Staff Responses to Comments on September 2007 Proposed SQO Development Approach. Submitted to State Water Resources Control Board, Sacramento, CA. Report of G. Fred Lee & Associates, El Macero, CA, September 5 (2008).

At this time the SWRCB staff is attempting to develop SQOs to regulate chemicals in sediments that bioaccumulate in fish. The SWRCB staff is trying to use chemical concentrations in sediment to determine if they are a source of bioaccumulation of chemicals in fish tissue. This approach has been found to be unreliable. Instead, the logical and straight-forward approach is to determine if the fish in a waterbody have excessive concentrations of chemicals that are a threat to the people who consume them is to measure the concentrations in representative fish samples. Using approaches discussed therein it will be possible to determine if the sediments of an area of a waterbody are the source of chemicals that is bioaccumulating to excessive concentration in edible fish in the waterbody.

Evaluating the Adequacy of Sediment Remediation
It has been well-established that it is not possible to reliably evaluate the adequacy of sediment remediation of PCBs and other contaminants based on concentrations of the chemical in the sediment. The US EPA developed the following guidance for using fish tissue data to monitor

the efficacy of remediation:

US EPA, "Using Fish Tissue Data to Monitor Remedy Effectiveness," Office of Superfund Remediation and Technology Innovation and Office of Research and Development, Sediment Assessment and Monitoring Sheet (SAMS) #1, OSWER Directive 9200.1-77D, July (2008). [http://www.epa.gov/superfund/health/conmedia/sediment/pdfs/fish_sams.pdf]

Chapter 8 of the US EPA's "Contaminated Sediment Remediation Guidance for Hazardous Waste Sites" (OSWER Directive 9355.0-85, December 2005) [http://www.epa.gov/superfund/health/conmedia/sediment/pdfs/guidance.pdf] presents an approach for developing an effective monitoring plan at contaminated sediment sites. As stated in that Guidance, one of the goals of monitoring is to "*evaluate long-term remedy effectiveness in achieving remedial action objectives (RAOs) and in reducing human health and/or environmental risk*." It also states:
"A fully successful sediment remedy typically is one where the selected sediment chemical or biological cleanup levels have been met and maintained over time, and where all relevant risks have been reduced to acceptable levels based on the anticipated future uses of the water body and the goals and objectives stated in the ROD."

The information in the following text box is Highlight 8-1 from the US EPA Guidance, US EPA, "Contaminated Sediment Remediation – Guidance for Hazardous Waste Sites," EPA-540-R-05-012, Office of Solid Waste and Emergency Response OSWER 9355.0-85, December (2005).

Highlight 8-1: Sample Measures of Sediment Remedy Effectiveness

Interim Measures:
1 - Short-term remedy performance (e.g., Have the sediment cleanup levels been achieved? Was the cap placed as intended?)

2 - Long-term remedy performance (e.g., Have the sediment cleanup levels been reached and maintained for at least five years, and thereafter as appropriate? Has the cap withstood significant erosion?)

3 - Short-term risk reduction (e.g., Do data demonstrate or at least suggest a reduction in fish tissue levels, a decrease in benthic toxicity, or an increase in species diversity or other community indices after five years?)

Key Measure:
4 - Long-term risk reduction (e.g, Have the remediation goals in fish tissue been reached or has ecological recovery been accomplished?)

The US EPA and FDA also provided guidance on assessing human health risks associated with eating chemically contaminated seafood:

US EPA/FDA, "EPA/FDA Summary Policy Statement on Chemical Residues in Fish and Shellfish," Appendix A in: US EPA, Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish: A Guidance Manual," EPA-503/8-89-002, US EPA, Washington, DC, September (1989).
http://nepis.epa.gov/Exe/ZyPDF.cgi/2000DGLF.PDF?Dockey=2000DGLF.PDF

Basically the US EPA's recommended approach recognizes that the purpose of remediation is achieving wholesome fish. It is an iterative approach whereby the sediment is "remediated," such as by dredging, and then the concentrations of contaminants are measured in the tissue of fish in the waterbody several years later. If the concentrations in fish are at acceptable levels, remediation will have been accomplished; if fish tissue still has excessive concentrations remediation continues, followed by re-assessment of fish tissue concentrations.

