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To:	Tim Gray; Murphy, Jim; heal; Tagliaferro, Dean; R1Housatonic
Subject:	Final Housatonic River ESC Comments
Date:	Thursday, October 23, 2014 7:17:26 PM
Attachments:	Final HRI ESC comments.pdf

All,

Please see attached Environmental Stewardship Concepts' final comments on EPA's Statement of Basis and Draft Permit for the Housatonic River. We are submitting these on behalf of the Housatonic River Initiative.

Thank you,
Peter deFur

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October 23, 2014

These comments by Environmental Stewardship Concepts, LLC have been submitted to the Environmental Protection Agency on behalf of the Housatonic River Initiative.

Reissued Draft RCRA Permit and Statement of Basis for EPA's Proposed Remedial Action for the Housatonic River "Rest of River"

Summary

The EPA released the two documents that cover the cleanup of the Housatonic River, the Draft RCRA permit (Permit) and the Statement of Basis (Basis) for the permit modification, in June of 2014 for a public comment period. Together, these two documents constitute the Proposed Cleanup Plan (Plan). These two documents replace the Proposed Plan that would be issued under Superfund (CERCLA). The remedial action in this case is conducted under RCRA, pursuant to a Consent Decree between GE and EPA. The modified permit describes the actions that GE will undertake in general, and the Statement of Basis gives the underlying technical justification for remedial actions described in the permit.

The two documents include reference to the State of Massachusetts information on wildlife and habitats in the Housatonic River watershed. The Basis includes a very brief written letter of transmittal and copies of several maps that indicate habitat areas in the Housatonic watershed below Pittsfield, MA. MA has denoted "Areas of Critical Concern." These areas are singled out for special treatment with elevated levels of PCBs remaining in certain areas.

Monitored natural recovery (MNR) or some derivation thereof is first raised in the summary of the Basis. The Basis provides no documentation for using MNR, does not give an evaluation of the approach and gives no examples of where MNR has been used effectively with PCBs or other chlorinated organic contaminants with physical and chemical characteristics similar to PCBs and in rivers that have characteristics in common with the Housatonic.

A number of issues arise in the Basis and Permit, including the absence of information and data. The major problem areas are listed below, with further elaboration on each point later in these comments.

Major Issues:

- The Permit and Basis leave high levels of PCBs in areas of the river and watershed where wildlife will remain contaminated for the foreseeable future. As such, the Permit and Basis give no logic or explanation for this strategy that is counter to the latest (and increasing) evidence that PCBs are more toxic at lower levels than previously considered.
- There is no definition with supporting materials for the "Areas of Critical Concern," or Core Habitats.
- The Basis and Permit do not provide any documentation of the rationale or technical analysis of habitats to reach a conclusion that these places are "Areas

of Critical Concern." Such a major departure from the practice of active remediation should demand thorough documentation and there is none.

- The Plan sets a performance Standard for PCBs in Biota of 1.5 mg/kg (ppm) in fish tissues in 15 years and 0.064 mg/kg for the "long term" in MA. These values are too high and do not protect against cancer or non-cancer effects, according to EPA guidance. Fish tissue PCB levels of 0.012 mg/kg or less are necessary to reduce cancer risk to acceptable for one fish meal a week.
- No place in the document discusses the efficacy of Monitored Natural Recovery (MNR), nor is any evidence presented to support the use of MNR; there are abundant data that demonstrate that MNR does not work for persistent bioaccumulative chlorinated organic chemicals, of which PCBs are but one present example.
- The Plan does not consider the EPA data that demonstrate the effectiveness of removing PCBs to reduce fish tissue PCB levels. EPA has supported the effectiveness of removal through the Hudson River remediation of PCBs.
- The Plan will use Woods Pond as an intentional catch basin for PCB contaminated sediments that are carried downriver as a result of erosion and scour. The Plan does not offer precedent or explanation for such an approach.
- Reaches 5 through 16 include PCB-contaminated soil greater than 1 ppm in adjacent floodplain. However, the PCB floodplain removal level changes throughout the Reaches; sometimes 1 ppm, 5 ppm, or 50 ppm, and without justification or explanation.
- New remediation methods with up-to-date equipment can provide more efficient remediation with a lesser impact and footprint than presented in the Permit and Basis. The options for remediation are much broader than what's considered.
- Stream restoration is a fully developed field of practice and research. Current procedures and standards of practice offer sophisticated approaches to restoring waterways such as the Housatonic, points not acknowledged in the Plan.
- The substantial literature on the harmful effects of PCBs on wildlife and humans, summarized here, is justification for a more aggressive remediation based on removal and treatment rather than capping and MNR (literature citations attached as an Appendix A);
- Housatonic River (and floodplain) PCBs will contaminate Long Island Sound and contribute to the global PCB loads for the foreseeable future.

These major issues are covered in the following sections:
1) Leaving PCBs in "Core Habitats" will cause continued harm to human health and the environment.
2) Fish tissue PCB Levels must be lower.
3) PCB toxicity
4) Advances in PCB removal and remediation rechnology
5) Stream restoration is effective.
6) Adaptive management

The **Specific Comments on the Proposed Plan** follows along with the Statement of Basis and points out other issues relevant to the Housatonic cleanup.

1) Leaving PCBs in "Core Habitats" will cause continued harm to human health and the environment

The Plan will leave substantial quantities of PCBs in the Housatonic River, especially in habitats where sensitive species are most likely to be exposed and suffer the harmful effects of these chemicals. EPA and MassDEP propose to leave PCBs in sediments and soil (including riverbanks) in critical habitat areas for various animals and plants. Some of the animals (i.e. mink and freshwater mussels) are so sensitive to PCBs that their populations are already greatly reduced or absent from the areas. Despite the well-documented high toxicity of PCBs, the Plan would leave PCBs in place. An updated literature review of PCBs indicates the wide range of effects already known to be caused by PCBs has expanded even more in recent years. The PCBs left in the Housatonic River and nearby watershed can be reasonably expected to exert toxic effects on the animals for the foreseeable future, causing reproductive impairments, developmental abnormalities, behavioral abnormalities and other effects.

Humans will continue to be exposed to the Housatonic River PCBs via several exposure routes. First, fish will remain contaminated for decades to come. Knowledge of fish consumption advisories is not unanimous among those who fish the Housatonic. Furthermore, some subsistence fishers rely on fish as a major source of protein. Another notable exposure pathway is airborne distribution via volatilization and condensation. Research into this phenomenon in the regions of New Bedford Harbor and the Upper Hudson River indicates that community members in the vicinity of PCB Superfund sites have elevated levels of PCBs in their bodies. These PCB exposures are associated with impairments of the central nervous system, and are correlated with increased risks of ADHD in children, and impaired reasoning in elderly citizens near the Upper Hudson.

The Plan provides no documentation, no references and no serious explanation for most of the important and critical approaches, particularly the approaches that diverge from EPA practice and are inconsistent with the evaluation of the National Remedy Review Board (NRRB). The approach of leaving substantial quantities of PCBs in the "core areas" of Reach 5B is substantiated by references, documentation, raw data or acknowledgement of the literature. Major decisions that depart from Agency practice, policy and the recommendations of the NRRB need to have the rationale carefully explained, and the decision substantiated with a record of data and analysis, none of which is present in this case.

