Proposed Plan for the Remediation of Portland Harbor Superfund Site
Comments of Environmental Stewardship Concepts, LLC
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On behalf of Willamette Riverkeeper
September 6, 2016

In these comments, we begin with listing the recommendations that are covered in the comments. Next we address general aspects of the Proposed Plan and Feasibility Study (FS) as published for public comment. Finally, our comments address a number of topics with specific comments, listed below, in the order presented. Some recommendations are to strengthen the language or the action that is stated in the Proposed Plan because these elements need to be required and not optional elements. In the experience of ESC, LLC and many communities, necessary elements of Superfund remedies must be required elements in the Record of Decision and not left to the interpretation of future decision-makers and litigation by PRPs.

Please address the question: How much chemical contamination, in Kg, will be removed by the final remedy, how much left in place and how much will be capped?

To summarize, we find that Alternative G best achieves the objectives and goals that EPA sets out in the Proposed Plan, and that Alternative I, the preferred alternative, does not meet the goals. In this regard we agree with the Plan that reaches the same conclusion. Alternative G reduces exposures to a greater extent and faster than any other alternative. Alternative G addresses to substantial spatial extent of scour, including in the ship docking areas. Alternative I does not consider that all of the contaminants except PAHs will not break down and will forever contaminate fish, seafood and the local biota. This point is important because this western river system is home to species such as sturgeon, that are highly sensitive to the contaminants present in the Harbor (PCBs, dioxins and furans, DDx, metals) that will remain as contaminants for hundreds of years if not forever. **We urge EPA to adopt Alternative G with enhancements in the ROD.**

Other recommendations for elements to include in the ROD are listed below.

Recommendations

General comments on the Proposed Plan/FS

I. Alternative G
II. Community Considerations
III. Institutional Controls
IV. Monitored Natural Recovery (or attenuation)
V. Atmospheric Transport as an Exposure Pathway
VI. New Technologies
VII. Upland Source Control

VIII. Confined Disposal Facility
IX. Environmental Monitoring During Remediation
X. Fish Tissue Monitoring
XI. Habitat Restoration
XII. Timeframe for Estimating Costs
XIII. Compliance with CWA
XIV. Design Phase data collection

Recommendations:

1) Adopt Alternative G with enhancements to improve the long term effectiveness, cost effectiveness, increase treatment, reduce exposures and fluxes and increase community acceptance, as described below in details.
2) Select disposal options that do not include a Confined Disposal Facility and that do include maximum possible treatment of dredged sediment to breakdown or bind contaminants. Pilot projects should be considered for sediment treatment.
3) Because Institutional Controls (IC) are not effective, especially in the long term, EPA needs to reduce the need for ICs, and include in the ROD provisions for PRPs covering the full costs of ICs, as long as ICs are in place, and provisions for evaluating the IC effectiveness with regular program modifications.
4) Monitored Natural Recovery (MNR), with or without enhancement has not been shown to be effective with contaminants that do not break down and therefore EPA needs to reduce the use of MNR, enhance the monitoring to annually, and include provisions in the R.O.D. for contingency actions if monitoring data indicate unsatisfactory performance results.
5) Accept the new technology options that will reduce costs and improve long term effectiveness. These may be conducted as pilot projects.
6) Include atmospheric transport in analysis of exposures. This inclusion will indicate the extent to which remaining contamination will expose humans in the community to unacceptable risks.
7) Require the state of Oregon to continue upland sources control via legally enforceable means; the current text indicates that this approach “May” be taken; the text needs to indicate that this approach shall be used..
8) EPA needs to require installation of environmental and quality of life monitoring during the construction phase, with the PRP’s covering the cost. This provision needs to be a required element and clearly stated.
9) The general goals and design characteristics/requirements of the fish tissue monitoring need to be specifically listed in the R.O.D.
10) Habitat restoration following remedy construction needs to be a required element in the R.O.D. Aquatic habitat that is disturbed by the remedy must be restored and the full cost paid by the PRPs. When nearshore and intertidal habitat has to be removed, it must be replaced and replanted with SAV that thrives.

11) This remedy will have features that must be maintained in perpetuity and thus analyses need to account for a longer time frame in estimating costs and benefits.
12) The community expects the final remedy to comply with state environmental quality, especially the water quality criteria for the PTW contaminants. PCBs, dioxins and DDTs in water and fish must meet state water quality standards.
13) When the data are obtained for the remedial design, these must be shared with the community.
14) This site presents characteristics of an Environmental Justice community, yet EPA has not addressed this issue. EPA needs to assess the EJ aspects of this site and take appropriate action to enhance protective and remedial measures.

The FS was revised and released with the Proposed Plan after comments from the National Remedy Review Board, the community and Tribes, and included new analyses and alternatives. Specifically, the FS and Proposed Plan now include alternatives for dredging the entire contaminated area (footprint) of the Portland Harbor Superfund site. EPA is to be commended for including alternatives that cover the widest possible range of remedial actions for this site, providing the public with a complete perspective. The procedural challenge with the way in which the new alternatives were added is that the public did not have a chance to examine the alternatives until June 2016, unlike all of the other elements of the FS that were released in August-September 2015. The Proposed Plan, however, does not explain how EPA derived Alternative I, the logic behind Alternative I, or how Alternative I meets the goals and objectives of this remedial action.

The preferred alternative , Alternative I, is far less effective and less protective than Alternative G in the Proposed Plan for a number of reasons that justify EPA selecting Alternative G in the ROD. These reasons are:

1. Alternative G removes 5.5 - 6 million cubic yards more than Alternative I. The real question is how much more contamination is removed by Alternative G in the 5.5-6 million cubic yards. The FS and Proposed Plan do not provide us with the level of spatially specific analysis to estimate the contaminants removed, but some data do permit gross estimates. We estimate that Alternative G will remove as much as 4000 Kg more PCBs than Alternative I (assuming volume removed, 1800 lb/cubic yard and up to 1 ppm PCBs).
2. Alternative I does not effectively consider the scour of Portland Harbor and will leave in place acres of contaminated sediment that EPA's own analysis indicates are in non-depositional areas of the harbor.
3. Alternative G with additional shoreline remediation will address one of the high contact exposure areas for people, especially children.
4. The contaminants in Portland Harbor are both concentrated in identifiable areas, many of them near shore-based source areas (e.g. Arkema) plus broadly distributed contamination across the harbor; both need attention or the remedy will not effectively address the problem.

It is not clear why EPA did not include any new treatment methods, or options for considering these in the remedial action. Some of these options, listed in these comments under “New Technologies,” offer sufficiently substantial advantages that these methods could reduce cost, or treat contaminants or shorten construction. We note these advantages in the section on Technologies.

Alternative G offers the best and effective remediation of the Portland Harbor Superfund site, short of complete removal and ESC recommends adoption of Alternative G with enhancements to further protect health and the environment and insure long term effectiveness. The details of the enhancements are described below in the section on Alternative G.

The Proposed Plan engages in an analysis that approaches the remedy selection from the perspective of a pre-selected approach- that capping is the standard. On page 14 of the Proposed Plan, the text under the section “PTW that cannot be reliably contained” indicates that PTW was considered for other options if that PTW could not be reliably contained by a cap. This text at least implies, if not states that the first analysis of PTW was to cap, and only after a cap was evaluated would other options be analyzed or considered.

EPA needs to provide in the ROD estimates of the contaminants removed, remaining in each category: capped, shoreline, ENR and MNR.

I. Alternative G

The 2016 Portland Harbor Superfund Site Proposed Plan indicates a preference for Alternative I, which is a combination of Alternatives B through F, with Disposed Material Management (DMM) Scenario 1. The EPA justifies this decision by stating that Alternative I “addresses the most significantly contaminated sediment to achieve a substantial and consistent risk reduction in all areas of the river at the time of construction completion” (US EPA Region 10 2016, page 66). However, the Proposed Plan states that “Alternative I does not meet all of the risk reduction goals at construction completion, but it does achieve a consistent amount of risk reduction throughout the Site when compared to the other alternatives” (US EPA Region 10 2016, page 67). The Proposed Plan admits that only Alternative G achieves the remediation goals set out by the Agency.

However, EPA admits that Alternatives F and G offer a greater risk reduction post-construction completion, since 3-4 times more volume of contaminated material would be removed. The justification for not choosing Alternatives F or G is that increased removal would “impose significantly greater impacts to the environment and community and have much greater costs that are not commensurate with the additional risk reduction relative to Alternatives E and I” (US EPA Region 10 2016, page 60).

As stated previously in this document, certain remedies, such as dredging and capping, can disrupt critical surrounding habitats and threaten the overall health of the ecosystem. However, these effects are temporary, modern methodologies provide substantial risk prevention, and habitat restoration can offset the impacts (Committee on Sediment Dredging at Superfund Megasites et al. 2007). Additionally, newer technologies like environmental dredging reduces the number of disturbances to the ecosystem and contaminants while removing the contaminants from the site (TAMS and Malcolm Pirnie 2004). Furthermore, the costs of Alternatives F and G can be reduced if the construction duration is shortened.

Environmental Stewardship Concepts and several community groups recommend Alternative G as the selected remedy for the Site. Out of all the alternatives given, Alternative G is the most protective of human and environmental health and has the best chance for restoring the Portland Harbor and Willamette River.

The following table compares Alternative G to Alternative I:

Remedial Activity	**Alternative G**	**Alternative I**
Dredging	571.1 acres 6,221,000-8,294,000 cy	167.1 acres 1,414,00-1,885,000 cy
Excavation	139,000 cy	103,000 cy
Capping	184.7 acres	64.1 acres
Ex Situ Treatment	156,000 – 208,000 cy sediments 9,500 cy soil	156,000 – 208,000 cy sediments 9,500 cy soil
ENR	19.5 acres	59.8 acres
MNR	1,391 acres	1,876 acres

As indicated in the table above, Alternative G includes more active remediation, dredging, excavation, capping, and e*x situ* treatment of the contaminated sediments and soil than Alternative I; therefore, more contamination will be removed from the Site with Alternative G. Excavation and removal are the only remedies that ensure contaminants will not resurface in the future and are therefore the most protective of human and environmental health. Dredging and excavation can result in the least uncertainty regarding future environmental exposure to contaminants when cleanup levels are achieved since the contaminants are permanently removed from the ecosystem and disposed of in a contained environment(US EPA Office of Wetlands 2011).

While Alternative G is the most protective option of human and environmental health, more needs to be done to reach the target faster. Right now the construction duration is estimated to be 19 years. With the right enhancements this timeframe could be shortened, thus making Alternative G the optimal choice. Enhancements should include more shoreline remedial action and more dredging. The best way to keep historically contaminated sediments from serving as a source of contamination would be to remove an additional 750 acres of contaminated surface sediments from the Site.

The long term effectiveness of a remedy is greatly increased with more removal and treatment of contamination at any Superfund site. The greater the remaining contamination in place or in a CDF, the greater the need for monitoring and greater the probability of remedy failure. We note the experience of an Early Action on the Lower Duwamish River at the area known as Slip 4, with Boeing Corporation as the Potentially Responsible Party. Boeing had the option of a partial capping/partial removal of PCB contaminated sediment and shoreline area. Boeing opted for a permanent remedy via complete removal, with restoration. The complete removal eliminated long term liability to Boeing by eliminating the presence of the contamination and eliminating a need for long term monitoring, maintenance and possible further action. We note that contamination left in place will require monitoring in perpetuity.