Some of the studies of the longer-term impacts of remediation of PCB-polluted sediments on fish tissue residues and excerpts from them include the following:

CDM, "Summary of Baseline PCB Concentrations in Surface Water and Fish Tissue; Evaluation of Pre- and Post-TCRA Data from the Bryant Mill Pond; and Site-Wide Trends in Fish Tissue PCB Concentrations," Report on the Allied Paper Inc./Portage Creek/Kalamazoo River Superfund Site, MI, for Michigan Department of Environmental Quality, May (2009).
http://www.michigan.gov/documents/deq/deq-rrd-KzooRiv-2009-LTM-Report_302666_7.pdf

"The purpose of this report is to summarize the analytical results of surface water and fish sampling activities from 1999 to 2004 that represent a baseline data set for PCBs in these media. The report also includes fish data from 2006 which represent the first trend monitoring dataset."
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GE (General Electric Company Corporate Environmental Programs), "Environmental Dredging: An Evaluation of Its Effectiveness in Controlling Risks," General Electric Company Corporate Environmental Programs, Albany, NY, August (2000).
http://archlib.njit.edu/docs/dredging.pdf

"this paper reviews major sediment remediation projects undertaken in the United States and summarizes key aspects of these projects, such as the objectives of the sediment remediation projects, the technologies being employed, and the capabilities and limitations of those technologies. Finally, recommendations are provided on needed programmatic change. Supporting documentation and project details are provided in the associated tables and appendices."
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ASTSWMO (Association of State and Territorial Solid Waste Management Officials), "Sediment Remedy Effectiveness and Recontamination: Selected Case Studies," Report of ASTSWMO, CERCLA and Brownfields Research Center, Sediment Focus Group, Washington, DC, April (2013).
http://www.astswmo.org/Files/Policies_and_Publications/CERCLA_and_Brownfields/2013-04-Sediment_Remedy_Effectiveness_and_Recontamination.pdf

"This document discusses causes and issues related to recontamination. Discussion topics include new contamination of sediment sites from both known sources and newly identified sources, including contamination from new chemicals or those not addressed in previous assessments, and identification of pollutants most commonly found in areas where recontamination has occurred. Also included are case studies at sediment remediation sites where inadequate source control and/or recontamination have been documented after remedy efforts have commenced."

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Krawczyk, K., Kern, J., Santini, A., King, T., and French, R., "Evaluating the Effectiveness of a Sediment Time-Critical Removal Action Using Multiple Lines of Evidence," IN: A.K. Bullard and E.A. Stern (Conference Chairs), Remediation of Contaminated Sediments—2013," Seventh International Conference on Remediation of Contaminated Sediments, Dallas, TX, Battelle Memorial Institute, Columbus, OH. February (2013). ISBN 978-0-9819730-6-7
https://projects.battelle.org/sediments-conference/2007Sed_Proceedings_Download.zip
"The goal of this evaluation was to document the remedial effectiveness on fish tissue, surface water, and sediment as a result of the U.S. Environmental Protection Agency (US EPA) time-critical removal action (TCRA) that was conducted at the former Bryant Mill Pond (BMP) on Portage Creek in Kalamazoo, Michigan. The primary contaminant of concern at the site is polychlorinated biphenyls (PCBs)." "In total, 112,000 cubic meters of material were removed from the BMP. PCB concentrations in two species of resident fish (carp and white suckers), caged channel catfish, surface water, and sediment were all reduced by over one order of magnitude immediately following the TCRA. The success of the methods used suggest that commitment to remediation of large proportions of contaminated surface area that are in-stream, prone to inundation, or susceptible to erosion into the aquatic system, is required to achieve meaningful reductions in sediment and, correspondingly, fish tissue and surface water PCB concentrations."

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NRC, "Sediment Dredging at Superfund Megasites:: Assessing the Effectiveness," by Committee on Sediment Dredging at Superfund Megasites, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, National Research Council of the National Academies, National Academies Press, Washington, DC (2007).
http://www.nap.edu/openbook.php?record_id=11968&page=R1

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Field, L., Kern, J., and Sloan, R., "PCB Concentrations in Fish Following Partial Remediation of a Small Hazardous Waste Site,"
http://www.darrp.noaa.gov/library/pdf/1452_SETAC_07_Fish_PCB_poster.pdf

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"PCB Contaminated Sediment Remediation in Waukegan Harbor," International Joint Commission for Great Lakes
http://www.ijc.org/php/publications/html/cases/waukegan/waukegan.html