The following analysis of the effects of PCBs on the wildlife of the Housatonic River watershed provides a fuller picture of the possible short and long term changes taking place in the watershed while PCBs remain in the environment.

PCB Ecotoxicology in the Housatonic River Watershed

Introduction

The Housatonic River is inundated with PCBs and is in dire need of remediation and restoration. PCBs have a wide-range of negative impacts on fish, wildlife, and humans. Although there is extensive documentation on the impacts of PCBs in humans, here the focus is on the wildlife of the Housatonic watershed. Exposure to PCBs results in effects to nearly every body system in complex organisms, reducing their ability to survive in their native habitats. The organisms within the Housatonic River and nearby riparian habitats have experienced these effects for many years. If PCBs are not removed from the Housatonic, the watershed risks a loss in species richness and abundance. Although a significant amount of damage is already done, a swift and efficient cleanup of the river can still help preserve the function and integrity of the ecosystems so that they may better thrive in the future. It is essential that the EPA conduct a full-river cleanup, not just a cleanup of the PCB hotspots. In the pages below we outline the specific impacts of PCBs on organisms native to the Housatonic River.

Birds

Insectivorous Birds

The Housatonic river habitat supports a large variety of insectivorous birds including red-headed woodpecker, grasshopper sparrow, American robin, black-capped chickadee, and the house wren. Insectivorous birds living near rivers are vulnerable to PCB exposure primarily through the ingestion of contaminated aquatic insects. Numerous studies have described the link between PCBs and health effects for these species. However, some key additions to the literature are discussed below.

A recent study on the Hudson River Valley looked at the effects of PCBs on the songs of black-capped chickadees and song sparrows. Deleon et al. (2013) recorded bird songs as well as blood serum PCB concentrations in specimens from both highly contaminated areas near the GE plant and locations in the Ithaca valley with no known PCB point sources. Average PCB concentrations in the Hudson sites for sparrows were greater than 1100 ppb while chickadee concentrations were greater than 300 ppb. Chickadees from the Hudson valley were reported to exhibit significant deviation in the glissando and interval ratios; sparrows were noted to have increased frequency of “high-performance trill” singing (DeLeon et al., 2013).

DeLeon et al. (2013) propose that the observed changes are likely due to neurological or endocrine system effects and may be an indication of more extensive neurological changes. While augmentation of song does not necessarily affect reproductive success or result in immediate population level effects, the full extent to which these changes may do so over time is not known. Song is a major behavioral facet and is associated with many life history processes including foraging, mating, and nesting. Modulating song could disrupt each of these practices and ultimately affect success on the population scale. Such population level effects can lead to losing out in competition with unaffected species and shifts in the species composition on the ecosystem level.

In a 2007 study, Neigh et al. found exposure to PCBs in eastern bluebird and house wren were linked to a number of reproductive effects across both species. The study compared PCB concentrations from eggs sampled within the Kalamazoo/Allied Paper Superfund site, with those from a non-contaminated site. PCB concentrations were 33-133 fold greater in the Kalamazoo site, with a mean of 8.3 mg/kg in bluebird eggs and 6.3 mg/kg in house wren eggs (Neigh et al., 2007). Within the contaminated area eastern bluebirds exhibited fewer nesting attempts; house wrens experienced fewer hatch successes, smaller clutch size and predicted brood size. Neigh et al. suggest that while PCBs were a likely contributor, other contaminants may add or augment the effects noted; variations in habitat and food availability are also a source of uncertainty in such field work. It is highly likely PCBs contribute to a synergistic effect with other contaminants, as contaminants are rarely found in isolation.

Both house wren and eastern bluebird are found within the Housatonic River valley and are at high risk of exposure through their diet. While not endangered, these species can be useful as a reference for possible effects on endangered or threatened species that are more challenging to study in the field.

Piscivorous Birds

Piscivorous birds, like insectivorous birds, are primarily exposed to PCBs through diet. The Housatonic supports many species of piscivorous birds including kingfisher, heron, osprey, as well as bald eagle. Because most piscivorous birds are classed at higher trophic levels, they are additionally at risk through the tendency of PCBs to bioaccumulate and biomagnify. For these reasons, piscivorous birds are commonly used as assessment endpoints in risk assessments for PCBs and many other contaminants. Bald eagles within the Great Lakes have been the subject of several studies suggesting a variety of teratogenic, endocrine, and reproductive effects from PCBs on the previously endangered national bird (Bowerman et al., 2000). PCBs and dioxins have also been linked to major declines in water bird populations observed in the Hudson between 1996 and 2002 (Grasman et al., 2013).

The means by which PCBs affect such declines have been difficult to conclude. Grasman et al. conducted immunological blood sampling, biopsies, and reproductive success assessments on herring gull and black-crowned heron adults and chicks in the Hudson (2013). The study reported links between PCB exposure, at mean liver PCB concentrations of 380 ng/g, and effects on a suite of immunological functions as well as decreased survivability of pre-fledgling gulls and herons. Specifically several effects are reported including “severely suppressed T lymphocyte function, fewer developing lymphocytes, and altered in vitro lymphoproliferation responses” (Grasman et al., 2013). Decreases in pre-fledgling survival may be primarily due to deaths via bacterial and viral routes; however, Grasman et al. suggest that PCB exposure weakens the immune system elevating natural levels of contagion mortality. These kinds of population effects are difficult to quantify as a direct effect of PCB contamination but are important to consider in terms of the Housatonic River valley, which shares many ecosystem and contaminant characteristics with the Hudson, including providing habitat for several endangered and threatened piscivorous and insectivorous birds.

Fish and Shellfish

As PCBs tend to accumulate in sediment and persist for long periods of time, benthic dwelling fish such as the brown bullhead are at particular risk of PCB toxicity. Brown bullhead is also considered an excellent sentinel species, or a reference for environmental contamination, due to their opportunistic benthic diet and small home range (Iwanowicz, 2009). The species has been used as a bioindicator of carcinogenic and noncarcinogenic effects for decades. Farewell et al. have published several studies on brown bullhead and PCB toxicity (2012, 2013). The researchers compared wild caught brown bullhead from contaminated great lakes sites to those caught and "cleared", or maintained in clean sediment for one year prior to the study. Field sediment concentrations ranged from 75 ug/kg to more than 500 ug/kg. Bullhead caught in contaminated sites exhibited declines in egg diameter as well as in gonad mass (Farwell, 2012). Alternatively, cleared bullhead exhibited an increase in egg diameter and gonad mass. This study suggests that PCBs at levels found in sediment can have reproductive effects on sentinel species such as the brown bullhead; however, the study also suggests that cleaning up PCB contamination can result in reversal of these effects in as little as a year.