Conclusion

ESC and numerous Portland Harbor community groups urge the EPA to support the adoption of Alternative G with the necessary aforementioned enhancements. Alternative I is inadequate because too many contaminants will be left at the Site and will continue to threaten human health and the environment, including ESA species.

References

Committee on Sediment Dredging at Superfund Megasites, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, and National Research Council. *Sediment Dredging at Superfund Megasite: Assessing the Effectiveness*. Washington, D.C.: National Academies Press, 2007.

TAMS and Malcolm Pirnie, Inc. 2004. *Lower Passaic River Restoration Project: Dredging Technology Review Report*.

United State Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds. 2011. *PCB TMDL Handbook*. Vol. EPA 841-R-.

United States Environmental Protection Agency, Region 10. 2016. *Portland Harbor Superfund Site Proposed Plan*.

II. Community Considerations: Environmental Justice; Hiring Locally; State and Community Acceptance; and Tribal Consultation

There are several community considerations that need to be included in the Site's cleanup plans.

Environmental Justice

Environmental justice (EJ) is given little, if any, attention in this proposed cleanup plan. There are no identifiable actions to protect communities that have suffered harm as a result of background, income, ethnicity, or race.

Remediation will reduce risks caused by the Site's contaminants for the entire population. However, the vulnerable population is unfairly exposed to risks from multiple sources and contaminants. Therefore, they need more risk reduction to offset their cumulative risks.

Voluntary actions need legally binding elements to ensure the utmost protection for those most vulnerable. The following should be considered and acted upon from an EJ standpoint:

- Cumulative Risks
- Source control
- Risk reduction does not mean that the gap in unfair contaminant distribution between the general population and the vulnerable population goes away
- Jobs
- Health screenings

Federal EJ guidance is valuable for developing approaches that help address risks faced by EJ communities, such as NEPA's six guiding principles:

1. Consider the composition of the affected area to determine if there are any EJ communities affected by the proposed action. If so, determine if there may be disproportionately high and adverse environmental or human health impacts on the minority, low-income, or tribal populations.
2. Consider relevant industry and public health data concerning the potential for multiple or cumulative exposure to environmental or human health hazards in the impacted communities. Agencies should also consider these population's historical patterns of exposure to environmental hazards.
3. Recognize the interrelated cultural, occupational, economic, social, or historical factors that could amplify the environmental effects of the proposed action.
4. Develop effective participation strategies open to the public. All linguistic, institutional, cultural, geographic, and other barriers should be acknowledged and addressed. Agencies should incorporate active outreach to these communities.
5. Assure meaningful community participation throughout the process. Community participation must occur early on to be meaningful.
6. Seek tribal representation consistent with the government-to-government relationship between the U.S. and tribal governments, any treaty rights, and the federal government's trust responsibility to federally-recognized tribes (Council on Environmental Quality 1997).

Culturally appropriate measures should be taken to protect EJ communities until protective risk levels are achieved. All decision documents for the Site should acknowledge and account for the latest science on cumulative exposures and the potential for more negative health effects on EJ communities as a result of these multiple exposures.

Hiring Locally

Qualified community members from the Portland area should receive priority in the hiring process. As individuals directly impacted by the contamination and future remedial efforts, they should be the first to benefit from any job creation stemming from remedial activities.

State and Community Acceptance

Both the state of Oregon and the surrounding communities will be greatly impacted by all remedy decisions. Therefore, state and community acceptance is an important component of the Portland Harbor Superfund Site final cleanup plan. Already, the Port of Portland has indicated that a CDF is not acceptable due to long term liability and cost. We applaud the Port's decision and recognition of long term viability as a critical element in the remedy selection.

State Acceptance

The State of Oregon should have meaningful involvement throughout the entire Superfund process, including determining appropriate remedial actions and identifying remediation standards and requirements. Once Portland Harbor's remedial actions are fully implemented, the State of Oregon will be responsible for maintaining the remedy and implementing and maintaining institutional controls where wastes are left in place.

Considering the state will play a greater role once the remedy is complete, the state must concur with the remedy. We have no indication that the state is satisfied with the Plan.

Community Acceptance

Agencies should seek and provide opportunities for meaningful participation from the surrounding community. Community members, and the public as a whole, should have access to enough information to be well informed and to provide constructive input. The community's collective input should be carefully considered in developing and implementing remedial plans.

The Portland Harbor community has rejected the Proposed Plan as inadequate. Since they are the ones directly impacted by the contamination and future remedial activities, their collective concerns and opinions should be taken into consideration.

Tribal Consultation

Agencies should seek active participation from affected Indian tribes early on in the decision process. According to National Environmental Policy Act's Environmental Justice guidance, tribal representation should be sought by agencies in a manner consistent with the government-to-government relationship between the US and tribal governments, any treaty rights, and the federal government's trust responsibility to federally-recognized tribes (Council on Environmental Quality 1997).

So far during the decision processes at the Site, tribal consultation and coordination has been nominal. There is no indication that the Portland Harbor Proposed Plan has been modified to meet the needs of the impacted tribes.

Conclusion

From the start of the remedial process, EPA has an obligation to consider environmental justice implications, hire locally, and work with the state, community, and Indian tribes. So far in the processes, there seems to be no effort made in ensuring these obligations are met.

References

Council on Environmental Quality. 1997. *Environmental Justice: Guidance Under the National Environmental Policy Act*. *Theory of Ordered Sets and Its Applications*.

III. Institutional Controls

Institutional Controls(ICs)can have major shortcomings if not implemented, monitored, and enforced correctly. ICs are defined as non-engineered tools that aid in protecting the integrity of a remediation remedy and/or in minimizing the potential for human exposure to contaminationthrough restricting land or resource use and by managing human behavior. They are not meant to be the primary or sole remedy at a site; they supplement engineering controls (USEPA 2015). Examples of ICs include deed and zoning restrictions, public advisories, signs, and fencing.

EPA's cleanup alternatives in the Willamette River Proposed Plan rely too heavily on ICs to protect human health and the environment. According to the EPA, ICs decrease risks from exposure to contaminated sediments, fish/shellfish consumption, and other potential exposure pathways. However, they are not sufficient and should therefore not be used as a central means of reducing potential on-site exposures. For example, signs in English are not effective for non-native English speakers. ICs used to protect sediment caps will have to be enforced in perpetuity, which is not a permanent, protective solution.

The United States Government Accountability Office (US GAO) released a report on the effectiveness of controls at sites in 2005. A key finding in the report is that "relying on institutional controls as a major component of a selected remedy without carefully considering all of the applicable factors- including whether they can be implemented in a reliable and enforceable manner- could jeopardize the effectiveness of the site remedy" (US GAO 2005).

EPA's guidance at the time of this report did not specify when it is necessary to use controls, making it unclear whether or not a specific site needs to implement them. Available guidance stated that ICs are "generally required" or "likely appropriate" for sites unable to accommodate unrestricted use and unlimited exposure. Additionally, EPA guidance identified four factors that need consideration during the remedy decision stage: 1.) the objective of the IC; 2.) the mechanism or type of control used to achieve that objective; 3.) the timing of the implementation of the control and its duration; and 4.) the party who will bear the responsibility for implementing, monitoring, and enforcing the ICs. To help ensure the control will be sufficiently protective of human health, all four of these factors need to be adequately addressed. If the consideration of these factors are not documented, there is no assurance that enough thought went into the design of the ICs, which is a critical aspect in ensuring they can be effectively implemented, monitored, and enforced (US GAO 2005).

Monitoring is necessary to ensure the continued effectiveness of the ICs. The US GAO report noted that current monitoring efforts may not occur frequently enough to identify problems within a timely manner no rdo they always include checks on controls. EPA faces many challenges in ensuring ICs are adequately implemented, monitored, and enforced. Despite being an EPA requirement, the report found that Superfund site controls were not often implemented before site deletion. Furthermore, EPA officials have acknowledged that the required Five Year Reviews could be too infrequent to determine if institutional controls are still effective. EPA also recognized that it could have difficulties enforcing ICs at some sites. Informational ICs, such as public advisories and deed notices, do not legally limit or restrict use of the site. Additionally, local or state laws can limit the available enforcement options for the selected ICs (US GAO 2005).

At the time of the US GAO report, only minimal information on ICs were able to be tracked; information on long-term monitoring and enforcement were not included (US GAO 2005). This is a major hurdle to determining whether ICs are an effective method for risk reduction at any future sites.

EPA's own report, *Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites*, released in 2012, states its own findings in regarding IC limitations. Reporting is one of the most critical components of ICs once they are instated. To ensure the effectiveness of the ICs, monitoring reports must be kept up-to-date and reported to the appropriate regulatory authorities. The reports need to evaluate the status of the ICs. If the property has been transferred to a new owner, the reports should also evaluate whether or not use restrictions and controls were properly communicated in the deed(s) and whether or not notifications of the use restrictions and controls were sent to the new owner(s) and state and local agencies (USEPA Office of Solid Waste 2012). The report also states that creating ICs without creating any type of accurate enforcement can lead to problematic outcomes (USEPA Office of Solid Waste2012). Overall, the report illustrates numerous ways ICs can be ineffective at protecting human health solely due to poor reporting and enforcement.

The Environmental Law Institute(ELI) released the *Institutional Controls in Use* report in 1995. The report provides an analytical review on how ICs have been used at Superfund sites in order to inform policymakers on how to best use ICs to protect human health. ELI's main findings are as follows:

- If ICs are to be put into place, the variability of human response to rules, warnings, restrictions, and institutions must be taken into account.
- Dispersal of contaminants can negate ICs regarding zoning and land use. For example, migrating contaminated groundwater and pesticide drift can cause the contaminant to disperse, or move, to nearby properties not covered under the IC.
- Conservation easements are often problematic to the EPA, as they are governed by property law, which differs between states. Therefore, creating a federal methodology for using easements as a type of IC would create serious administrative burdens.
- Communication barriers between informative warning signs and future generations arise for contaminants with long residence times.
- ICs, unlike other types of remediation methods, can be ignored by the public.
- Often, ICs put limitations and/or restrictions on land instead of doing a comprehensive cleanup.
- If not properly enforced, ICs can potentially lead to more problems.
- ICs can fail if the institutions fail or stop performing their function.
- Signs, barriers, and fences often fail due to weathering and natural degradation or vandals (ELI 1995).

In the 2016 Proposed Plan, EPA states that ICs "should be relied upon to the minimum extent practicable, the less reliant an alternative is on ICs the more protective the alternative" (USEPA Region 10 2016). Therefore, we recommend a higher emphasis be placed on contaminant removal.

References

Environmental Law Institute. 1995. *Institutional Controls in Use*.

United States Environmental Protection Agency. "Superfund: Institutional Controls." EPA. September 30, 2015. Accessed July 07, 2016. https://www.epa.gov/superfund/superfund-institutional-controls.

United States. Environmental Protection Agency, Office of Solid Waste and Emergency Response. *Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites*. 2012. 1-40. Print.

United States Environmental Protection Agency, Region 10. 2016. *Portland Harbor Superfund Site Proposed Plan*.

United States Governmental Accountability Office. 2005. *Hazardous Waste Sites: Improved Effectiveness of Controls at Sites Could Better Protect the Public*.