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Santini, A., King, T., Krawczyk, K., and Kern, J., "Effectiveness of a Sediment Time Critical Removal Action - PCB Reduction in Fish Tissue, Surface Water and Sediment via Wet Excavation," Integr Environ Assess Manag. 11(1):161-70. [doi: 10.1002/ieam.1569. Epub 2014 Oct 27] January (2015).
http://www.ncbi.nlm.nih.gov/pubmed/25070026
"Documenting successful remediation of polychlorinated biphenyl (PCB)-contaminated sediments is limited; potentially due to inadequate monitoring methods, complexities associated with the environment, and selected remedial techniques." "This paper presents baseline and post-removal data documenting reduced PCB concentrations in fish tissue, surface water, and sediment in response to the U.S. Environmental Protection Agency (US EPA) Time-Critical Removal Action (TCRA) that was conducted at the former Bryant Mill Pond (BMP) on Portage Creek in Kalamazoo, Michigan."
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WDNR (Wisconsin Department of Natural Resources), "Lower Fox River Operable Unit 1, Post-Remediation Executive Summary," Report by the Agencies/Oversight Team, US EPA Region 5, March 29 (2011).
http://www.epa.gov/region5/cleanup/foxriver/pdf/foxriver-pres-2011.pdf
"The Record of Decision (ROD) issued for Operable Unit 1 (OU1), also known as Little Lake Buttes des Morts, based its polychlorinated biphenyls (PCBs) remedy on attaining sediment concentrations that corresponded with expected risk reductions to human health and ecological factors. The ROD called for remediation of all sediment that was contaminated with PCB concentrations greater than 1.0 parts per million (ppm or mg/kg) on a dry weight basis. The remedy also specified that all targeted sediment be removed, covered, and/or capped.

The OU1 remedy was implemented from 2004 through 2009 and resulted in a reduction of PCB concentrations in 2010 for the three media of interest: fish, sediment, and water. Natural recovery was occurring in these media pre-remedy, i.e., the PCB concentrations in fish, sediment, and water were declining; however, the remedy has markedly accelerated the rate of decline for PCB concentrations in all three media."

Monitoring PCBs in Stormwater Runoff
from Hazardous Chemical Sites and Urban Streets
Drs. Lee and Jones-Lee have developed several professional papers and reports on monitoring hazardous chemicals, including PCBs, in stormwater runoff from hazardous chemical sites including:

Lee, G. F., and Jones-Lee, A., "Issues in Monitoring Hazardous Chemicals in Stormwater Runoff/Discharges from Superfund and Other Hazardous Chemical Sites," Journ. Remediation 20(2):115-127 Spring (2010).
http://www.gfredlee.com/HazChemSites/MonitoringHazChemSW.pdf

As discussed Lee and Jones-Lee have found that the allowed stormwater runoff water quality monitoring from landfills and hazardous chemical sites is inadequate to properly evaluate the hazardous chemicals in the runoff waters.
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It has been found that some urban stormwater contains PCBs derived from leaching of PCBs from caulking compounds in construction and demolition wastes. That issue is reviewed in:

Lee, G. F., and Jones-Lee, A., "PCBs as Contaminants in Construction and Demolition (C&D) Wastes," Report of G. Fred Lee & Associates, El Macero, CA, December 5 (2010). http://www.gfredlee.com/Landfills/CD-LandfillsPCB.pdf

PCB TMDLs

Drs. Lee and Jones-Lee have found that the approach being used by some regulatory agencies to establish TMDLs (total maximum daily loads) for PCBs in water and sediments is not technically valid. The following discuss this issue:

Lee, G.F, and Jones-Lee, A., "Developing TMDLs for Organochlorine Pesticides and PCBs," Presented at the American Chemical Society Environmental Chemistry Division national meeting in San Diego, California, April (2001). http://www.gfredlee.com/Runoff/sandiego_030801.pdf

Lee, G. F., and Jones-Lee, A., "PCBs as an Unlikely Cause of Urban Aquatic Sediment Toxicity: Colorado Lagoon Sediment TMDL," Report of G. Fred Lee & Associates, El Macero, CA, December 3 (2010). http://www.gfredlee.com/Sediment/PCBs-SedToxicity.pdf

TCLP Unreliable for Evaluating Sediments/Soils for Leachable PCBs That Can Bioaccumulate in Fish Tissue

In the 1970s the US EPA developed its "EP TOX" test procedure for classifying a solid waste as "hazardous" or "non-hazardous" for the purpose of directing its disposal to a municipal solid waste landfill or to a hazardous waste landfill. That procedure was replaced by the Toxicity Characteristic Leaching Procedure (TCLP). Dr. Lee has had extensive experience and conducted substantial research devoted to evaluation of the factors that influence the leaching of chemicals from solids such as sediment, soils, and wastes. He and Jones addressed technical issues with using those approaches for categorizing wastes in the following paper that tied for first place as one of two best papers presented at the ASTM conference:

Lee, G.F. and Jones, R.A., "Application of Site-Specific Hazard Assessment Testing to Solid Wastes," IN: Hazardous Solid Waste Testing, ASTM STP 760, American Society for Testing and Materials, pp. 331-344 (1981). http://www.gfredlee.com/HazChemSites/hazassesstest.pdf