As brown bullheads are present in the Housatonic, and function as sentinel species, the specific effects of PCBs on their success is useful as a predictor of effects on the Housatonic's other fish species. A 2009 study suggested Aroclor 1240 likely leads to immunomodulation, decreased disease resistance, and endocrine disruption in brown bullheads (Iwanowicz et al., 2009). Lab-captive brown bullhead were exposed to a single dose of Aroclor 1240 at either 50 ug/kg or 5 mg/kg, via intraperitoneal injection and then biopsied for comparison. Iwanowicz et al. found that Aroclor 1240 modulated plasma cortisol and triiodothyronine, as well as cytochrome P4501A expression and hepatic somatic index. The researchers also exposed the fish to *Edwardsiella ictaluri*, a common bacterium to which brown bullhead are naturally resistant. The study found bullhead exposed to PCBs exhibited less natural immune response to the bacterium leading to higher mortality. Such cases are particularly important to understand due to the possibility of confusing natural mortality from these bacteria with PCB mediated mortality resulting from decreased immunological response.

The effect of PCBs on the endocrine system of fish has been suggested in numerous studies. The endocrine system is responsible for modulating many of the body's other systems, as well as controlling growth and development. Effects on this system are often subtle and may be multigenerational. Baldigo et al. examined PCBs and mercury as potential endocrine disrupters in several species of carp, bass, and bullhead in the Hudson River (2006). PCB sediment concentration ranged from 0 ug/kg to 2,480 ug/kg, depending on the proximity to the PCB source. The study concluded a suite of synergistic endocrine effects resulting from PCB and mercury exposure including: increased 11-ketotestosterone concentrations, decreased ratio of 17β-estradiol to 11-ketotestosterone, and increased vitellogenin concentrations (Baldigo et al., 2006). The effect on these endocrine biomarkers varied by species and sex and their own effect on the body systems is often subtle and difficult to quantify. Many more studies will be necessary to fully explore the effects of these changes. It is worth noting again that the Hudson shares some of these same species and contaminants with the Housatonic, as well as demonstrating the importance of examining the more subtle and yet wide ranging effects of PCBs on wildlife.

Many studies on the impacts of PCBs on wildlife show that PCBs tend to damage the reproductive organs of exposed organisms. This effect is particularly dangerous at the population level, as it can endanger reproductive success within a breeding group. In 2007, Lehmann et al. conducted an experiment on the effects of Aroclor 1260, a common PCB congener, on the clam species *Corbicula fluminea*. The clams were exposed to Aroclor 1260 for 21 days at 0, 1, 10, or 100 ppb. Although increasing cell injury was associated with increasing concentrations of PCBs, physiological impacts were visible when clams were exposed to concentrations of just 1 ppb. While exposure to Aroclor 1260 led to reduced glutathione and total protein concentrations, the most noteworthy impact was significant gonadal atrophy. Aroclor has been shown to have significant oxidative effects on clam tissue in both lab and field settings. Exposure to PCBs compromises antioxidant systems and increases biological energy demands, both of which reduce the ability to cope with environmental change and possible predation. In this experiment, Lehmann et al. (2007) proved that PCBs cause significant damage to gonad architecture, which could prevent or make difficult clam reproduction. Lehmann et al. states, “These changes in the gonads of exposed clams suggest that a serious threat to bivalve reproduction exists due to PCB exposure.”

Fish and shellfish are of particular concern in terms of ecotoxicology due to their consumption by humans. The bioaccumulation of toxic contaminants within larger fish and shellfish has been well documented, and has resulted in fishing bans on various species of shellfish and fish in waterways across the country. However, size is not necessarily an indicator of contaminant levels, as organisms such as clams, mussels, or oysters can deliver just as much contamination as large fish when eaten in bulk. Thus, it is important to consider the contaminants loads of not just large fish, but shellfish and smaller fish as well.

Benthic Organisms and Aquatic Insects

The effects of PCBs on benthic organisms and aquatic insects are not as well documented or understood as they are in other animals. PCBs persist and are passed from prey to predator, where they persist and bioaccumulate over a lifetime. Because benthic organisms and aquatic insects constitute a lower trophic level and have relatively short lifespans, they are less likely to accumulate high levels of PCBs. However, benthic organisms and aquatic insects are important to this discussion because they are exposed to PCBs in sediment and their consumption by higher trophic level animals is a primary route through which PCBs move through an ecosystem and become more concentrated. At the same time, benthic organisms, through breaking down larger organic materials, also facilitate the biodegradation of PCBs in sediment by microorganisms. This particular point is important because in cases of extreme PCB concentrations, benthic activity can decrease dramatically and slow the degradation of PCBs.

In a 2006 study, Fuchsman et al. developed "sediment-quality benchmarks" that could be used to predict toxicity to benthic organisms from PCBs. In doing so, the researchers examined sediment and benthic health in eight Superfund sites. Some key findings include: in New Bedford, Massachusetts, benthic degradation was observed in average sediment concentrations of 12 mg/kg while areas with 89 mg/kg exhibited both amphipod toxicity and more severe benthic degradation; in Brunswick Estuary, Georgia, decreased leaf consumption was observed at 18-25 mg/kg, while a population shift toward surface feeders was observed at concentrations of 4,400 µg/g OC (micrograms per gram of organic carbon); in the Housatonic River, extreme concentration variability prevented definitive conclusions but the authors suggest concentrations above 4,000 µg/g OC would upset benthic equilibrium, and reported that areas of Housatonic sediment have been measured above that level (Fuchsman et al., 2006).

The work of Fuchsman et al. to develop a congener and species specific benchmark speaks to the variability in the benthic and aquatic insect response to PCB toxicity. Due to the differing effects of each congener and their mixtures, as well as the numerous species of benthic organisms and aquatic insects, each site must be approached as a unique case. As Josefsson et al. concluded, even within a specific community, the PCB concentrations in benthic invertebrates varies significantly depending on the typical burial depth of the species (2011). It is important to recognize the importance of these lower trophic levels to the health and survival of an ecosystem, and to act upon that recognition through careful consideration of the effects PCBs may have upon these communities.

Reptiles

Many PCB congeners act as environmental estrogens, and have been shown to alter sexual differentiation. In a study on the effects of PCBs as environmental estrogens, a team of zoologists at the University of Texas demonstrated that certain PCB congeners can reverse gonadal sex in a population of red-eared sliders (Bergeron et al., 1994). Red-eared sliders, although not a common species in the Housatonic watershed, are a subspecies of the pond slider, which is common throughout the U.S. Red-eared sliders are a species where egg sex is temperature dependent; warm incubation temperatures (e.g., 31°C) produce all females, and cooler temperatures (e.g., 26°C) produce all males. Researchers set the temperature at 26°C, a temperature that normally produces 100% males. The scientists then applied a variety of PCB congeners to the eggs in a 95% ethanol solution. Results showed that two compounds, 2'4'6'-trichloro-4-biphenylol (compound F) and 2'3'4'5'-tetrachloro-4-biphenylol (compound G), significantly reversed sex at the all-male producing temperature. Compound F showed 100% sex reversal (all female) at 100 µg, or just below 9 ppm. When combined, compound F and compound G synergized, resulting in a significant increase in ovarian development at a dose of just 10 µg, which is less than 1 ppm. The authors of the study note that the PCB levels in this study that were effective in disrupting normal gonadal differentiation in the turtles are comparable to average PCB levels found in the breast milk of humans living in industrialized nations (Bergeron et al., 1994).