IV. Monitored Natural Recovery

Monitored Natural Recovery(MNR)is a tool used to supervise the progress of natural attenuation processes (Gomes et al. 2013). It has not been shown to effectively remediate contaminants that do not degrade, which includes metals, PCBs, and dioxins and furans, among other chemicals. MNR may work to degrade PAHs that are easily broken down by bacteria under specific, controlled environmental conditions, not so with PCBs, dioxin/furans and metals.

In 2009, the Environmental Security Technology Certification Program (ESTCP) released a *Technical Guidance: Monitored Natural Recovery at Contaminated Sites* report. ESTCP stated that MNR can offer low implementation risk with a high level of remedy effectiveness *if* implemented under the appropriate site conditions. Natural processes are ongoing and can be used in conjunction with other engineering approaches to increase overall effectiveness and success of remedial action. It is typical for a site to combine dredging, capping, and MNR as its remedial action. However, MNR should be used to address areas of low risk areas already showing evidence of recovery, whereas dredging and capping should be used on areas of elevated risk. MNR can also be used after dredging and capping to contribute to the long-term, post-remediation recovery (Magar et al. 2009).

MNR is *not* effective for all site conditions. Conditions that are particularly conducive to MNR include the following:

- Natural recovery is expected to continue at rates that contain, reduce, or destroy the bioavailability or toxicity of contaminants within an acceptable time frame
- Institutional Controls (ICs) can reasonably limit human exposure during the recovery period
- In the biota and biologically active zone of sediment, contaminant exposures are moving toward risk-based goals
- The sediment bed at sites where buried contaminants are left in place is reasonably stable and is expected to remain so (Magar et al. 2009).

Additionally, MNR effectiveness relies on contaminant transformation, isolation, immobilization, and removal processes used to reduce site risks over time. Remedy risks associated with MNR include the following:

- Continual exposure to contaminants during the MNR period

- Risk that assumptions about the MNR modeling are incorrect, so short- and long-term exposures will not decline or will increase
- MNR acceptability is dependent on the uncertainties related to the natural recovery process rates predictions and the amount of time necessary to meet remedial goals (Magar et al. 2009).

The EPA is relying too heavily on the use of MNR in the Proposed Plan alternatives being considered to clean up the Willamette River. Cleanup options with high reliance on MNR would leave the Willamette River severely contaminated and threaten the surrounding communities and fish and wildlife populations. MNR should be a very limited option only utilized in areas of lowest concentration of the least toxic contaminants and where there is a very high degree of certainty that it will be effective. Based on decades of data, MNR is not generally an effective strategy for persistent contaminants, such as PCBs, PAHs, dioxins and furans, and heavy metals. Portland Harbor is contaminated with highly toxic, pervasive contaminants, which have already been left in place for decades with little or no sign of abating. It is unreasonable to suggest MNR as an effective cleanup method when these contaminants have already remained in the river at unacceptable levels for 50+ years.

Furthermore, projections for MNR and the future recovery of the River over time depend on the reduction of contaminants from upriver sources and floodplain areas adjacent to the Willamette in Portland. Source control is critical to the MNR success. The contaminants, which are already unlikely to degrade naturally, cannot decrease through MNR if the sources are not addressed. Moreover, the ability to monitor and quantify MNR processes can become compromised if there is a lack of understanding and management of sources. MNR will be ineffective if natural recovery rates are overcome by ongoing releases (Magar et al. 2009).

Additionally, MNR is not a suitable option for the Site due to the nature of the Willamette River. MNR is essentially the burial of contaminants in place. The Willamette is not a depositional river due to flooding, tidal action, fast currents, and prop wash. Therefore, any burial or sand covering will not stay in place. Instead, the pollutants will likely spread further downriver and to the Columbia River. Therefore, we recommend that MNR is only used sparingly.

Concerns exist regarding the time required for recovery and the potential for exposure to contaminants remaining at the site. Comprehensive MNR site assessments are needed to determine if MNR can be implemented appropriately and effectively. MNR site assessment should include extensive risk assessment, site characterization, predictive modeling, and targeted monitoring. Evidence of the appropriateness and effectiveness of MNR for reducing human health and environmental risks should be identified by a conceptual site model (CSM) and properly documented (Magar et al. 2009).

ESTCP developed the following checklist for evaluating the feasibility of MNR at a site:

1. Have sources at the site been sufficiently controlled to support effective natural recovery?
2. Do historical data show decreasing exposures over time?
3. What evidence exists of chemical transformation at the site?
4. What evidence exists for reduced chemical bioavailability and mobility at the site?
5. What evidence exists for physical isolation of contaminants at the site?
6. What evidence exists of natural recovery via chemical or sediment dispersion processes?
7. To what extent do process interactions influence natural recovery?
8. How effectively will natural recovery processes reduce risks (Magar et al. 2009)?

When using this checklist on the Portland Harbor Superfund Site, MNR does not seem like a feasible remediation method. Upland sources have not been adequately controlled and data do not indicate that contaminant concentrations have been decreasing with time. Moreover, the nature of the River is not conducive to successful MNR, meaning that unacceptable levels of contaminants will remain.

In some cases where there is minimal contamination or infrequent disturbance, MNR may be an effective, economically feasible method of remediation. However this is not the case for the Willamette River.

References

Gomes, H.I., C. Dias-Ferreira, A.B. Ribero. 2013. Overview of in situ and ex situ remediation technologies for PCB-contaminated soils and sediments and obstacles for full-scale application. *Science of the Total Environment* 445-446:237-260.

MacDonald, J.A. 2000. Evaluating natural attenuation for groundwater cleanup. Environ mental Science & Technology 34(15):346-353.

Magar, V.S., D.B. Chadwick, T.S. Bridges, P.C. Fuchsman, J.M. Conder, T.J. Dekker, J.A. Steevens, K.E. Gustavson, and M.A. Mills. 2009. *Technical Guidance: Monitored Natural Recovery at Contaminated Sediment Sites*. *Environmental Security Technology Certification Program*.

V. Atmospheric Transport as an Exposure Pathway

The atmospheric release of PCBs is not included in any part of the EPA's analysis of the Portland Harbor Superfund Site or the Portland Harbor Proposed Plan. Recent research confirms that PCBs can be released into the air. Contaminated air is a pathway for human exposure, and inhalation exposure can cause adverse health effects in people. Consequently, atmospheric release of PCBs should be included in the Site's analysis and selected cleanup remedy.

Atmospheric Release, Transport, and Deposition

Dating back to the origins of PCB synthesis, there have been numerous cases of PCBs being released into the environment during industrial fires, as they are fire resistant. After industrial fires occur, airborne particles deposit on water, land, and vegetation, which increase the likelihood for human exposure (Dayan et al. 2002).

Global Distillation is the process in which persistent organic pollutants (POPs) are transported from hotter to colder places on the plant. The primary mechanism behind the transport associated with Global Distillation is due to meteorological factors as well as a particular POPs physicochemical property. Methods of transport for Global Distillation are primarily atmospheric, however hydrologic and organismal methods of transport do occur (US EPA 2002).

POPs are susceptible to long range atmospheric transport (LRAT), evident in the discovery of POPs in parts of the world where they have never been utilized. Due to the phsyicochemistry of particular POPs, LRAT spreads POPs globally and tends to deposit them in high altitude or polar regions. Since these regions of the world are generally more pristine and remote, this illustrates the importance of traditional, localized sinks for POPs such as sediment, vegetation, and water(Guzzella et al 2016).

Impact of PCBs on Human Health

Ample research provides evidence of PCBs' harmful effects on human health. These impacts include immune system suppression, reduced IQ, altered behavior, thyroid, and reproductive function, increased risk of liver and cardiovascular disease and diabetes, low birth rate, and tumor promotion (Carpenter 2006).

PCB Inhalation as an Exposure Pathway

While consumption of PCB-contaminated fish is the primary pathway for human exposure, inhalation of PCB-laden particles and volatile congeners, dermal absorption following direct contact, and ingestion of contaminated dusts or soil are also possible pathways (Knobeloch et al. 2012). Data specifically focused on human PCB exposure via inhalation are sparse. However, animal studies and the few human studies conducted suggest that inhalation exposures could contribute more to the total PCB exposure than previously suspected (Lehmann et al. 2015). For instance, PCB levels detected in non-fish eating populations indicate that eating contaminated fish is not the only exposure pathway (Knobeloch et al. 2012).

A study conducted by Ampleman et al. (2015) analyzed congener-specific inhalation exposure, as well as dietary exposure, for 78 adolescent children and their mothers in a study assessing Airborne Exposure to Semi-volatile Organic Pollutants (AESOP).Using 293 measurements of outdoor and indoor airborne PCB concentrations at schools and homes and questionnaire data from the AESOP Study, congener-specific PCB inhalation exposure was modeled. PCB inhalation was found to be a source of PCB exposure for the studies' mothers and children. Dietary exposure was higher than inhalation exposure for the sum of all PCB congeners analyzed; however, inhalation exposure was as high as one-third of the total exposure (inhalation and dietary) for individual lower-chlorinated PCB congeners (Ampleman et al. 2015).

Carpenter (2006) suggests that dermal absorption and inhalation are viable routes of PCB exposure. Animal studies conclude that inhalation of vapor-phase PCBs is a significant route of exposure, which can bioaccumulate and cause medical and behavioral issues. Carpenter's investigation provided evidence that PCB inhalation is a significant route of exposures in humans as well. PCB-contaminated hazardous waste sites produce notably elevated levels of vapor-phase PCBs, which can lead to various health effects among communities living near such contaminated sites (Carpenter 2006).

Carpenter (2006)also analyzed a study conducted by Kudyakov et al., which examined hospitalization rates in relation to residence near PCB-contaminated sites. There were significantly elevated hospitalization rates for acute and chronic infectious respiratory diseases in people living in zip codes contaminated by PCBs in the Hudson River vs. those in zip codes without PCB-contaminated hazardous waste sites. These residents had higher family incomes than those living in zip codes without PCB-contaminated hazardous waste, suggesting that they exercise more, smoke less, and eat healthier than less affluent New Yorkers. Therefore, the increased hospitalization rates were attributed to PCB exposure from the Hudson River (Carpenter 2006).

Data collected near a municipal solid waste incinerator in Catalonia, Spain were used to assess air concentrations of polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), and polychlorinated naphthalenes (PNCs). Results were used to estimate the nearby population's exposure and to evaluate carcinogenic and non-carcinogenic risks related to the inhalation of persistent organic pollutants (POPs). Air inhalation was found to be the predominant exposure pathway for the sum of all seven PCB congeners analyzed, as well as PCDD/Fs, and PCNs (Vilavert et al. 2014).

Two urban centers in China were analyzed to determine the human daily intake of PCBs via indoor and outdoor dust (Wang et al 2013).Moderate dust inhalation accounted for 99.5% of non-dietary exposure for adults and 97.1% for children. High dust inhalation rates accounted for 89.4% for adults and 65.0% for children. Dust inhalation exposure was estimated to be higher than the dust ingestion pathway, particularly for adults. The researchers concluded that the inhalation of airborne PCBs should be considered as a major contributor to non-dietary exposure in humans (Wang et al. 2013).

Conclusions

Atmospheric deposition influences land and water quality, as atmospheric contaminants will eventually deposit to the ground surface. In Portland, where there is a densely populated urban area in close proximity to the Willamette River and the Portland Harbor, atmospheric deposition to ground surfaces plays an important factor in determining the biological integrity of the river in addition to deposition directly to the water (Gunawardena et al. 2013). The 2016 Portland Harbor Superfund Site Proposed Plan even lists atmospheric deposition as a source of off-site contaminants reaching the Site (US EPA Region 10 2016).