As they discussed, the TCLP testing procedure was politically motivated and designed to limit the amount of the hazardous wastes requiring management in hazardous waste landfills. The conditions of the TCLP are not appropriate for the reliable assessment of the leachability of a chemical from a solid. Guidance on how to make more reliable assessments was provided in:

Lee, G.F. and Jones, R.A., "A Risk Assessment Approach for Evaluating the Environmental Significance of Chemical Contaminants in Solid Wastes," IN: Environmental Risk Analysis for Chemicals, Van Nostrand, New York, pp. 529-549 (1982).

http://www.gfredlee.com/HazChemSites/SiteSpecificTCLP.pdf

Despite its unreliable technical foundation, the TCLP procedure was subsequently adopted by some regulatory agencies, without proper technical review, for evaluating the leaching potential of a chemical such as PCBs from a soil or sediment. An additional problem with how that procedure has been used for this purpose is that analytical methods used to evaluate the release of PCBs do not have adequate analytical sensitivity for measuring PCB at concentration levels that are a threat to bioaccumulate to excessive levels in eatable aquatic life such as fish and shellfish. The use of analytical methods that are not sufficiently sensitive to properly evaluate the release of PCBs from sediments and soils to prevent PCB bioaccumulation in fish tissue to hazardous levels is a common problem among regulatory agencies and consultants. These issues and the inappropriateness of the TCLP for this purpose are discussed 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

PCB Disposal in Landfills

Drs. Lee and Jones-Lee have extensive experience in evaluating the potential for PCBs disposed in landfills to lead to environmental pollution. Papers/reports on this issue include:

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). Last updated October (2012). http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf

Lee, G. F., and Jones-Lee, A., "Practical Environmental Ethics: Is There an Obligation to Tell the Whole Truth?" Published in condensed form as "Environmental Ethics: The Whole Truth," *Civil Engineering*, Forum, 65:6 (1995). http://www.gfredlee.com/Landfills/ethics.pdf

Lee, G.F., "Review of the Adequacy of the BFI/CECOS Aber Road Hazardous Waste Landfill Facility Closure and Post-Closure Plans to Protect Public health and the Environment," G. Fred Lee & Associates, El Macero, CA, January, 19 (1999).
http://www.gfredlee.com/Landfills/bfi_cecos.pdf

Lee, G. F., and Jones-Lee, A., "Superfund Site Remediation by Landfilling - Overview of Landfill Design, Operation, Closure and Postclosure Care Issues," *Remediation* **14(3)**:65-91, Summer (2004). http://www.gfredlee.com/Landfills/LFoverviewRemediation.pdf

Lee, G. F., "Problems with Landfills for Superfund Site Remediation." Presentation at the US EPA National Superfund Technical Assistance Grant (TAG) Workshop, Albuquerque, NM, February (2003). http://www.gfredlee.com/Landfills/Show-SuperfundAlbuquerque.pdf

Lee, G. F., and Jones, R.A., "Is Hazardous Waste Disposal in Clay Vaults Safe?" Journ. American Water Works Association 76:66-73 (1984). (This paper was judged by the Water Resources Division of the AWWA as the Best Paper published in the JAWWA in 1984.)

http://www.gfredlee.com/HazChemSites/ClayVault.pdf

Following is a description of a number of projects undertaken by Drs. Lee and Jones-Lee related to the evaluation of impacts of PCBs on environmental quality and public health.

There are numerous areas in the Upper Midwest that have PCB-containing sediments and wastes that are being remediated by removal to landfills. The US EPA Region 5 (Upper Midwest-Chicago) adopted the policy of allowing PCB-containing wastes including as PCB-polluted sediments to be disposed of in municipal solid waste landfills in order to reduce the disposal costs. That approach, however, ignores the inability of municipal landfills to contain such contaminants for as long as they will remain a threat. PCBs in a landfill do not decompose to render them no longer a threat; they will remain a threat for as long as they remain in the landfill. As the landfill cover and liner systems deteriorate and allow leachate generation, and the necessary postclosure monitoring and maintenance will be inadequate to prevent pollution by the landfill leachate. Many of these issues have been discussed with regard to particular landfill situations investigated by Drs. Lee and Jones-Lee in reports cited below.