In a study on cause-effect linkage between environmental contamination and snapping turtle egg development, Bishop et al. (1991) collected eggs of the common snapping turtle (*Chelydra s.serpentina)* from wetland sites along the shores of Lake Ontario, Lake Erie, and one control site in Ontario, Canada. Eggs were artificially incubated to determine hatching success. The presence of unhatched eggs and deformed eggs occurred at significantly higher rates in eggs from the Lake Ontario wetlands, where two of the three sites had substantially higher levels of PCBs. The authors concluded that the statistical association between the presence of PCBs in developing eggs and poor egg development supported the hypothesis that eggs from the sites with the highest levels of contamination had the highest rates of abnormalities. The control site, where no notable contamination was present, had excellent hatching success and low numbers of egg deformities (Bishop et al., 1991). This study suggests that contaminated sites led to abnormalities within snapping turtle eggs, decreasing the chances for reproduction and long-term survival for snapping turtles with physiological abnormalities. Although contaminants other than PCBs were present at the sites, the authors note that both theoretical and factual information on the effects of PCBs on wild-caught snapping turtles support their hypothesis that higher contamination levels lead to more abnormalities. The authors also point out that the rate of deformities and unhatched eggs in this study was similar to rates in other vertebrates collected from highly contaminated sites within the Great Lakes (Bishop et al., 1991).

Mammals

In a particularly important study for the Housatonic River, Bursian et al. (2006) documented the physiological impacts on farm-raised mink from eating PCB-contaminated fish from the Housatonic. The scientists found that including PCB-contaminated fish in only 4% of the minks' diet negatively impacted kit survival. Diets containing 3.54% Housatonic River fish provided 3.7 µg PCBs/g feed. Female mink were fed these diets for eight weeks before breeding and for six weeks while they were weaning kits. The kits stayed on the diet for an additional 180 days. When dams were fed 3.7 µg total PCBs/g feed, the survivability rates of mink kits three to six weeks old and three-week body weights were significantly lower compared to controls. This same concentration of PCBs in feed caused maternal liver concentrations of 3.1 µg PCBs/g wet weight. Additionally, kits exposed to contaminated feed had mandibular and maxillary squamous cell proliferation when contaminated Housatonic fish made up only 0.89% of their diet. While squamous cell proliferation may not result in population-level effects, it is evident that very low concentrations of PCBs in the minks' diet causes physiological damage. The authors state,"...it is possible that consumption of up to 30-fold that quantity of [Housatonic River] fish, as could be expected for wild mink, would result in more severe lesions characterized by loss of teeth, thus impacting survivability" (Bursian et al., 2006).

In a study on wild mink and river otters in the Columbia and Fraser Rivers of the American northwest, researchers found a significant negative correlation between total concentration of PCBs in mink livers and baculum (penile bone) length in juvenile males (Harding et al., 2014). Researchers collected mink and river otter carcasses over the span of two winter seasons and performed full necropsies on the bodies. For PCBs in mink, Harding et al. analyzed wet weight of total PCBs in livers. Total PCB concentrations in mink livers ranged from 0 to 0.18 µg/g wet weight. The graph below depicts the decline in baculum length as total PCB concentration increases.

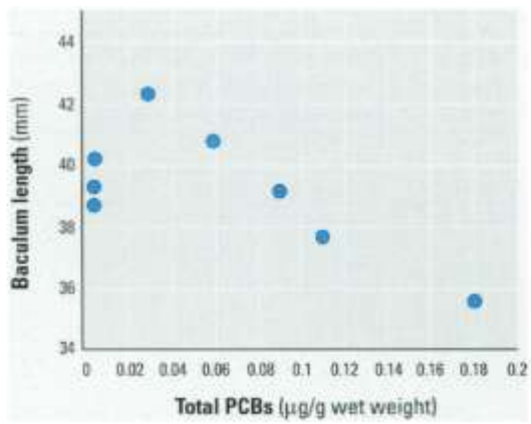

Figure 3. Relationship between total polychlorinated biphenyls (PCBs; as Aroclor 1260) and baculum length in juvenile mink collected from British Columbia, 1994–1996 ($r = 0.707$; $p = 0.033$).

Although there is not yet a proven association between juvenile baculum length and eventual reproductive success, smaller baculum sizes could prove to be disadvantageous in terms of reproduction and competing for females (Harding et al., 2014). Regardless of a proven causation between juvenile baculum length and reproductive success, it is important to note the general correlation in all the studies thus far between PCB contamination and reduced reproductive function in mammals and non-mammals alike.

While ecosystem models are not direct reflections of a wild ecosystem in action, they are important for assessing the impacts of toxic contaminants on population-level endpoints. In a model-based study on the impacts of PCB cleanup strategies on mink populations, Salice et al. (2011) tracked hypothetical individual mink from birth to age seven, in a 100 mink population and a 1000 mink population. The researchers found that the most positive impacts on mink populations came from initiating cleanup as soon as possible after the initial contamination. More importantly, the researchers found that the rate of cleanup did not have as strong an impact as the initiation of cleanup. The mink populations with the lowest probabilities of extinction and the highest recovered populations resulted from a cleanup that started five years after initial exposure, versus the population with lowest recovered populations, where cleanup started twenty years after the initial contamination. As the start-year for cleanup decreased from year 40 to year 25 within the model, the probability of extinction decreased by 50% or more. This is to say that the urgency with which the cleanup began was more important than how long the cleanup took. The study also found that attacking hot spots first is one of the most beneficial strategies in a PCB cleanup. It is important to note however that the authors of the study stress the need to completely clean up hot spots before moving on, “avoiding large but infrequent clean-up actions.” (Salice et al., 2011).

Amphibians

In a crucial study from 2005, Qin et al. demonstrated forelimb malformations in frogs caused by PCBs. The research team exposed *Xenopus laevis*, a commonly studied frog species used in the laboratory setting, to test the impacts of PCBs in water. Tadpoles in a tank of water were exposed to PCB concentrations of 10 µg/L of water. However, due to absorption by the glass tank and debris within the tank, PCB levels decreased by 90%, bringing the concentration down to 1 µg/L; 1 µg/L is higher than the general level reported in wild environments, but when considering bioaccumulation of PCBs and the trophic level of amphibians in the food chain, 1 µg/L can be considered close to the exposure levels that amphibians in the wild would experience. Exposure to the 1 µg/L concentration caused forelimb malformation in over 70% of frogs. Malformed forelimbs were fixed in the adduction-backward rotation position, rendering the male frogs unable to grasp females for mating. Thus, male frogs were unable to produce offspring (see images below). In addition, testes from more than a third of the male frogs exposed to PCBs exhibited feminization, with fewer or abnormal spermatogonia and oocytes. The authors of the study point out that this would lead directly to reproductive dysfunction and population decline (Qin et al., 2005).