Ample evidence exists for the harmful impacts of PCBs on human health. While the majority of studies focus on the consumption of contaminated fish as the primary exposure route, inhalation of volatilized PCBs and PCB-contaminated dust also contribute to human exposure.

With recent research confirming that PCBs can be released into the air and that exposure by inhalation can cause harmful health effects in people, the atmospheric release of PCBs should be considered a source of PCB contamination at the Site, and subsequently included in the Site's analysis and potential cleanup remedies.

References

Ampleman, Matt D., Andres Martinez, Jeanne DeWall, Dorothea F K Rawn, Keri C. Hornbuckle, and Peter S. Thorne. 2015. "Inhalation and Dietary Exposure to PCBs in Urban and Rural Cohorts via Congener-Specific Measurements." *Environmental Science and Technology* 49: 1156–64. doi:10.1021/es5048039.

Carpenter, David O. 2006. "Polychlorinated Biphenyls (PCBs): Routes of Exposure and Effects on Human Health." *Reviews on Environmental Health* 21 (1): 1–23. doi:10.1515/REVEH.2006.21.1.1.

Dayan, Uri, and Jean Koch. "Dispersion of PCB in the Environment following an Atmospheric Release Caused by a Fire." *The Science of the Total Environment*, 2002, 147-53.

Gunawardena, Janaka, Prasanna Egodawatta, Godwin Ayoko, and Ashantha Goonetilleke. "Atmospheric Deposition as a Source of Heavy Metals in Urban Stormwater." *Atmospheric Environment*, 2013.

Guzzella, Licia, Franco Salerno, Michele Freppaz, Claudio Roscioli, Francesca Pisanello, and Guilia Poma. "POP and PAH Contamination in the Southern Slopes of Mt. Everest (Himalaya, Nepal): Long-range Atmospheric Transport, Glacier Shrinkage, or Local Impact of Tourism?" *Science of the Total Environment*, 2016.

Knobeloch, Lynda, Mary Turyk, Pamela Imm, and Henry Anderson. 2012. "Polychlorinated Biphenyls in Vacuum Dust and Blood of Residents in 20 Wisconsin Households." *Chemosphere* 86. Elsevier Ltd: 735–40. doi:10.1016/j.chemosphere.2011.10.048.

Lehmann, Geniece M., Krista Christensen, Mark Maddaloni, and Linda J. Phillips. 2015. “Evaluating Health Risks from Inhaled Polychlorinated Biphenyls: Research Needs for Addressing Uncertainty.” *Environmental Health Perspectives* 123 (2): 109–13. doi:10.1289/ehp.1408564.

United States Environmental Protection Agency. 2002*The Foundation for Global Action on Persistent Organic Pollutants: A United States Perspective*.

United States Environmental Protection Agency, Region 10. 2016. *Portland Harbor Superfund Site Proposed Plan*.

Vilavert, Lolita, Mart Nadal, Marta Schuhmacher, and Jos Luis Domingo. 2014. “Seasonal Surveillance of Airborne PCDD/Fs, PCBs and PCNs Using Passive Samplers to Assess Human Health Risks.” *Science of the Total Environment* 466-467. Elsevier B.V.: 733–40. doi:10.1016/j.scitotenv.2013.07.124.

Wang, Wei, Min Juan Huang, Jin Shu Zheng, Kwai Chung Cheung, and Ming Hung Wong. 2013. “Exposure Assessment and Distribution of Polychlorinated Biphenyls (PCBs) Contained in Indoor and Outdoor Dusts and the Impacts of Particle Size and Bioaccessibility.” *Science of the Total Environment* 463-464. Elsevier B.V.: 1201–9. doi:10.1016/j.scitotenv.2013.04.059.

VI. New Technologies

In the 2016 Portland Harbor Proposed Plan, EPA chose cleanup alternatives that relied on older remedial technologies. Due to the widespread problem of PCB, PAH, and heavy metal contamination across the globe, new methods are emerging to treat these contaminants. Many of these new methods have proven to be less disruptive to the surrounding ecosystems and communities, and in some cases, just as-or-more effective and cheaper than older methods. Treatment of dredged material is more viable than ever before and needs to be given greater attention in the Proposed Plan and Feasibility Study. Additionally, newer treatments are available for riverbank contamination as well. EPA should reevaluate their emphasis on traditional dredging, institutional controls (ICs), and monitored natural recovery (MNR) and consider implementing more of the newer, emerging technologies.

The following includes a list of methods shown to successfully remediate PCBs and other persistent contaminants across different matrices.

Environmental dredging

Environmental dredging is more precise than navigational dredging, thus ensuring more removal with fewer disturbances to the ecosystem and contaminants. It is cheaper than other removal technologies and has less of an impact on the surrounding community and wildlife. Mechanical and hydraulic dredging are two examples of environmental dredging. Mechanical dredges handle debris well and are better suited for shallow areas and smaller sediment volumes. Hydraulic dredges can handle high sediment volume, work well in deep water, and provide ease of transport for sediment and water; they are not well suited for large debris. The effectiveness of environmental dredging depends on the type and size of equipment used and the operating conditions (TAMS and Malcolm Pirnie 2004).

If cleanup levels are achieved, dredging and excavation can result in the least uncertainty regarding future environmental exposure to contaminants, as the contaminants are permanently removed from the ecosystem and disposed of in a contained environment. Removal requires less long-term maintenance operations than other methods(US EPA Office of Wetlands 2011). While dredging can cause contaminant concentration increases in fish tissue and the water column during or immediately after dredging, these increases are temporary and the levels subsequently fall to concentrations much lower than before the dredging began (Committee on Sediment Dredging at Superfund Megasites et al. 2007).

The cleanup of the Hudson River PCB site in New York and New Jersey relied on mechanical dredges with environmental buckets for PCB remediation (US EPA Region 2 2015). Contaminated sediments were scooped up from the river bottom and loaded into hopper barges. Computer software was used to identify where to dig, and depth and location of digging was determined by satellites (US EPA Region 2 2015), making for a very precise remediation effort.

Soil Washing

Soil washing is a water-based, multi-step process of remediating sediment *ex situ* to top soil quality by mechanically mixing, washing, and rinsing soil (US EPA 2013). Solvents can be combined with the water during the washing process. Contaminant removal occurs in one of two ways: 1) dissolving/suspending them in the wash water that can be sustained by chemical manipulation of pH or 2) by concentrating them into a smaller volume of soil (US EPA 2013).

Reducing the volume of material requiring further treatment by another technology makes soil washing a cost-effective technology (Khan et al 2004). It also has the ability to recover metals and clean a wide range of inorganic and organic contaminants from coarse grain soils. Soil washing facilities can also be constructed where the sediment is unloaded, eliminating the cost of transporting the sediment elsewhere. Depending on site-specific conditions and the target waste quantity and concentration, the average cost for soil washing technology, including excavation, is approximately $170/ton (Khan et al. 2004).

BioGenesis^{SM}

BioGenesis^{SM} sediment washing was patented in December 2001 to decontaminate coarse- and fine-grained particles. It is a low-temperature decontamination process, which uses a proprietary blend of chemicals, impact forces from high pressure water, and aeration to decontaminate sediments off-site. It isolates individual particles and removes contaminants and naturally occurring material adsorbed to the particles (BioGenesis 2008).

The end result of the BioGenesis^{SM} process is treated soil or sediment. Depending on the results achieved and on obtaining any necessary regulatory approvals, the treated soil or sediment can either be disposed of or potentially used as fill material or as raw material (BioGenesis 2008). BioGenesis^{SM} offers the advantage of handling large volumes of soil. Additionally, a BioGenesis^{SM} treatment facility can be constructed where the sediment is unloaded, eliminating the need for and cost of transportation.

A full-scale operation using BioGenesis^{SM} was conducted on dredged material from the New York/New Jersey Harbor. Analytical tests on the treated sediment showed reductions in PCBs, dioxins, and all heavy metals except arsenic. The concentration of total PCBs in decontaminated sediment was below the standard of 490 µg/kg, but still above the 2008 New Jersey Residential Direct Contact Soil Remediation Standard of 200 µg/kg. Many contaminants were readily removed; however, others, such as PAHs, were difficult to remove (BioGenesis 2009).

In a commercial scale facility (500,000 cubic yards/year), the cost of BioGenesis^{SM} is very competitive at approximately $50-59 per cubic yard (BioGenesis 2009).

Bioremediation

Bioremediation uses indigenous microbial populations to consume target contaminants *ex situ*. The process relies on enzymes expressed from microorganisms to break down contaminants into non-toxic, less-complex organic constituents, which are then used for bacterial growth and reproduction (BioTech Restorations*)*. PCB microbial degradation occurs via two paths: aerobic and anaerobic (Gomes et al 2013).

Bioremediation is a natural process that improves the overall quality of soils, different types of bioremediation technologies are available, and costs are relatively low to moderate. The addition of phosphorous, supplementary carbon sources, nitrogen, oxygen, primers, and analog enrichment can improve efficiency. Bioremediation does require particular environmental conditions for microbes to grow, and the process is therefore very sensitive to abiotic factors such as temperature. Additional disadvantages include the inability to introduce microbes to grow at depths sufficient to reach contaminants, and the slow rate of PCB removal (Gomes et al 2013).

BioPath Solutions

The company formerly known as BioTech Restorations, Inc. (BTR) pioneered a new method of treating contaminated soil and sediment by employing tilling to prepare for bacterial breakdown treatment. It works on a variety of pollutants, including PCBs and pesticides, and can be employed in soil, groundwater, and dredged marine sediments.

BioPath Solutions, an environmental remediation company specializing in the cleanup of persistent organic pollutants (POPs), is now the sole licensee of this technology. Bacteria's ability to discharge reductive enzymes is impaired by the presence of POPs. BioPath's team developed a Factor treatment, which restores the indigenous bacteria's microbial enzyme production, allowing for enzymatic de-chlorination of target contaminants and the prompt microbial utilization of residual organic constituents (BioTech Restorations).

A first generation Factor was developed in 1998 to remove toxaphene from soils in the former Hercules pesticide production facility in Brunswick, Georgia. Within 24 weeks, a single Factor application decreased toxaphene from 3500 ppm to non-detect.
BTR treatment Factors have been successfully implemented to reduce PCB and other persistent chlorinated organic pollutant concentrations in soils of 17 different laboratory and field investigations including:

- Housatonic River- Pittsfield, MA
- New England Log Home Bench Study- Great Barrington, MA;
- Blue Jay Ct. 2 acres- East Palo Alto, CA;

This method is less expensive than offsite disposal, but is not appropriate for soil volumes of less than 500 cubic yards. Nutrient control is a critical element of the process, and therefore the method may not be applicable within a river. However, for dredged sediment or in situ soils, BioPath can develop specific "bioblends," treatments that are site specific and account for a particular mix of contaminants. After two to four treatment cycles, PCB levels are reduced to non-detect levels, or 99.99% reduction (Chris Young, pers. comm.).

Carbonaceous Materials
Carbonaceous materials are simply carbon-based materials. Activated carbon, biochar and grapheme are some commonly used carbonaceous materials.

Activated Carbon

In a 2014 study, Beless et al. compared the efficiency of activated carbon, charcoal, carbon nanotubes, grapheme, and grapheme oxide as sorbent materials for 11 PCB congeners. Results showed that activated carbon was the superior sorbent material (Beless et al 2014).