PCB Disposal in Wayne Disposal Landfill:
Lee, G. F., "Comments on Wayne Disposal Incorporated's Proposal to Renew the License/Permit for Continued Operation of its Hazardous Waste Landfill, Wayne Disposal Landfill Site #2, and the Expansion of this License/Permit to Include the Acceptance of PCB Wastes," Report of G. Fred Lee & Associates, El Macero, CA , July 27 (1996).
http://www.gfredlee.com/Landfills/WayneDispYpsilanti.pdf

PCB Disposal in the Clinton Landfill:
Lee and Jones-Lee reviewed potential public health impacts associated with the acceptance of PCBs in a TSCA PCB landfill unit in the DeWitt County MSW landfill, on behalf of DeWitt County, IL. Their findings are described in:

Lee, G. F., and Jones-Lee, A., "Evaluation of the Potential for Area Disposal Company Proposed Chemical Waste Unit Landfill to Pollute the County Water Resources with Hazardous Chemicals," Report to County Board, DeWitt Co., IL. Report of G. Fred Lee & Associates, El Macero, CA, May 7, (2009). http://www.gfredlee.com/Landfills/Clinton_IL_CWU.pdf

Development of Protective Landfills
As discussed in the following report, it is possible to develop landfills for disposal of PCB-polluted soils and sediments that are more protective of environmental quality and public health than typical landfills that receive such wastes today. Key features of such landfills are discussed by Lee in:

Lee, G. F., "Developing Protective Landfills," Report of G. Fred Lee & Associates, El Macero, CA, January 19 (2013).
http://www.gfredlee.com/Landfills/Sum_Developing_Protective_Landfills.pdf

Appendix A
PCB Pollution – Summary of G. Fred Lee's Background & Examples of Experience

Overall Experience

Dr. Lee's pioneering work on PCBs, which began in the 1960s, gained national recognition in the technical community as well as in the public arena, for example in his being interviewed by Walter Cronkite for the CBS Evening News. Dr. Lee's experience in working on issues of environmental pollution by PCBs is summarized in:

Lee, G. F., "Experience in Working with PCB Pollution Issues," Report of G. Fred Lee & Associates, El Macero, CA (2014).
http://www.gfredlee.com/HazChemSites/PCBExperience.pdf

Work on PCB pollution issues was a key component of the Water Chemistry Program at the University of Wisconsin, Madison as well as the other university graduate programs that Dr. Lee developed. The development and nature of that program is summarized in:

Lee, G. F., and Jones-Lee, A., "Development of the Water Chemistry Program at the University of Wisconsin Madison & Follow-on Activities of Dr. Lee in Developing the Water Chemistry Field," Report of G. Fred Lee & Associates, El Macero, CA, January 1 (2012).
http://www.gfredlee.com/Education/WaterChemProgramDevel.pdf

Examples of Specific Studies Conducted

Milwaukee River PCB Studies

In the mid-1960s Dr. Lee served as the PhD dissertation advisor to Gilman Veith whose work focused on investigating the occurrence of PCBs in the Milwaukee River, WI. Several publications resulted from those studies including the following that discuss the occurrence of PCBs in the Milwaukee River fish, sediments and some domestic waste water treatment plant effluents:

Veith, G., and Lee, G. F., "A Review of Chlorinated Biphenyl Contamination in Natural Waters," *Water Research* **4**:265-269 (1970).
http://www.gfredlee.com/HazChemSites/Veith-Lee-ReviewPCB.pdf

Veith, G., and Lee, G. F., "PCBs in Fish from the Milwaukee Region," Proc. 14th Conf. Great Lakes Res., Internat. Assoc. Great Lakes Res. pp. 157-169 (1971).
http://www.gfredlee.com/HazChemSites/Veith-Lee-PCBFishMKE.pdf

Veith, G., and Lee, G. F., "Chlorobiphenyls (PCBs) in the Milwaukee River," *Water Research* **5**:1107-1115 (1971). http://www.gfredlee.com/HazChemSites/Veith-Lee-PCB-MKERiver.pdf

Dube, D. J., Veith, G. D. and Lee, G. F., "Polychlorinated Biphenyls in Treatment Plant Effluents," Journ. Water Pollut. Control Fed. 46:966-972 (1974).
http://www.gfredlee.com/HazChemSites/Dube_Veith_Lee_PCB_WWTP.pdf

Advisor for PCB Remediation
The advice of Dr. Lee has been sought in the identification, impact evaluation, and management of PCB-polluted sediments in a number of areas including the Hudson River and Hudson River Estuary near New York City. Those waterbodies were highly polluted with PCBs derived from a GE electrical condenser manufacturing plant that discharged PCB-containing wastewaters to the Upper Hudson River. Information on this issue is provided in:
http://www.dec.ny.gov/docs/fish_marine_pdf/pcbhudsonecosys.pdf
http://www.epa.gov/hudson/plans.html

On several occasions the US EPA Region 2 asked Dr. Lee for advice on approaches that should be used to control excessive PCB accumulation in striped bass in the Hudson River. The issue of concern was whether models that were used to evaluate the release of PCBs to Hudson River fish were reliable and could be used to estimate the reduction in concentrations of PCBs in river fish that could be expected to occur from selective dredging of PCB-polluted sediments from "hot spots."