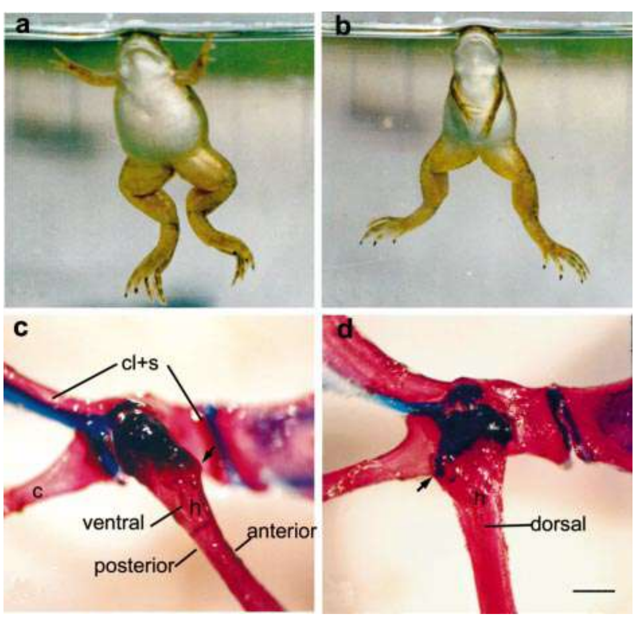

Figure 1 from “Potential Ecotoxic Effects of Polychlorinated Biphenyls on *Xenopus laevis.*”**(a)** A normal frog in the water. **(b)** A malformed frog in the water. **(c)** Left glenohumeral joints of a normal frog. **(d)** Left glenohumeral joints of a malformed frog.

Ecosystem Effects

Ecosystems are inherently complex. As such, to determine risk to an ecosystem is significantly more challenging than doing so for an individual, as we would with humans, or with a population, as we do with a specific animal species. Much of this challenge stems from an incomplete understanding of the toxicological profile of PCBs. As PCBs and their effects differ from congener to congener, research on the contaminant is fragmented and difficult to use on an ecosystem, or even population level. Through developing Toxic Equivalents (TEQ) for PCB congeners, better predictions of toxicity can be made. However, as Ottinger et al. (2013) found in their extensive study of PCB toxicity in lab raised and wild birds, TEQ values are commonly a poor predictor of congener toxicity; in some cases congeners were less toxic than expected, while in others, especially where congener mixtures were examined, toxicity was much greater than expected (Ottinger et al., 2013). Ottinger et al. suggest the need for a new Endocrine Disruption Index (EDI), which would provide a better tool for assessing risk from PCB toxicity, but also speaks to the inadequate tools available for assessing risk at the moment.

Ecosystem effects are also difficult to predict or understand because they often occur over generations. Species that exhibit greater toxic effects to PCBs, such as the brown bullhead's decreased immunological capacity, will lose out to fish species less affected by the contaminant. At the same time, established relationships between predator and prey, host and parasite, and other basic constructs of the ecosystem are disturbed. Such disruption of speciation and ecosystem equilibrium has already been observed. In a 2010 study, Clark et al. document a resistance to PCB toxicity in the Atlantic killifish which allows the species to survive at concentrations toxic to most other species. The researchers also indicate that this resistance tends to increase generationally, such that each succeeding generation is better adapted to the contaminant. Where this occurs, killifish are likely to become a more dominant species, replacing species it once competed against. The result of these adaptive changes in the killifish and the maladaptive changes in the brown bullhead are an unnatural selection brought on by long-term exposure to a contaminant.

These disruptions can occur at the lowest trophic levels as well. As Kostel et al. demonstrated using a simulated stream habitat, exposure to PCBs can cause changes in periphytic and algal communities, reducing biodiversity and increasing the success of some producers at the expense of others (1999). Disruption at the producer level inevitably affects trophic levels above. Unfortunately, it is difficult if not impossible to predict the long-term effects such changes may have on an ecosystem.

Many of the other effects discussed in this report are likely to compound with time as well. Decreased reproductive success can take many generations to become disruptive or even noticeable. Reproductive mutations can be passed down and increase in frequency from generation to generation. Endocrine changes can augment behavioral patterns, as observed in the songs of chickadees and sparrows on the Hudson River

(DeLeon et al., 2013). These changes in behavior may be harmless, or they may catastrophically interrupt activities such as foraging, feeding, mating, or nesting.

The study of endocrine disrupting chemicals (EDCs) is a relatively new area of toxicology and much more research is needed before the mechanisms of action at work are fully understood. In a 2009 paper, Wingfield and Mukai examined the effect of EDC's in the context of life cycles. They suggest that EDC's, which includes PCBs, may affect the way organisms perceive and respond to the environment, as well as how they communicate that information to other individuals and to their young. Wingfield and Mukai argue that EDC's may affect the ability of an individual to correctly respond to environmental, social, and even physical signals. They further suggest that such effects on individuals, populations, and entire ecosystems may not be immediately apparent. While the researchers acknowledge that their work is primarily qualitative, and that more research needs to be done in this area, their suggestions provide further indication of the danger posed by PCBs in the environment. The literature provides numerous examples of the effects PCBs have on humans, wildlife, and the environment.

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2) Fish Tissue PCB Levels must be lower

The Biota Performance Standard in the Permit is woefully inadequate. EPA guidance lists PCB levels in fish that are protective for cancer or non-cancer effects, associated with a range of fish consumption rates. The Permit indicates that a fish tissue PCB concentration of 1.5 mg/kg (ppm) shall be achieved within 15 years (Permit page 13, section 2 a), but EPA recommendations for PCB levels are orders of magnitude lower than 1.5 mg/kg for any level of fish consumption (see table below taken from EPA guidance: EPA-823-F-99-019 September 1999). PCB levels in fish need to be less than 0.006 mg/Kg in order to allow one meal a week without an increased cancer risk. The EPA plan will not support safe fish consumption for the anticipated future in MA or CT.

The following table is taken from EPA's fish consumption advisory information for PCBs:

Table 2. Monthly Fish Consumption Limits for PCBs

Risk-Based Consumption Limit	Noncancer Health Endpoints	Cancer Health Endpoints
Fish Meals/Month	Fish Tissue Concentrations (ppm, wet weight)	Fish Tissue Concentrations (ppm, wet weight)
16	>0.006 - 0.012	>0.0015 - 0.003
12	>0.012 - 0.016	>0.003 - 0.004
8	>0.016 - 0.024	>0.004 - 0.006
4	>0.024 - 0.048	>0.006 - 0.012
3	>0.048 - 0.064	>0.012 - 0.016
2	>0.064 - 0.097	>0.016 - 0.024
1	>0.097 - 0.19	>0.024 - 0.048
0.5	>0.19 - 0.39	>0.048 - 0.097
None (<0.5)[a]	>0.39	>0.097

[a]None = No consumption recommended.
NOTE: In cases where >16 meals per month are consumed, refer to EPA's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories,* Volume 2, Section 3 for methods to determine safe consumption limits.

EPA-823-F-99-019, September 1999

3) PCB Toxicity

The Plan does not account for recent publications on PCB toxicity which further reinforce the importance of removing (or treating to detoxify) the PCB contaminated sediments. The result of the Plan will be continued harm to human health and the environment from PCBs. A brief summary of PCB toxicity with updated information is presented here to substantiate the point that PCB removal is needed.