A 2012 study by the same group examined PCB levels in contaminated sediment five years after initial activated carbon treatment. PCB levels in sediment cores post-treatment had remained at the reduced levels first observed five years prior, supporting long-term effectiveness of *in situ* activated carbon (Cho et al. 2012).

Biochar

Biochar is the byproduct of thermal decomposition of organic matter. Biochar can be used to reduce the bioavailability and phytoavailability of PCBs in soil and improve soil quality. Denyes et al. conducted a study on biochar as a reductor for PCB levels in plants, and found that adding 2.8% (by weight) of biochar to contaminated soil reduced PCB root concentration in two different plants by 77% and 58%, respectively (Denyes et al 2012). When 11.1% biochar was added to the soil, reduction of 89% and 83% were observed. In addition, Denyes et al. found that biochar amended to PCB-contaminated soils increased the amount of aboveground biomass and worm survival rates (Denyes et al. 2012).

Electroremediation

Applying electric potential to contaminated sediment can stimulate the breakdown of contaminants by microorganisms. Voltage applied to contaminated sediment provides electron-donors and/or acceptors to PCB dechlorinating and degrading microorganisms. In a 2013 study by Chun et al., scientists applied voltage to PCB-contaminated sediment from the Fox River Superfund site under *in situ* conditions. Applying voltage did stimulate oxidative and reductive microbial transformation, with increased voltage enhancing overall degradation. Using electrolytic biostimulation, approximately 62% of weathered Aroclor was removed from sediments within 88 days (Chun et al. 2013).

Electroremediation can provide a more environmentally sustainable remediation method for *in situ* contamination compared to other forms of remediation requiring combustion or excessive use of non-renewable natural resources. Electrodialytic remediation is based on the combination of the principle of electrodialysis with the electrokinetic movement of ions in soil. This method has been found to successfully remediate contaminants across different matrices, such as *ex situ* soils, fly ash, mine tailings, freshwater and harbor sediments, and sewage sludge. A study conducted in 2015 using electrodialytic remediation with iron nanoparticles resulted in an 83% PCB removal rate when direct current was used (Gomes 2015).

Phytoremediation

Phytoremediation uses plants and their associated microorganisms to sequester, extract, and degrade contaminants from soil or water either *in situ* or *ex situ* (Gomes et al 2013). Plants take up various organics and either process them for use in physiological processes or degrade them. Some plants have the ability to store large amounts of metals that do not seem to be utilized by the plant (Cronk and Fennessy 2001).

Phytoremediation is effective in upland and shallow areas as well as shorelines. It can be used alongside bioremediation with dredged sediment. The majority of research centered on phytoremediation has shown that the bacteria growing in the rhizosphere does most of the remediation (US EPA 2013).

Rhizoremediation refers to plant enhancement of microbial activity, which takes place in the root zone and improves bioremediation through the release of secondary metabolites. To improve the effectiveness of phytoremediation, genetically-modified bacteria or bacterial genes involved in the metabolism of PCBs can be introduced into the phytoremediation process (Gomes et al 2013).

Phytoremediation provides a noninvasive means of removing/degrading contaminants. It can be implemented using a variety of plants; canarygrass and switchgrass were found to be particularly effective on soil (Chekol et al., 2004). Other plants, including pine tree, alfalfa, flatpea, willow, deertongue, tall fescue, poplar, tobacco, and mustard, have been tested for their efficiencies to reduce PCBs in contaminated soils (Jha et al 2015).

In a 60-week study, Huesemann et al (2009) used eelgrass to remove PAH- and PCB-contaminated marine sediment *in situ*. PAHs and PCBs were removed to a larger extent from planted sediments than from the unplanted control. After the 60 weeks of treatment, PAHs declined by 73% in the presence of plants but only 25% in the controls. Total PCBs decreased by 60% in the planted sediments while none were removed in the unplanted control. The presence of eelgrass likely stimulated the microbial biodegradation of PAHs and PCBs in the rhizosphere by releasing plant enzymes, root exudates, or oxygen (Huesemann et al. 2009).

Phytoremediation is a solar energy-driven system requiring minimal maintenance and environmental disturbance, creating a low-cost remediation method. It garners high public acceptance due to its great aesthetic value (Jha et al 2015). Other advantages include: it is a passive remediation method; organic pollutants can be converted to carbon dioxide or water instead of transferring toxicity; secondary waste is minimal; the uptake of contaminated groundwater can prevent the migration of contamination; and it can be used on a wide range of contaminants (Khan et al. 2004). The few disadvantages include: bioaccumulation is dependent on soil properties (pH, organic carbon content), high contaminant concentrations inhibit plant growth, efficiency is affected by plant stress factors, and plant disposal must be assessed to prevent the transfer of pollution (Gomes et al. 2013).

UV Treatments

UV-oxidation treatment is a viable technology for treating contaminated groundwater by using an oxidant in conjunction with UV light. This technology is applicable to all types of petroleum products, PCBs, dioxins, PAHs, and other various forms of organic carbons (Khan et al. 2004). Costs range from $10 to $50 per 1000 gallons of water, and are affected by several factors, including the degrees of contaminant destruction required, the type and concentration of the contaminants, the flow rate of the groundwater system, and the requirement for pre- and post- treatment (Khan et al. 2004).

Mobile UV Decontamination

A study conducted in 2013 by Kong et al. demonstrated that using UV and visible light is effective in treating PCBs in transformer oil (Kong et al. 2013). Researchers developed a mobile PCB remediation unit showing ultraviolet light's capability of effectively degrading PCBs in transformer oil, soils, and sediment. The project is a 15 meter long mobile unit that combines UV and visible light technologies to degrade PCBs by as much as 94%, at a fraction of the cost of inicineration while remaining on site (Unviersity of Calgary 2013). This technology is well suited for areas where soil or sediment could be removed and processed nearby.

Capping

While traditional capping passively contains a pollutant, reactive capping is an emerging technology that caps the designated area with additives that can absorb and immobilize, increase degradation, or reduce the bioavailability of contaminants. Additives used include activated carbon, biochar, and metals such as zero-valent iron coated palladium (Gomes et al. 2013). In a pilot study at Hunters Point Shipyard in San Francisco, CA, activated carbon added to the capping layer decreased the transfer of PCBs from sediment to the aquatic environment by 73% over the course of five years (Gomes et al 2013). CETCO®, a minerals technologies company, markets the *Reactive Core Mat (RCM)*, a cap which can be tailored to meet the specific needs of a remediation project by augmenting the additives included in the product.

Aquablok® and Aquagate® are two complimentary reactive containment technologies from Aquablok Ltd that can be used to form a "funnel and gate" system in sediment. Aquablock® acts as a low permeability barrier to contain wastes while Aquagate® allows specific treatment materials for bioremediation or phytoremediation to interact with contaminated sediment, thus improving the remediation outcome (AquaBlock 2014).

***In situ* Sediment Ozonation (ISO)**

In situ sediment ozonation (ISO) is a new technology developed by the University of Utah in cooperation with the National Oceanic and Atmospheric Administration (NOAA). ISO uses a floating rig equipped with ozone reactors and conveyors to remediate without dredging. Ozone reacts with PCBs by forming more biodegradeable products and boosting biological activity in sediment or soil (Gomes et al. 2013). ISO enhances this process using pressure-assisted ozonation, which injects sediment with ozone and rapidly cycled pressure changes to increase the efficacy of the ozone. This technology also naturally enhances biological activity and would be a logical choice to increase remediation efficieny of more passive technologies such as bioremediation or phytoremediation. Researchers report that the treatment could cost as little as $50 per cubic yard using pressure-assisted ozonation compared to $75-$1,000 per cubic yard for other exisiting methods (Hong 2008).

nZVI Dechlorination

Nanoscale zero-valent iron remediation (nZVI) is primarily an *ex situ* treatment based on zero-valent iron (ZVI), a technology which has been used to clean up aquifers contaminated with a variety of chemicals (Gomes et al. 2013). nZVI improves upon ZVI through a reformulation using nanoparticles, which exhibits superior reactivity and more consistent PCB removal in groundwater and soil (Mikszewski 2004). While nZVI can be used *in situ*, most commercial and academic uses are conducted off-site. However, NASA currently licenses an associated technology, emulsified zero-valent iron (eZVI), and has demonstrated successfully removing a variety of contaminants both *in situ* and *ex situ*(Parrish 2013).

Solvent Extraction
Green PCB Removal from Sediments System

NASA scientists have developed a redeployable polymer blanket for *in situ* removal of PCBs in sediment systems. Their Green PCB Removal for Sediments System (GPRSS) blanket is filled with an environmentally safe solvent (e.g. ethanol) that attracts PCBs. The PCBs migrate into the solvent-filled spikes inside the blanket, and the PCB-laden solvent is extracted from the blanket and treated *ex situ* using a derivative of the NASA's Activated Metal Treatment System (see section below) to break down the PCBs(Parrish 2013).

A recent field study showed that the GPRSS is capable of removing an average of 75% of PCBs by mass from contaminated sediments (DeVor et al 2014).

Activated Metal Treatment System (AMTS)

The Activated Metal Treatment System (AMTS) is a solvent solution developed by NASA to remove PCBs from paint, caulk, concrete, brick, and wooden surfaces (Parrish 2013). The product allows extraction of PCBs without removal of the structures. While AMTS is primarily used for structure remediation, Bio Blend ® Technologies, a company currently licensing AMTS, is testing the technology in a variety of applications including *in situ* extraction of PCBs from soils and sediment (Parrish 2013). In a pilot study in Salem, Massachusetts, AMTS testing indicated that PCB concentrations in concrete decreased by as much as 78% in two weeks (Bio Blend).

Solidification and Stabilization

Solidification and stabilization (S/S) involves adding a binding agent to the contaminated soil in order to convert the soil into an insoluble, less mobile, and less toxic form (US EPA Office of Wetlands 2011). S/S can be applied *ex situ* or *in situ* for soil or *ex situ* for sediment. For *ex situ* S/S, the soil is excavated, sorted to remove excess debris, and mixed and poured with the stabilizer. The resultant slurry can be poured into molds and disposed of in waste management cells, injected into the subsurface environment, or reused as construction material. For the *in situ* process, S/S agents are usually injected into the subsurface environment and mixed with soil. While S/S can successfully immobilize PCBs, environmental conditions like extreme temperatures and acid rain can negatively affect the chemical stabilizer during application (US EPA 2013), and degrade the stabilized mass over time. Costs for *in situ* S/S range from $80 per cubic meter for shallow applications to $300 per cubic meter for deeper applications (Khan et al. 2004).

Thermal Desorption

Thermal desorption physically separates organic wastes from the solid matrix (sediment, sludge, and filter cakes) using temperatures high enough to volatilize the organic contaminants. Although thermal desorption is both an *ex situ* and *in situ* method, the more common and largest volume applications are on *ex situ* soils. Unlike other methods, thermal desorption is a physical separation process (US EPA 2013). Since this method uses heat to vaporize contaminants, it cannot be used to treat non-volatile contaminants. Applying heat to contaminated soil forces wastes with low boiling points to turn into vapor, which are then collected and treated (McCreery and Linden 2015).