He was an advisor on issues of PCB accumulation in waterbodies in the state of Wisconsin, including the Milwaukee River. His work on managing PCB-contaminated sediments included serving as an advisor to Outboard Marine Corporation to assess whether the PCB-polluted sediment in Waukegan Harbor was a significant source of PCBs for Lake Michigan.

California Central Valley Waterbodies PCB Studies
On behalf of the Central Valley Regional Water Quality Control Board, Drs. Lee and Jones-Lee conducted a review of the State Water Resources Control Board data base for organochlorine legacy pesticides and PCBs in Central Valley fish. The following publications resulted from those studies:

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

Lee, G. F., and Jones-Lee, A., "Need for Funding to Support Studies to Define the Magnitude of the Excessive Bioaccumulation of Organochlorine 'Legacy' Pesticides and PCBs in Edible Fish That Can Cause Cancer in Those Who Use Delta/Central Valley Fish as Food," Report of G. Fred Lee & Associates, El Macero, CA, April 4 (2005)
http://www.gfredlee.com/Runoff/OClProblemProject.pdf

Lee, G. F., and Jones-Lee, A., "Update of Organochlorine (OCl) 'Legacy' Pesticide and PCB Concentrations in Delta and Central Valley Fish," Report of G. Fred Lee & Associates, El Macero, CA, September 10 (2007).
http://www.gfredlee.com/SurfaceWQ/UpdateLegacyPestCVFish.pdf

It was found that some of the fish such as largemouth bass contained sufficient concentrations of PCBs to pose a threat to human health for those who relied on the fish for food.

Draft EIS for US Gypsum Facility
Dr. Lee was asked to evaluate the adequacy of a draft environmental impact statement (EIS) for a proposed US Gypsum facility at the Port of Stockton, CA. The soils of the area to be developed contained PCBs. A report on those studies is:

Lee, G. F., Jones-Lee, A. "Comments on the 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, submitted to Lozeau / Drury Alameda, California December 2008. http://www.gfredlee.com/HazChemSites/USGypsumDEIR.pdf

Their work showed, contrary to statements made in EIS, PCBs in area soils would pollute the waters of the San Joaquin River that would receive runoff from the area.

Remediation of Sydney Tar Ponds, Nova Scotia, Canada
On behalf of the Sierra Club of Canada Lee and Jones-Lee conducted a review of the proposed remediation of the Sydney Tar Ponds in Nova Scotia that had been polluted by a former steel mill wastewater discharges that included PCBs. The focus of that reviewed was the adequacy of Sydney Tar Ponds Agencies' and the Canadian regulatory agencies proposed approach for remediation of the Sydney Tar Ponds hazardous chemical site, polluted with PCBs and PAHs, using in situ cement-based solidification/stabilization. The following publications resulted from that study:

Lee, G. F., "Comments on, 'Remediation of Sydney Tar Ponds and Coke Ovens Sites Environmental Impact Statement, Sydney, Nova Scotia,' dated December 2005," Report of G. Fred Lee & Associates, El Macero, CA, USA, May 15 (2006). http://www.gfredlee.com/Landfills/SydneyTarPondsReport.pdf

Lee, G. F., "Assessment of the Adequacy & Reliability of the STPA Proposed Approach for Remediation of the Sydney Tar Ponds' Sediments," Presentation to the Sydney Tar Ponds and Coke Ovens Sites Remediation Project Joint Review Panel, Sydney, Nova Scotia, CANADA, PowerPoint Slides; G. Fred Lee & Associates, El Macero, CA, May 15 (2006). http://www.gfredlee.com/Landfills/SydneyTarPondsPowerPt.pdf

Lee, G. F., "Unreliable/Inadequate Information on the Efficacy of Solidification/ Stabilization of Sydney Tar Pond Sediments," Report of G. Fred Lee & Associates, El Macero, CA, February (2007). http://www.gfredlee.com/Landfills/SydneyTPSedSolidif.pdf

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

Lee, G. F., "Update on the Remediation of the Sydney Tar Ponds: Potential Health Effects of Offsite Odor Problems," Report of G. Fred Lee & Associates, El Macero, California November (2009). http://www.gfredlee.com/Landfills/SydneyTarPondsOdors.pdf

Lee, G. F., and Jones-Lee, A., "Comments on the Adequacy of the Sydney Tar Ponds Agency SS Remediation Objectives," Report of G. Fred Lee & Associates, El Macero, CA, June 14 (2010). http://www.gfredlee.com/Landfills/STP_SSRemObjectives.pdf

It was found that the approach adopted to remediate the PCB polluted estuarine sediment was inadequately evaluated the ability of the cement based treated sediments through the use of the TCLP and inadequate analytical methods for measuring PCBs released from the treated sediments.