Introduction

Polychlorinated biphenyls (PCBs) are industrial chemicals that were manufactured under the trade name Aroclor for use in transformers, electrical equipment, motor oils, plastics, paint, and numerous other applications. Although banned thirty-five years ago, these contaminants are still widely detected in humans and the environment.

PCB's primarily accumulate in soils and sediment as a result of spills, leaking toxic landfills, or contamination from products containing the chemicals. While PCBs do pollute the air via volatization and dispersion, the contaminants are most problematic in soils and sediments where they adhere to organics and are very slow to degrade. The primary route of exposure for humans and wildlife is through the ingestion of contaminated dietary items. PCBs are highly lipophilic and dissolve in fatty tissues and bioaccumulate over an organism's lifespan. This property is important to both human and ecological toxicology because bioaccumulation leads to biomagnification, the process by which persistent toxins increase in concentration upward through the food chain (Faroon et al., 2003). As a result, the highest concentrations of PCBs are often observed in top predators with long life-spans and high fat deposits such as dolphins, whales, and humans.

In the United States, PCBs are regulated by several different agencies and regulatory frameworks. The Environmental Protection Agency (EPA) requires drinking water to have a maximum contaminant level (MCL) of 0.5 parts per billion (EPA, 1996); fish consumption advisory numbers are also maintained in contaminated waters. States are increasingly being urged by EPA to develop PCB total maximum daily loads (TMDLs) goals for reducing PCB concentrations in affected waterways. Disposal and remediation of PCBs is regulated under the Toxic Substances Control Act (TSCA) (EPA, 2005). Finally, the Federal Drug and Food Administration (FDA) publishes tolerances for PCB concentrations and residues in foods such as milk, eggs, and poultry and enforces bans on the use of the compound in product packaging.

Brief Review of Human and Ecological Toxicology

PCBs are a broad category of compounds consisting of 209 individual congeners differentiated by the position and number of chlorine atoms that make up the molecule (Lauby-Secretan et al., 2013). Part of the complexity of studying PCB toxicity is recognizing that the chemical, physiological, and ecological effects of these distinct congeners can vary. PCBs are classified as endocrine disrupters because of their ability to mimic hormones and activate, deactivate, and even damage receptors that modulate and control cellular and body systems (Lauby-Secretan et al., 2013). The specific receptors affected varies based on the congener or mixture of congeners involved and these multiple mechanisms of action result in a wide range of possible human and environmental effects. The following section provides an overview of toxicological effects of PCBs with the understanding that these general conclusions do not apply to all congeners.

Carcinogenic Effects

Increasingly the consensus points towards a strong link between cancer in humans and wildlife exposed to PCBs. In 2013 the International Agency for Research on Cancer (IARC) upgraded PCBs from “probable carcinogen to humans” to “carcinogenic to humans”. This decision was made based on 70 epidemiological studies which showed elevated risks of melanoma in both individuals with occupational exposure and the general public; increased risks of breast cancer and non-Hodgkin’s lymphoma were also noted (Lauby-Secretan et al., 2013). This report aligns and strengthens the position of EPA's 1996 report which concluded that PCBs are likely carcinogenic with evidence of increased risk of thyroid, liver, and gastrointestinal cancer from PCB exposure.

Non-Carcinogenic Effects

PCBS have been shown to affect most of the major body systems including the respiratory, cardiovascular, gastrointestinal, renal, endocrine, and musculoskeletal (Faroon & Olson, 2000). PCBs can also affect the reproductive system; studies on rats have documented decreased litter sizes and body weight, as well as reduced sperm count and conception rates (Faroon et al., 2003). In both humans and rats, neurological and developmental deficits have been observed in children with high *in-utero* exposure (EPA, 1996). Children exposed to PCB’s at an early age have been reported to exhibit weaker reflexes, reduced memory, and a higher likelihood of attention deficit issues (Faroon et al, 2003). PCBs have also been linked to immunological effects that range from a weakening of the immune system to increases in inflammatory disorders such as tonsillitis and bronchitis (Faroon et al, 2003).

The toxicology of PCBs continues to be an area of extensive international research and each year brings numerous new studies on the contaminant.

2013-2014 Literature Search

The current literature search is an update of one conducted in August-September 2013 (Appendix B) that covered PCB in the literature from 2002 to 2013. The review of the literature published in 2013 and 2014 on PCB toxicology returned over 150 relevant publications. These publications are listed in Appendix A for the reader's convenience. While it is not within the scope of this memo to address them all, a few key studies are discussed in brief below.

Carcinogenic Effects

As stated above, IARC's 2013 classification of PCBs as carcinogenic is significant and several recent studies support this classification. Dong et al. (2014) found some PCBs are both cytotoxic and genotoxic in liver cells and increased DNA and chromosome breaks were observed in cells exposed to this congener. Ruder, Hein, Hopf, & Waters (2014) examined a cohort of 24,865 workers exposed to PCBs at manufacturing plants in the U.S. and found elevated overall mortality and an increased risk of melanoma and stomach, prostate, and nervous system cancers. Similar studies conducted by Li et al., (2013) and Onozuka, Hirata, and Furue (2014) examined workplace exposure cohorts and found decreased net survival rates primarily caused by increased cancer rates. PCB exposure was also linked to chemoresistance of liver cancer, resulting in a poorer prognosis in patients with the disease (An et al., 2014).

Non-carcinogenic Effects

Several new studies have addressed the link between PCBs and neurological effects. Gaum et al. (2014) studied individuals with work-related exposure to PCBs and found a significant relationship between PCB burden and increased depression and psychosomatic symptoms. Wigestrand, Stenberg, Walaas, Fonnum, & Andersson (2013) found PCBs can inhibit uptake of dopamine in the same manner as cocaine; the researchers suggest this mechanism is a likely factor in PCB neurotoxicity and behavioral effects such as depression.

The effects of PCB’s on human development have been well-documented but several new studies provide an international scope to the literature. A 2014 study of toddlers in Japan found a relationship between prenatal exposure of PCB congeners in cord blood and decreased IQ (Tatsuta et al., 2014). This is significant because prenatal exposure continues to be a significant exposure pathway in the U.S.; Nanes et al. (2014) surveyed 43 human placentas from several U.S. locations and found PCBs in all specimens. Dallaire et al. (2014) studied a cohort of Inuit children and found a correlation between concentrations of PCB 153 in blood and lower weight, shorter height, and smaller head circumference across a range of ages and suggest PCBs are disrupting thyroid function. Decreased motor coordination was also positively correlated with PCB exposure; a study of 97 Dutch infant-mother pairs found high PCB 107 and 187 blood concentrations were associated with decreased motor coordination (Berghuis, Soechitram, Hitzert, Sauer, & Bos, 2013).

Finally, a 2014 paper corroborates previous epidemiological studies that suggested a link between exposure to PCBs and auditory impairment in children and adults; data surveyed from 1999-2004 indicated a positive relationship between serum PCB levels and hearing impairment in U.S. adults (Min, Kim, & Min, 2014).