A disadvantage of this treatment is that it is not particularly effective at separating inorganics from contaminated medium. This limitation can potentially cause problems at sites where PCBs and heavy metals coexist. High moisture content medium may result in lower contaminant volatilization and an increased need to dry the soil before treatment begins (US EPA 2013). Soils consisting of a majority of fine particles like clays and silts are undesirable for this treatment. Fine particles tend to be emitted as dust, which can clog and destroy the machinery used to collect the vaporized contaminants (McCreery and Linden 2015).

During a cleanup of the former Industrial Latex production site in Wallington, New Jersey, a “triple shell dryer” thermal desorption unit was used to reduce PCB concentrations to 0.16 ppm. A triple shell dyer is an indirect form of heated thermal desorption that uses a rotating cylindrical kiln to supply heat (McCreery and Linden 2015).

Landfarming

Landfarming is an *ex situ* biological treatment process that can be applied to contaminated soils, sediments, or sludges. A pilot-scale land treatment study used approximately one cubic meter of sludge and sediment materials of industrial waste containing PCBs. Results indicated that complete biostabilization can be achieved when reversibly sorbed PCB and PAH are biodegraded. Irreversibly sequestrated PCB and PAH remain immobile in soil particles. The study also showed that degradation was caused by a combination of processes, volatilization, photolysis, and biodegradation (Gomes et al. 2013).

Conclusion

While additional methods for treating *organic* contaminants exist, they are not suited for successfully remediating *organochlorine* compounds like PCBs and should not be considered for the cleanup of the Willamette River. Examples of these technologies include natural attenuation, chemical oxidation, and certain thermal treatments. Natural attenuation is a passive remediation method that requires a large sediment influx to essentially bury contaminants but does not remove the contaminant from the environment (Gomes et al. 2013). Additionally, many chemical oxidation and thermal treatments are better suited for PAHs and will not effectively cleanup the PCB contamination at the Site.

Some contaminated sites may be best suited for a mix of two or more remediation methods making up a "treatment train". Contaminated materials can be "primed" by one type of remediation method, and then "polished" using another. While there is much more scientific literature on individual treatments than combination treatments, recent trends towards adaptive management are gradually increasing the amount of literature on treatment trains (Cummings 2007).

Other sites may contain amounts of contaminated material that are too large to remove but too small to implement any of the above mentioned technologies. In these scenarios, implementation of best management practices (BMPs) could be the preferred remediation option.

Due to the widespread problem of PCB and PAH contamination, efficient and cost-effective remediation methods are highly sought after. Therefore, newer treatments for dredged materials and riverbank contamination need to be given greater attention in the Portland Harbor Proposed Plan and Feasibility Study.

References

AquaBlok Ltd. 2014. *AquaBlok Composite Particle System*.

Beless, Bradley, Hanadi S Rifai, and Debora F Rodrigues. 2014. Efficacy of Carbonaceous Materials for Sorbing Polychlorinated Biphenyls from Aqueous Solution. *Environmental Science & Technology* 48: 10372–79. doi:10.1021/es502647n.

Bio Blend Technologies. n.d. *Case Study—AMTS*.

BioGenesis Enterprises, Inc. 2008. *BioGenesis Sediment Washing Technology: Bench-Scale Treatability Study Report, Housatonic River - Rest-of-River Site*.

BioGenesis Washing BGW, LLC. 2009. *Demonstration Testing and Full-Scale Operation of the BioGenesis Sediment Decontamination Process*.

BioTech Restorations, LLC. n.d. *Biotechnology for Environmental Cleanup*.

Chekol, Tesema, Lester r. Vough, and Rufus L. Chaney. 2004. Phytoremediation of Polychlorinated Biphenyl-Contaminated Soils: the rhizosphere effect. *Environmental International* 30:799-804. doi:10.1016/j.envint.2004.01.008.

Cho, Yeo-Myoung, David Werner, Yongju Choi, and Richard G. Luthy. 2012. Long-Term Monitoring and Modeling of the Mass Transfer of Polychlorinated Biphenyls in Sediment Following Pilot-Scale in-Situ Amendment with Activated Carbon. *Journal of Contaminant Hydrology* 129-130. Elsevier B.V.: 25–37. doi:10.1016/j.jconhyd.2011.09.009.

Chun, Chan Lan, Rayford B. Payne, Kevin R. Sowers, and Harold D. May. 2013. Electrical Stimulation of Microbial PCB Degradation in Sediment. *Water Research* 47 (1): 141–52. doi:10.1016/j.watres.2012.09.038.

Cronk, Julie K. and M. Siobhan Fennessy. Wetland Plants in Restored and Constructed Wetlands. *In Wetland Plants: Biology and Ecology*. Boca Raton, Fla: Lewis Publishers, 2001.

Committee on Sediment Dredging at Superfund Megasites, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, and National Research Council. *Sediment Dredging at Superfund Megasite: Assessing the Effectiveness*. Washington, D.C.: National Academies Press, 2007.

Cummings, Jim. May 2007. Combining Remedies/Treatment Trains for NAPL Site Remediation. Federal Remediation Technologies Roundtable, Arlington, VA.

Denyes, MacKenzie J., Valérie S. Langlois, Allison Rutter, and Barbara a. Zeeb. 2012. The Use of Biochar to Reduce Soil PCB Bioavailability to Cucurbita Pepo and Eisenia Fetida. *Science of the Total Environment* 437. Elsevier B.V.: 76–82. doi:10.1016/j.scitotenv.2012.07.081.

DeVor, Robert, James Captain, Phillip Maloney, Greg Booth, Chris Audo, and Jacqueline Quinn. 2014. *Initial Field Deployment Results of Green PCB Removal from Sediment Systems (GPRSS)*.

GE. Periodic review available to the public. General Electric Spokane Site, 4323 East Mission Avenue, Spokane, Spokane County, Washington, Facility Site ID 630; 2008.

Gomes, Helena I., Celia Dias-Ferreira, and Alexandra B. Ribeiro. 2013. Overview of in Situ and Ex Situ Remediation Technologies for PCB-Contaminated Soils and Sediments and Obstacles for Full-Scale Application. *Science of the Total Environment* 445-446. Elsevier B.V.: 237–60. doi:10.1016/j.scitotenv.2012.11.098.

Gomes, Helena I, Lisbeth M Ottosen, Alexandra B Ribeiro, and Celia Dias-ferreira. 2015. Treatment of a Suspension of PCB Contaminated Soil Using Iron

Nanoparticles and Electric Current. *Journal of Environmental Management* 151. Elsevier Ltd: 1–6. doi:10.1016/j.jenvman.2015.01.015.

Hong, Andy, and Salt Lake City. 2008. In Situ Sediment Ozonator for Remediation of PCB, PAH, DDT and Other Recalcitrant Chemicals. *In Situ*, 1–14.

Huesemann, Michael H., Tom S. Hausmann, Tim J. Fortman, Ronald M. Thom, and Valerie Cullinan. 2009. In Situ Phytoremediation of PAH- and PCB-Contaminated Marine Sediments with Eelgrass (Zostera Marina). *Ecological Engineering* 35: 1395–1404. doi:10.1016/j.ecoleng.2009.05.011.

Jha, P., J. Panwar, and P. N. Jha. 2015. Secondary Plant Metabolites and Root Exudates: Guiding Tools for Polychlorinated Biphenyl Biodegradation. *International Journal of Environmental Science and Technology* 12: 789–802. doi:10.1007/s13762-014-0515-1.

Khan, Faisal I, Tahir Husain, and Ramzi Hejazi. 2004. An Overview and Analysis of Site Remediation Technologies. *Journal of Environmental Management* 71: 95–122. doi:10.1016/j.jenvman.2004.02.003.

McCreery, Ian and Vander Linden, Lukas. 2015. A Review of Thermal Desorption Technology for Waste Soil Remediation. *Geoengineer*. doi:10.1007/978-3-642-47495-8_16.

Mikszewski, Alex. 2004. *Emerging Technologies for the In Situ Remediation of PCB-Contaminated Soils and Sediments: Bioremediation and Nanoscale Zero-Valent Iron*.

Parrish, Lewis M. 2013. *Environmental Remediation Technologies*. NASA Kennedy Space Center: Technology Licensing. http://kscpartnerships.ksc.nasa.gov/Partnering-Opportunities/Emerging-Markets/R-and-T/Research

TAMS and Malcolm Pirnie, Inc. 2004. *Lower Passaic River Restoration Project: Dredging Technology Review Report*.

United State Environmental Protection Agency. 2013. *Technology Alternatives for the Remediation of PCB Contaminated Soils and Sediment*.

United State Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds. 2011. *PCB TMDL Handbook*. Vol. EPA 841-R-.

United States Environmental Protection Agency, Region 2. 2015. *Hudson River PCBs Superfund Site Phase 2 Dredging, Year 5 (2015).*

University of Calgary. 2013. “New Technology from University Destroys Hazardous PCBs Using UV Light | UToday | University of Calgary.” http://www.ucalgary.ca/utoday/issue/2013-09-11/new-technology-university-destroys-hazardous-pcbs-using-uv-light.

Williams, Jera. 2006. *Bioremediation of Contaminated Soils: A Comparison of in Situ and Ex Situ Techniques*.

Young, Chris. BioTech Restorations. Telephone interview by Peter deFur. October 14, 2015.

VII. Upland Source Control

Source control is used to eliminate or reduce the release of contaminants from both indirect and direct continuing sources to the site. Source control activities are broad-ranging in scope, including contaminant source isolation, elimination or treatment of contaminated waste water discharges, and removal or containment of mobile sediment hot spots, among others. Strategies for source control should contain plans to identify, characterize, prioritize, and track source control actions, as well as plans to evaluate the effectiveness of those actions. Source control should be implemented to prevent site recontamination (US EPA Office of Solid Waste 2005).

Control of upland and upriver sourcesfor the Portland Harbor Superfund Site is necessary and not complete. The Site’s 2016 Proposed Plan indicates a more pervasive influx of contaminants from the upland sources, many or all of which are uncontrolled. This problem must be remedied with source elimination in the harbor and source control upriver.

The State of Oregon Department of Environmental Quality (DEQ) released an updated Portland Harbor Upland Source Control Summary Report in 2016. DEQ conducted an eight-step discovery process to identify probable upland sources of contamination threatening the Willamette River. A total of 171 upland sites were investigated, roughly 35% of the industrial and commercial properties around the Portland Harbor study area uplands. The following were identified as potential contaminant migration pathways:

1. Direct discharge
2. Waste and wastewater
3. Stormwater
4. Overwater activities
5. Soil and bank erosion
6. Groundwater
7. Air deposition
8. Upstream sediment impacted by upland activities (DEQ 2016)

Of the total number of sites, 63 were excluded as not having a significant pathway for contaminant transport to the Site (DEQ 2016).

Remediated sites can become re-contaminated when upland sources of pollution are not controlled. According to the DEQ, there are significant environmental, economic, and political consequences when remediated sites are re-contaminated. In their review of case studies, DEQ determined that unidentified or adjacent sediment contamination or incomplete in-stream sediment removal is the predominant cause of recontamination of sites (DEQ 2016).

If continued contaminant releases pose an unacceptable risk to the site, sediment remedies will be ineffective. Therefore, irrespective of the chosen remedial alternative, source control needs to be implemented to prevent recontamination; the success of any sediment remedy relies on effective source control. All direct and indirect continuing sources of significant contamination need to be identified as early in the remediation process as possible (Magar et al. 2009). This notion is echoed in EPA's own *Contaminated Sediment Remediation Guidance*. Control should not just include primary sources; secondary sources like ongoing contaminant releases from soils should also be considered.