Review of the PCB-Pollution of the Upper Fox River, Wisconsin
In connection with litigation, Drs. Lee and Jones-Lee reviewed the history of PCB-pollution of the Fox River, WI during the 1960s to early 1970s, on behalf of the Upper Fox River Wisconsin paper mill group. This litigation was discussed in a March 3, 2011 Associated Press article published in the Washington Post, the headline of which was:

"NCR, others must pay $700M for Wis. River Cleanup
MILWAUKEE -- A federal judge in Wisconsin has ordered NCR Corp. and Appleton Papers Inc. to pay an estimated $700 million to clean a contaminated river, the latest effort to hold paper makers accountable for toxins in the Green Bay waterway."
http://www.washingtonpost.com/wp-dyn/content/article/2011/03/03/AR2011030303959.html

The basic issue was whether NCR should have to help pay for the remediation of PCB-polluted sediment in the Upper Fox River. NCR sold carbonless copy paper waste (broke) that contained PCBs to paper companies; the paper companies' use of the broke as feed stock resulted in PCBs in their wastewaters that were released to the Fox River and polluted the river sediments. Dr. Lee advised on what was known in the late 1960-early 1970s about the threat that PCBs in wastewaters represented to pollute waterbodies based on his and his graduate student's (G. Veith) work at the time.

Dr. Lee was involved in a similar manner with the Kalamazoo River Superfund Site described in the press articles:
"NCR Invented the PCB-containing Carbonless Copy Paper":
http://upperpeninsulabreakingnews.com/category/ncr-invented-the-pcb-containing-carbonless-copy-paper/ and

"NCR, Int'l Paper Liable For Mill Superfund Cleanup"
http://www.law360.com/articles/476154/ncr-int-l-paper-liable-for-mill-superfund-cleanup

Appendix B
Evolution of Water Quality Criteria for PCBs

The federal 1972 Clean Water Act mandated the development of water quality criteria to provide a basis for states to develop regulatory water quality standards. While the US EPA did not release criteria in a timely manner, the National Academies of Science and Engineering released its "Blue Book" Water Quality Criteria–1972 (NAS/NAE, 1973) (cited below), which was a synopsis of what was known about the impacts of chemicals, including PCBs, on beneficial uses of waters. Dr. Lee was an invited peer-reviewer for the NAS/NAE "Blue Book" water quality criteria.

NAS/NAE, "Water Quality Criteria of 1972," National Academies of Science and Engineering, EPA/R3-73-033, US Environmental Protection Agency, Washington, D.C. (1973).
It is available online at:
http://nepis.epa.gov/Exe/ZyNET.exe/2000XOYT.TXT?ZyActionD=ZyDocument&Client=EPA&Index=Prior+to+1976&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C70thru75%5CTxt%5C00000003%5C2000XOYT.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7CMaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

While the NAS/NAE "Blue Book" did not fulfill the mandate of the Clean Water Act, it was comprehensive and peer-reviewed. Its discussion of PCBs concluded with the statement: *"Because too little is known about the levels in water, the retention and accumulation in humans, and the effects of very low rates of ingestion, no defensible recommendation can be made at this time."*

In 1976, under pressure from legal action taken against it and without proper peer-review, the US EPA released its "Quality Criteria for Water" ("Red Book").
US EPA, "Quality Criteria for Water," US Environmental Protection Agency, Washington, D.C. (1976).
http://water.epa.gov/scitech/swguidance/standards/criteria/current/upload/2009_01_13_criteria_redbook.pdf

The 1976 "Red Book" criteria for PCBs were:

- *"0.001 ug/L for freshwater and marine aquatic life and for consumers thereof"*
- *"Every reasonable effort should be made to minimize human exposure."*

Because the US EPA "Red Book" criteria had not been peer-reviewed, the American Fisheries Society Water Quality Section conducted a critical review of the US EPA "Red Book" criteria; Dr. Lee contributed to the review of a number of the criteria, including PCBs. In 1979 the AFS Water Quality Section published its findings:

Thurston, R., Russo, R., Fetterolf, C., Edsall, T., and Barber, Y., Jr. (eds), "A Review of the EPA Red Book: Quality Criteria for Water," Water Quality Section, American Fisheries Society, Bethesda, MD (1979). http://books.google.com/books/about/A_review_of_the_EPA_red_book.html?id=IFfxAAAAMAAJ

The AFS review contained a peer-reviewed chapter devoted to the criteria for PCBs; Dr. Lee participated in that peer-review:

Veith, G. D. (coordinator), Carver, T. C., Jr., Fetterolf, C. M., Lee, G. F., Swanson, D. L., Willford, W. A., and Zeeman, M. G., "Polychlorinated Biphenyls," In: A Review of the EPA Red Book: Quality Criteria for Water, American Fisheries Society, Bethesda, MD, pp 239-246 (1979). http://www.gfredlee.com/SurfaceWQ/AFS_PCB_RedBookReview.pdf

It stated that some members of the PCB criteria panel were concerned that the water quality criteria for PCBs presented in the "Red Book" were not protective and should be lowered by a factor of 10.