Environmental and Ecological Effects

PCBs are potent contaminants in the environment as well; many of the same effects seen in humans have been documented in wildlife. However, international bans and cleanup efforts have resulted in a reduction of PCB levels in soils and sediments in some cases. Everaert et al. (2014) report two to threefold reduction in PCB concentrations between 1991 and 2010 in an open water ecosystem near Belgium; no significant decrease was observed in an industrial estuary receiving no remediation. As Bruckman et al. (2013) indicate in their survey of PCB soil depositions in Germany, PCB congeners have long half-lives and can be retained in sediment for decades unless the PCBs are cleaned up.

Remediation of PCB contamination has been shown to be effective in many cases. A 2013 study by Ficko, Luttmer, Zeeb & Reimer compared PCB concentrations in vegetation and field mice on an abandoned Air Force station before and after PCB remediation work was conducted; the study found vegetation concentrations were four times lower while concentrations in deer mice were three times lower.

Several new studies add to the well-established ecotoxicological profile of PCBs. A 2013 study of six arctic birds found that migration and opportunistic feeding increased PCB burden equivalent to one full increase in trophic level (Baert, Janssen, Borgå, & De Laender, 2013). Evidence of these effects on migratory birds reinforces the international scope of PCB contamination. Persson & Magnusson (2014) surveyed 101 wild mink and found that PCBs alter the size and shape of mink reproductive organs, likely leading to reproductive effects. Similarly, Carpenter et al. (2014) found high PCB concentrations in Illinois river otters and concluded the species is at risk of PCB toxicity.

Marine mammals such as whales and dolphins have been shown to retain high PCB concentrations decades after the PCB ban. Dorneles et al. (2013) found high accumulation of PCBs in false killer whales and rough-toothed dolphins off the coast of Brazil. Similarly, a survey of beluga whales found moderate levels of PCB exposure and confirmed the contaminant can disrupt vitamin profiles in the large mammals (Deforges et al., 2013). As Kubo et al. (2014) report in their study of Steller sea lions, marine mammals are also at risk of PCB exposure through maternal-to-fetal transfer.

Summary

As investigations into all aspects of PCBs continue around the globe, new information continues to reveal several trends:

- PCBs are toxic at lower levels than previously believed
- PCBs cause a wide range of toxic effects on wildlife and humans, including cancer
- Remediating PCB contamination is effective in reducing the PCB burdens

PCB contamination is a local, regional and global problem- the PCBs in one locality will contaminate the living and non-living environment, contribute to the regional PCB burden, and add to the global PCB burden for generations to come.

4) Advances in PCB Removal and Remediation Technology

The Plan relies primarily on capping and MNR for remediation, the result of which is that much of the PCB mass will remain in place. This strategy is based on a series of erroneous assumptions, one of which is that the removal methods are not sufficiently sophisticated to prevent extensive physical damage to the river system. This assumption is not at all supported by the current practices as carried out by the private sector and by the US Army Corps of Engineers. This section explains some of the newer methods and equipment in use today.

Introduction

Polychlorinated biphenyls (PCBs) are industrial chemicals that were manufactured under the trade name Aroclor for use in transformers, motor oils, plastics, paint, and numerous other applications. Although banned thirty-five years ago, PCBs are still widely detected in humans and the environment. According to the EPA Superfund site database, 359 of 1313 currently active superfund sites are contaminated with PCBs. The pollutant is considered a known human carcinogen by the International Agency for Research on Cancer (Lauby-Secretan et al. 2013) and non-carcinogenic health effects have been documented in nearly every major body system (ATSDR 2000).

PCBs are classified by distinct “congeners” based on the quantity and location of chlorine atoms within the molecule (EPA 2012). PCBs are generally hydrophobic, tending to adhere to organic and inorganic materials and accumulate in soils and sediment. Congeners with more chlorine atoms exhibit higher resistance to biological degradation and can persist in the environment for decades (Mikszewski 2004). As such, PCBs pose many challenges for remediation and as yet no consistent “best practices” have been determined.

The most common remediation technologies for contaminated sites involve media removal either via excavation or dredging followed by land filling or incineration (Gomes, Dias-Ferreira, and Ribeiro 2013). However, in many cases such options are neither economically or environmentally sustainable. In the last decade emerging technologies developed by remediation firms and academic institutions are providing a number of viable alternatives to incineration and land filling.

***In Situ* Technologies**

PCB remediation is an expensive process and removal of the contaminated soil or sediment, whether by excavation or dredging, contributes a large part of that cost. These processes also risk disturbing and dispersing PCBs. In situ remediation technologies are designed to clean up PCBs without removal from the environment. Most in situ technologies remain difficult to implement on a large scale and are typically suited to low concentrations of contamination, however, several emerging technologies may be viable alternatives to traditional practices.

Bioremediation

Bioremediation is a process through which microbial degradation of PCBs is facilitated through creating a favorable environment for the process; this can be done through controlling the physical, chemical, and microbial aspects of the environment (EPA, 2012). This process generally begins with instigating anaerobic dechlorination, or the removing of chlorine atoms by anaerobic bacteria; this results in lightly chlorinated PCBs that are both less toxic and degrade more readily into inert molecules through the secondary process of aerobic biodegradation (Gomes, Dias-Ferreira, and Ribeiro 2013). Bioremediation may be of particular use in combination with active containment technologies such as reactive capping or phytoremediation.

There are many examples of bioremediation used in the remediation industry. One such example of note is the North Carolina company BioTech Restorations[1]. BioTech specializes in the bioremediation of chlorinated contaminants including PCBs through application of a proprietary protein "factor" which stimulates the indigenous microbial population and enhances their ability to degrade PCBs. While previously demonstrated in soils, dredged sediment could also be treated in this manner. Some of BioTech's successful remediation projects include the cleanup of the former New England Log Homes factory site in Great Barrington, Massachusetts and the Hercules Chemical Plant in Brunswick, Georgia.

Phytoremediation

Phytoremediation is an increasingly popular technology that employs specific plants to sequester, extract, and degrade contaminants in situ. Phytoremediation of PCBs works through three main pathways: i) uptake by the roots (sequestration), ii) degradation through plant enzymes, and iii) improving natural bioremediation through root activity in the soils (Gomes et al., 2013). While PCBs are partially retained in plant biomass, phytoremediation provides a noninvasive means of removing/degrading the contaminants. PCB contaminated plant matter may also be converted into biofuels during which the remaining concentrations would be destroyed. Phytoremediation can be implemented using a variety of plants; canarygrass and switchgrass were found to be particularly effective on soil (Chekol et al., 2004) while eelgrass was effective in aquatic sediment (Huesemann et al. 2009). Phytoremedation is also a good candidate for use in conjunction with bioremediation due to the root and rhizomatic boosts to biological activity.

There are several exampes of phytoremediation in the field. In 2015, the Iowa Superfund Research Program will finish a full scale study of employing phytoremediation to remove PCBs from soil and groundwater at a confined disposal facility in East Chicago. A similar test is being conducted on a PCB contamined wastewater pond in Altavista, Virginia. Several engineering and remediation firms use

[1] Disclaimer: Environmental Stewardship Concepts, LLC worked with BioTech Restorations on the first draft of the QAPP for the Housatonic River cleanup. ESC completed the project in May 2014 and is no longer under contract to BioTech Restorations.

phytoremediationto remove PCBs including Edenspace, TRC Companies, and EADHA enterprises.