At the Sangamo Weston/Twelve-Mile Creek/Lake Hartwell Site in Pickens, South Carolina, source control was not completed. While general trends point to significant PCB reductions in surface sediments, the edible fish from Lake Hartwell continue to exceed the FDA's PCB tolerance limit. PCB-contaminated groundwater is suspected to be the continuing source. In contrast, the Bellingham Bay site offers an example of a site that implemented source controls effectively and early on, helping lead to the Site's successful remediation (Magar et al. 2009).

Conclusion

The Portland Harbor Superfund Site has an influx of pervasive contaminants from uncontrolled, upland sources. History has shown that re-contamination at remediated sites is probable when upland sources of pollution are not controlled. Source elimination in the harbor and source control upriver is necessary to ensure a long-lasting, successful remediation.

References

Magar, V.S., D.B. Chadwick, T.S. Bridges, P.C. Fuchsman, J.M. Conder, T.J. Dekker, J.A. Steevens, K.E. Gustavson, and M.A. Mills. 2009. *Technical Guidance: Monitored Natural Recovery at Contaminated Sediment Sites*. *Environmental Security Technology Certification Program*.

State of Oregon Department of Environmental Quality. 2016. *Portland Harbor Upland Source Control Summary Report Table of Contents*.

United States Environmental Protection Agency, Office of Solid Waste and Emergency Response. 2005. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*.

VIII. Confined Disposal Facilities

In August 2016, the Port of Portland recognized that a CDF is a long term liability from several perspectives, in large part because it will require monitoring forever -forever is a long time to budget. In so doing, the Port recognized the critical nature of long term effectiveness in remedy selection. We applaud the Port and urge EPA to also consider long term effectiveness in remedy selection.

Confined Disposal Facilities (CDFs) are structures that store contaminated dredged material. They are typically built on land with a portion extending into the sediment bed of the adjacent waterbody. The structures, or dykes, typically extend above the adjacent water's surface, thus isolating the dredged material from the adjacent water (Palermo and Boswoth 2008). Once filled, a CDF is then capped, thus converting open water into dry land.

The Portland Harbor community has opposed the use of CDFs since the concept was first raised. The community does not want to have a CDF in perpetuity. While CDFs may arguably be considered a viable and cost effective way to dispose of contaminated sediment, there are downsides that the surrounding community does not want to contend with. As the individuals directly impacted by the remediation efforts, their concerns deserve to be evaluated.

Limitations

Although CDFs are still considered by some agencies as an economically feasible method for the disposal of contaminated sediments, they pose ecological concerns, especially in regards to keeping the material from leaching into the surrounding environment. Liners and barriers within the dykes of CDFs are usually put into place; however, over time these protective barriers tend to degrade and become ineffective. Furthermore, there is not a systemic monitoring program for CDFs. This limitation poses significant externalities since CDFs are monitored and designed in different ways, thus creating inherent problems for their management and oversight (Olsta 2014).

CDFs have a short period of implementation compared with the life of the contaminants in the CDF and compared with the duration of the remedy. Contaminants in CDFs will often not break down unless treated, in the case of organics, or, in the case of metals, will never breakdown. As a result, CDFs must last forever and the experience with CDFs in the US and worldwide is measured in decades, not even 100 years.

Natural Hazards

Earthquakes are a real threat to the Portland area. Oregon sits at number 10 on the United States Geological Survey's list of states with the most earthquakes (USGS 2016) and is one of three metropolitan cities located within the Cascadia Subduction Zone (CSZ) impact zone (Rizzo). The CSZ is located roughly 50 miles offshore of the Oregon coast and is capable of producing very large earthquakes with a magnitude of 9+ (Rizzo). Furthermore, geologic fault lines run directly through or adjacent to the Site. The Site's expected earthquake shaking, as determined by the Oregon HazVu: Statewide Geohazards Viewer, is between very strong to severe (Oregon Geology).

In addition to earthquakes, the Site is also at risk for flooding; it is situated within both the 100- and 500-year flood hazard zones (Oregon Explorer). Additionally, impacts of climate change and sea level rise will increase the flood potential and force at the Site.

Earthquakes and floods threaten the integrity and safety of CDFs. The CDF's proposed design of using an earthen berm and liquefiable contaminated soils does not adequately address the impact of a major earthquake or flood. During modeling, the proposed CDF was damaged during a 7.0 magnitude earthquake. A CDF failure occurred during the 1997 flood event in Silver Valley, Idaho, leading to a release of high lead levels. Either natural disaster could cause a breech that would contaminate the Willamette River and surrounding land.

Design Flaws

EPA has stated that the CDF will be unlined and located on a former slough with several sources of groundwater flowing into it. EPA explained that this flow through design is experimental. EPA has not yet supplied an example of a similar CDF located on an active, large volume river like the Willamette. Furthermore, the process for filling the slip has been described as adding a slurry of dredged spoils into a vat of water and letting the water flow through the front of the berm into the river. An engineer on the project stated that higher level contaminants could be placed towards the back of the slip. This plan would likely not succeed in confining the contaminants to the CDF. Instead, highly toxic pollutants could likely seep into the river through the berm and continue to affect human and environmental health.

Conclusion

The Portland Harbor community has been adamantly against the use of CDFs since the concept was first raised. Their primary argument is that they do not want to have a CDF in perpetuity. Additional concerns over the CDF include the potential for leaching contaminants back into the surrounding environment, and the lack of a systemic monitoring program to ensure the integrity of the CDF. Contamination left within a CDF is subject to re-exposure by earthquakes, floods, or design flaws that pose an ongoing risk to human and environmental health.

Apparently, the Port of Portland has concluded that a CDF is not a good choice for the Portland Harbor remediation, especially because of the long term costs. ESC, LLC applauds the decision of the Port and urges EPA to reject the CDF option in the R.O.D.

References

Olsta, Jim. *Confined Disposal Facilities: History and Trends*. Arlington Heights, IL, 2014.

Oregon Department of Geology and Mineral Industries. “Oregon HazVu: Statewide Geohazards Viewer”. Map. http://www.oregongeology.org/hazvu/

Oregon Explorer. “Oregon Hazards Reporter”. Map. http://oe.oregonexplorer.info/hazards/HazardsReporter/

Palermor, M. and W. Bosworth. 2008. Use of Confined Disposal Facilities for Sediment Remediation. Proceeding of the 39th Texas A&M Dredging Seminar and Western Dredging Association XXVIII Technical Conference, June 8-11, 2008, St. Louis MO.

Rizzo, Althea. “Cascadia Subduction Zone”. Oregon Emergency Management Geologic Hazards Program. Accessed July 21, 2016. http://www.oregon.gov/OMD/OEM/plans_train/Earthquake/eq_tsu_prep.pdf

United States Geological Survey. “Top Earthquake States”. Earthquake Hazards Program. April 6, 2016. Accessed July 21, 2016. http://earthquake.usgs.gov/earthquakes/states/top_states.php

IX. Independent Air and Water Monitoring During Cleanup

Monitoring tracks the levels of contamination over time, thus evaluating the effectiveness of a remedy. Therefore, it is important to institute air and water monitoring during cleanup. To verify and validate the data sampled during monitoring, data should be collected by an independent party. Furthermore, monitoring must include baseline data collected before remediation begins to ensure the success of long-term monitoring. Data collected in the early years of monitoring are compared to current samples in order to establish trend estimates for long-term monitoring. Therefore, a monitoring program should be employed early on to make certain all sampling and analytic methods are uniform throughout the entire monitoring period (Committee on Sediment Dredging at Superfund Megasites et al. 2007).

Monitoring during cleanup also helps understand the real-time exposure to air and water contaminants threatening the human and ecological communities near ongoing cleanup. The Hudson River Superfund site utilized real-time air and water monitoring to assess the surrounding communities’ PCB exposure and to determine if any operational adjustments were needed(GE 2013).

References

Committee on Sediment Dredging at Superfund Megasites, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, and National Research Council. *Sediment Dredging at Superfund Megasite: Assessing the Effectiveness*. Washington, D.C.: National Academies Press, 2007.

General Electric. 2013. *Hudson River Project Report*.

X. Monitoring of Fish Tissue

Fish contamination needs to be monitored to assess changes over time and space. A monitoring program should begin as soon as possible to establish a baseline. Clear baseline data ensures the success of long-term monitoring. Trend estimates for long-term monitoring are based on comparing data collected in the early years of monitoring. Therefore, baseline data needs to be collected before remediation begins. Additionally, a monitoring program should be implemented early on to ensure all sampling and analytic methods are consistent throughout the duration of monitoring (Committee on Sediment Dredging at Superfund Megasites et al. 2007).

Monitoring levels of contamination in fish tissue is one of the best ways to determine the effectiveness of remediation over time, as the individual health of biota is integral in determining the overall biological integrity of a particular ecosystem. Biota accumulate contaminants at different rates and degrees due to a combination of the functions of the environment, the organism, and the specific contaminant(s). An organism's metabolic rate plays a crucial role in determining its accumulation rates(US EPA Office of Superfund Remediation 2008). PCBs easily accumulate in biota since they are hydrophobic, or resistant to dissolution in water.

Certain considerations need to be considered when utilizing long-term fish tissue monitoring to determine remedy effectiveness. Sample handling and analysis techniques should be determined early on to keep data consistent and comparable (Uthe et al. 1991).

Geospatial Considerations

In order to ensure accurate and thorough samples, fish should be monitored and analyzed in multiple locations within a site. Areas of a site with human interaction, such as fishing or swimming areas, should automatically be chosen for fish monitoring (El-Shaarawi et al 2010). Areas suspected of having high contamination, such as CERCLA sites and industrial facilities should be selected (FTAC 1992). Fish tissue monitoring should also take place in areas of important habitat to threatened species.

Temporal Considerations

Seasonal variations in water quality, temperature, and hydrology can impact contaminant concentrations. Therefore, fish samples should be collected and analyzed at similar times throughout the year to achieve more accurate measurements (El-Shaarawi et al 2010).

The Fish Tissue Advisory Committee (FTAC) was formed to offer fish tissue monitoring recommendations to the Georgia Department of Natural Resources, Environmental Protection Division, and the Game and Fish Division to identify bodies of water with contaminants present in fish tissue and to issue specific fish consumption advice. They recommend collecting yearly samples during late summer through fall to avoid fish spawning season and to guarantee a relatively high and constant lipid content in the fish. Also, water levels tend to be lower during this time, which could make collection easier (FATC 1992).

Fish tissue monitoring must capture maximum contaminant concentrations in order to implement fish advisories and cleanup remedies that will be most effective in protecting human health. For that reason, samples should be collected during all four seasons to determine the highest contaminant concentration levels at the site.

Target Species and Age Considerations

The FTAC fish sampling guidelines recommend the use of indicator species since they readily accumulate contaminants. Target species should include one bottom-feeding species, such as catfish and carp, and one predator species like largemouth bass. These species tend to accumulate elevated levels of target contaminants in their tissues, which could provide a worst-case exposure condition. They are also regularly caught and consumed by anglers and are non-migratory, abundant, easily identified and collected, pollutant-tolerant, and large enough to provide sufficient tissue samples (FTAC 1992). Additionally, bottom-feeding species can accumulate high contaminant concentrations via direct contact with contaminated sediments or through eating the benthic organisms living in the contaminated sediment. Predatory species indicate persistent contaminants that can be biomagnified through the trophic levels of the food web (US EPA Office of Water 2009).