In the 1980s the US EPA revised its approach for developing water quality criteria; Dr. Lee was a US EPA-invited peer-reviewer of the revised approach. In 1986 the US EPA released its "Quality Criteria for Water 1986" (the "Gold Book") that reflected its new approach: http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/upload/2009_01_13_criteria_goldbook.pdf

The 1986 criteria presented somewhat revised criteria for PCBs as follows:

- *"For polychlorinated biphenyls the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.014 ug/L as a 24-hour average. The concentration of 0.014 ug/L is probably too high because it is based on bioconcentration factors measured in laboratory studies, but field studies apparently produce factors at least 10 times higher for fishes."*
- *For polychlorinated biphenyls the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.030 ug/L as a 24-hour average. The concentration of 0.030 ug/L is probably too high because it is based on bioconcentration factors measured in laboratory studies, but field studies apparently produce factors at least 10 times higher for fishes."*
- *"For the maximum protection of human health from the potential carcinogen effects of exposure to polychlorinated biphenyls through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero, based on the nonthreshold assumption for this chemical. However, zero level may not be attainable at the present time." It then noted that the PCB corresponding to a cancer risk of 10-6 is 0.079 ug/L for consumption of* water and organisms, and also for consumption of organisms only.

In 2002 the US EPA released its "National Recommended Water Quality Criteria: 2002" [http://water.epa.gov/scitech/swguidance/standards/upload/2008_04_29_criteria_wqctable_nrwqc-2002.pdf], which listed the following water quality criteria for PCBs:

- *for protection of freshwater aquatic life: Criterion Continuous Concentration (CCC): 0.014 ug/L [N, aa]*
- *for protection of saltwater aquatic life: CCC 0.03 ug/L [N, aa]*
- *for protection of human health: 0.000064 ug/L [B, C, N] for consumption of water and organisms or only organisms*

footnotes:

aa This criterion is based on a 304(a) aquatic life criterion issued in 1980 or 1986, and was issued in one of the following documents: Polychlorinated biphenyls (EPA 440/5-80-068).

B This criterion has been revised to reflect The Environmental Protection Agency's q1 or RfD, as contained in the Integrated Risk Information System (IRIS) as of May 17, 2002. The fish tissue bioconcentration factor (BCF) from the 1980 Ambient Water Quality Criteria document was retained in each case.*

C This criterion is based on carcinogenicity of 10-6 risk. Alternate risk levels may be obtained by moving the decimal point (e.g., for a risk level of 10-5, move the decimal point in the recommended criterion one place to the right).

N This criterion applies to total PCBs, (e.g., the sum of all congener or all isomer or homolog or Aroclor analyses.)

In 2005 the US EPA released its "National Recommended Water Quality Criteria of 2005," http://www.epa.gov/waterscience/criteria/wqctable/. Water quality criteria for PCBs for aquatic life toxicity and specified as applicable to total PCBs (e.g., the sum of all congener or all isomer or homolog or Aroclor analyses), were given for:

- *freshwater CCC (chronic): 0.014 ug/L*
- *saltwater CCC (chronic): 0.03 ug/L*

In 1999 the US EPA released "Human Health Water Quality Criteria for Polychlorinated Biphenyls (PCBs) in the National Toxics Rule (NTR) Summary of Final Rule Revision," EPA-822-F-99-003; September 1999 [http://water.epa.gov/lawsregs/rulesregs/ntrfact.cfm], which stated:

"The U.S. Environmental Protection Agency is revising the human health water quality criteria for polychlorinated biphenyls (PCBs) in the National Toxics Rule. When the National Toxics Rule was adopted, human health criteria for PCBs were calculated using the cancer potency factor entered in the Agency's Integrated Risk Information System (IRIS). The Agency is revising the human health water quality criteria for PCBs in the NTR, based on the Agency's reassessment of the cancer potency of PCBs."

"EPA now adopts an approach that distinguishes among PCB mixtures by using information on environmental mixtures and different exposure pathways. Based on this reassessment, EPA derived the new human health criteria for PCBs by using a cancer potency factor of 2 per mg/kg-day. This potency factor is considered protective of children and adults who drink surface water and eat fish from water contaminated with PCBs. The revised NTR human health criteria for PCBs are both 0.00017 ug/L for protection of human health from consumption of aquatic organisms and water, and consumption of aquatic organisms only."