Fish sampling should focus on young-of-year (y-o-y) fish species recently exposed to contamination at the site, as well as older predatory species commonly consumed by humans. Y-o-y fish make excellent bio-monitors, are relatively abundant and ubiquitous, are localized near shore, and most importantly, have a limited exposure period. Any contaminant concentrations discovered during this small window of exposure indicate current pollutant levels, making y-o-y fish beneficial for determining the effectiveness of cleanup efforts at hazardous waste sites. The New York State Department of Environmental Conservation has used y-o-y fish to monitor persistent organic contaminants for decades (Prediceet al 2011).

In addition to y-o-y species, older fish species should also be sampled. Due to temporal trends, y-o-y species may fail to capture the maximum concentration of contaminants still present at a site. Therefore, data from older and larger species help determine longer-term, temporal exposure. Additionally, larger species tend to represent fish pursued by anglers, thus more accurately indicating human exposure levels from fish consumption (Blocksom et al 2010).

Conclusion

Studying contamination levels in fish tissue over time and space and within target species provides important information regarding when and what fish are safe for human consumption, as well as determining the overall health of an ecosystem(El-Shaarawi et al 2010).Fish tissue monitoring needs to be implemented at the Portland Harbor Superfund Site in order to accurately assess the changes in contamination over time and space. A monitoring program should begin now in order to establish a clear baseline and to keep data consistent and comparable over time

References

Blocksom, Karen a., David M. Walters, Terri M. Jicha, James M. Lazorchak, Theodore R. Angradi, and David W. Bolgrien. 2010. “Persistent Organic Pollutants in Fish Tissue in the Mid-Continental Great Rivers of the United States.” *Science of the Total Environment* 408. Elsevier B.V.: 1180–89.

Committee on Sediment Dredging at Superfund Megasites, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, and National Research Council. *Sediment Dredging at Superfund Megasite: Assessing the Effectiveness*. Washington, D.C.: National Academies Press, 2007.

El-Shaarawi, Abdel, Sean Backus, Rong Zhu, and Yalin Chen. "Modeling Temporal and Spatial Changes of PCBs in Fish Tissue from Lake Huron." *Springer Science and Business Media*. Accessed March 6, 2010.

Predice, T.L., L. Skinner, and A. Gudlewski. 2011. *PCBs and Organochlorine Pesticide Residues in Young-of-Year Fish from New and Traditional Near-Shore Sampling Areas in the Western Portion of New York State’s Great Lakes Basin, 2009*.

The Fish Tissue Advisory Committee. 1992. *Recommendations for a Fish Tissue Monitoring Strategy for Freshwater Lakes, Rivers, and Streams*.

United States Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation and Office of Research and Development. *Using Fish Tissue Data to Monitor Remedy Effectiveness*. 2008.

United States Environmental Protection Agency, Office of Water and Office of Science and Technology. 2009. *The National Study of Chemical Residues in Lake Fish Tissue*. *Statewide Agricultural Land Use Baseline 2015*. Vol. EPA-823-R-006.

Uthe, J F, C L Chou, R K Misra, P a Yeats, D H Loring, C J Musial, and W Cofino. 1991. *Temporal Trend Monitoring: Introduction to the Study of Contaminant Levels in Marine Biota*. *Techniques in Marine Environmental Sciences*. Vol. 14.

XI. Habitat Restoration

Healthy riverine ecosystems provide an array of ecological and economic services. Remedial activities, such as dredging and capping, disrupt crucial surrounding habitats, which can threaten the overall health of the ecosystem.

Restoration of any lost habitat needs to be a requirement for the Site's final remedy. The 2016 Portland Harbor Superfund Site Proposed Plan does refer to restoration. This restoration must comprehensively include actions immediately following removal actions.

Habitat Loss During Dredging Activities

Remedial activities can disrupt valuable riverine habitats in and around the Site. Dredging removes subaqueous vegetation when excavation of contaminated sediment takes place. Likewise, capping covers the once diverse riverbed with a homogenized layer.

A study conducted in 2015 by Grygoruk et al. analyzed ecosystem deterioration from river dredging in small, lowland agricultural rivers in Poland. Dredging was found to lead to the homogenization of habitats and biodiversity loss. Dredged reaches had approximately 70% lower total abundance of riverbed macro invertebrates than non-dredged areas due to habitat alterations and loss. Overall, river dredging was found to pose a significant risk to the abundance and species diversity of bottom macroinvertebrates, which can threaten the health of the whole river ecosystem (Grygoruk et al. 2015). However, there are numerous benefits to a successful habitat restoration after remediation.

Successful river restorations offer numerous ecosystem services that would be valuable assets to the surrounding Portland community. Benefits of healthy riverine ecosystems can be broken down into three different services: provisioning, regulating, and cultural. Provisioning services deal with energy and material outputs, including infiltrated drinking water, wood and raw materials, and agricultural products. Regulating services, such as nutrient retention, drainage and flood control, and carbon sequestration, help regulate ecosystem processes. Recreational activities, biodiversity conservation, hunting and fishing, and an appreciation of scenic landscapes make up cultural services (Vermaat et al. 2016).

Vermaat et al. (2016) conducted a study comparing restored and unrestored rivers, and analyzing the increased societal benefits of river restorations. Eight studied pairs of river reaches across Europe were assessed. Overall, river restoration was found to economically benefit society. Recreational activities, tourism, aesthetic appreciation and other cultural services were the most positively impacted out of the three and were found to be particularly valuable in highly populated areas. Regulating services like erosion prevention and moderation of extreme weather events or natural hazards were also found to contribute to the societal benefits, whereas raw materials, food, and other provisioning services were least affected by restoration (Vermaat et al. 2016).

The Portland Harbor Superfund Site sits within a highly populated, urbanized area. Restoring the Willamette River will provide valuable, economic and societal benefits to the surrounding community, such as recreation and tourism, better climate and air quality, erosion prevention, flood control, and food. Most importantly, restoration will help ensure the health of the river long after the remedy has been implemented.

Example

The Hudson River PCB Superfund Site underwent habitat restoration after the river was dredged and capped. The habitat replacement program replaced, reconstructed, and/or stabilized the river bottom, wetlands, submerged aquatic vegetation, and shoreline areas. Once dredged areas were backfilled and/or capped, seed mixes and plants were planted in some areas and shoreline areas were stabilized. Five-Year Reviews inspect the physical integrity of the surface material and assess habitat functions.

Conclusion

A healthy river provides ecological and economic services to the surrounding communities. These services are diminished by certain remedial activities, such as dredging and capping. To assure a healthy Willamette River and Portland Harbor, habitat restoration needs to be required in the Site’s final remedy, and it must be implemented immediately following removal actions.

References

Grygoruk, Mateusz, Magdalena Fraak, and Aron Chmielewski. 2015. “Agricultural Rivers at Risk: Dredging Results in a Loss of Macroinvertebrates. Preliminary Observations from the Narew Catchment, Poland.” *Water* 7: 4511–22.

Vermaat, Jan E., Alfred J. Wagtendonk, Roy Brouwer, Oleg Sheremet, Erik Ansink, Tim Brockhoff, Maarten Plug, et al. 2016. “Assessing the Societal Benefits of River Restoration Using the Ecosystem Services Approach.” *Hydrobiologia* 769 (1): 121–35.

XII. Longer Time Frame for Estimated Costs

The time frame established for the Portland Harbor Superfund Site cost estimates needs to be extended to at least 100 years since the preferred remedy includes monitoring in perpetuity. Furthermore, EPA needs to estimate the economic benefits of a clean river, such as tourism revenue.

Time Extension

The usual practice for estimating a remedy's long-term cost is to assume a 30-year period of analysis. However, caps and confined disposal facilities (CDFs) require maintenance, monitoring, and inspection in perpetuity, which will lead to high costs. Therefore, EPA needs to extend the period of analysis to at least 100 years.

Economic Benefits of a Clean River

As stated above, a clean, healthy river offers numerous services that are beneficial to both the surrounding ecosystem and the economy. These services include drainage and flood control, recreational activities, nutrient retention, agricultural products, and biodiversity conservation (Vermaat et al. 2016). An economic value needs to be assigned to these services since they either save or bring in money to the surrounding community and the city.

Conclusions

The time frame established for the Portland Harbor Superfund Site cost estimates needs to be extended to at least 100 years considering the preferred remedy includes monitoring in perpetuity. Additionally, EPA needs to estimate the economic benefits of a clean river.

References

Vermaat, Jan E., Alfred J. Wagtendonk, Roy Brouwer, Oleg Sheremet, Erik Ansink, Tim Brockhoff, Maarten Plug, et al. 2016. "Assessing the Societal Benefits of River Restoration Using the Ecosystem Services Approach." *Hydrobiologia* 769 (1): 121–35.

XIII. Compliance with Standards (Clean Water Act)

During and after remediation, there should be compliance with all water quality standards. These include drinking water and surface water standards defined in the Clean Water Act.

Under the Clean Water Act, the maximum contaminant level (MCL) for PCBs in drinking water is 0.005 mg/L or 500 parts per million (ppm).

Water quality numeric criteria for total PCBs have been established by the State of Oregon Department of Environmental Quality to protect human health and aquatic life:

Human Health Criteria		Aquatic Life Criteria (Freshwater)		Aquatic Life Criteria (Saltwater)	
Water & Org (µg/L)	Org Only (µg/L)	Acute (µg/L)	Chronic (µg/L)	Acute (µg/L)	Chronic (µg/L)
0.0000064*	0.0000064*	2*	0.014*	10*	0.03*

***This criterion applies to total PCBs

Conclusion

Both the State of Oregon and the EPA have established water quality standards for PCBs. Once remediation activities are completed, the remaining concentrations of PCBs should be in compliance will all water quality standards, including both drinking and surface water.

References

State of Oregon. Department of Environmental Quality. 2014.*Implementation Instructions for Polychlorinated Biphenyls (PCBs) Water Quality Criteria*.

United States Environmental Protection Agency. “What Are EPA’s Drinking Water Regulations for Polychlorinated Biphenyls?” Ground Water & Drinking Water. Accessed July 15, 2016. https://safewater.zendesk.com/hc/enus/articles/212075717-6-What-are-EPA-s-drinking-water-regulations-for-polychlorinated-biphenyls-.

XIV. More Detailed and Site Specific Data Obtained During Design Phase

More detailed, site-specific data will be obtained during the design phase. This data will provide a better overview of the Site conditions, such as the Willamette River’s tidal action and currents, as well as the extent and nature of the contamination. The chosen remedy will not be successful if these details are not thoroughly researched and included in the final cleanup plan. Therefore, the Record of Decision, or ROD, must require removal that accounts for this collected data.

For example, the Willamette River is prone to flooding, tidal action, fast currents, and prop wash. These conditions make certain remedial techniques, such as monitored natural recovery, less suitable for this Site. If site specific data is not included and used as a focus for determining the Site's cleanup plan, the selected remedy is likely to be unsuccessful.

Disclaimer: These comments were prepared by ESC, LLC on behalf of the Willamette Riverkeeper; funding provided by an EPA Technical Assistance Grant. These comments do not represent EPA in any fashion. Mention of trade names or private companies does not constitute endorsement by ESC, LLC, EPA or WRK.