In Situ Sediment Ozonator

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 has been shown to react with PCBs by forming more biodegradeable products as well as boost biological activity in sediment or soil (Gomes, Dias-Ferreira, and Ribeiro 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 (Hong 2008). The final report on the technology suggests that the materials to build ISO rigs are readily available in current dredging technology and that contaminated sediment could be treated for as little as fifty dollars a cubic yard. 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.

***Ex Situ* Technologies**

In many cases, the most practical means to treat a contaminated area is to remove the target media with dredging or excavation. The materials can then be transported and treated ex situ, or off-site. Treating contaminations ex situ allows for the use of more intensive treatment technologies that would be unsafe or impractical in situ. While incineration remains the most common ex situ technology, several emerging technologies are showing promise.

BioGenesis^{SM}

BioGenesis Enterprises' proprietary BioGenesis^{SM} Soil/Sediment Washing Technology is one of the most well documented alternatives to incineration. BioGenesis^{SM} is a sequence of eight processing steps that treat contaminated sediment sufficiently to allow the post-treatment media to be used as high-end topsoil or construction grade products (BioGenesis 2009). BioGenesis^{SM} is designed to accommodate large volumes of contaminated sediment through the construction of a facility in a location where sediment can be directly delivered by barge or hydraulic pipe.

BioGenesis^{SM} has conducted several bench-scale studys and a recently completed full-scale demonstration of the technology in the New York/New Jersey Harbor which handled materials from the Raritan, Passaic, and Arthur Kill. According to the final report, the full-scale test facility was capable of remediating 250,000 cubic yards of sediment per year at a cost of $51-59 per cubic yard (2009). While initial costs of construction of these facilities is higher than other technologies, repeated demonstrations have provided enough data to conclude that BioGenesis^{SM} is an environmentally and economically sound alternative.

Mobile UV Decontamination

Researchers at the University of Calgary have developed a mobile PCB remediation unit that builds upon a study showing ultraviolet light's capability of effectively degrading PCBs in transformer oil, as well as soils, and sediment (Kong, Achari, and Langford 2013). The project, backed by SAIT Polytechnic and IPAC Services Corp., is a 15 meter long mobile unit that combines UV and visible light technologies to degrade PCBs 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 operation in areas where soil or sediment could be removed and processed nearby. The unit is currently designed to handle smaller contaminations but the project group plans to expand the technology to address the needs of larger remediation projects.

<u>nZVI Dechlorination</u>

Zero-valent iron nanoparticles (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. Where PCBs are concerned, ZVI works through dechlorination into less toxic and more biodegradeable constituents (Gomes, Dias-Ferreira, and Ribeiro 2013). ZVI has been tested in the sediment of both the Housatonic River and New Bedford Harbor; however mixed results have prevented ZVI from mainstream implementation. nZVI improves upon ZVI through a reformulation using nanoparticles which exhibits superior reactivity and more consistent removal of PCBs in groundwater and soil (Mikszewski 2004). While nZVI can be used in situ, due to limited research on the effects of nanoparticles on the environment, 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).

<u>Removal Technologies</u>

When *in situ* treatment is not possible, removal of the contamination, whether it be industrial waste, soils, or sediment is required before ex situ remediation is possible. Where PCBs are concerned, the most common, and often most concentrated contaminations are found in river sediment in and around industrial areas. Heavy dredging equipment is often required to remove and transport the sediment, the use of which can be expensive economically and environmentally. However, advances in removal technologies can reduce these costs through more precise and focused application.

<u>Environmental Dredging</u>

Environmental dredges are designed with the understanding that dredging can re-suspend and disperse contaminants beyond the original site. Most environmental dredging uses hydraulic cutter dredges, which break up and then pump sediment and water through pipes to a desired location. The Bean technical Excavation Corporation's (Bean TEC) *Bonacavor* builds upon that standard using a hybrid model: mechanical excavation and hydraulic transport. This hybrid model allows more precise control of dredging which reduces unnecessary dredge area or depth and sediment disturbance. The *Bonacavor* also features an advanced onboard GPS and Crane Monitoring System (CMS) that provides precise control of the crane while dredging, as well as a Slurry

Processing Unit (SLU) that increases solid concentration during dredging resulting in less water intake (Lally and Ikalainen). Smaller hydraulic cutter dredges have also been developed by companies such as Ellicott and Great Lakes Dredging (Randall, Drake, and Ii 2010). These dredges have smaller footprints and are able to facilitate removal at less cost and disturbance to the environment.

<u>Activated Metal Treatment and Green PCB Removal</u>
Technologies that allow PCBs to be removed without removing the contaminated media may offer alternatives to dredging in the future. NASA has also licensed two technologies that are designed to absorb PCB from the envrironment for removal. Activated Metal Treatment System (AMTS) is a solvent solution that can be applied to surfaces to remove PCBs from paints, caulk, or sealants (Parrish 2013). AMTS has been extremely successful during in situ remediation of industrial facilities where PCBs were used widely as paints and sealants on storage tanks, buildings, and other structures. The product allows extraction of PCBs without removal of the structures whereupon the contaminants can be treated safely ex situ. 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).

Specific to sediment and soil contamination, NASA is also developing GPRSS, or Green PCB Removal From Sediment Systems, which is a system that uses ”resevoir spikes” treated with AMTS to remove PCB from sediment in situ (Parrish 2013). The spikes are inserted into the target area wherein the AMTS breaks down and absorbs PCBs; the system can then be removed and decontaminated before reuse. While still in preliminary testing, GPRSS appears to be a promising technology for removal of PCBs without dredging.

<u>Reactive Capping</u>
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 PCBs; additives used in this process include Activated carbon, biochar, and metals such as zero-valent iron coated palladium (Gomes, Dias-Ferreira, and Ribeiro 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.

Summary

Advances in PCB remediation and removal technologies provide viable alternatives to incineration/landfilling and/or physical containment. General conclusions include:

- Viable technologies exist for in situ and ex situ treatment
- As circumstances differ dramatically from one project site to another, each should be assessed independently when determing appropriate remediation technologies.
- Dredging and removal technology has improved as well and can be more economically and envrionmentally sustainable.

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5) Stream Restoration is effective

Another erroneous assumption inherent in the Plan is that once the contamination is removed, the system cannot be restored to conditions at least similar to conditions prior to the remediation. Stream restoration is conducted with great success around the nation and quite a bit in Massachusetts and throughout New England.

<u>The practice of Stream Restoration</u>
Stream restoration becomes necessary in waterways where the ecosystem has become severely degraded by land use changes, pollution, channelization, or other anthropogenic disturbances. Examples of stream degradation include erosion, loss of habitat, increased suspended sediment load, eutrophication, and loss of channel stability. The purpose of stream restoration is to restore an ecosystem to its natural state and optimal function prior to degradation. Benefits of stream restoration include improved aquatic and riparian habitat, reestablishment of sensitive fish and wildlife populations, recreational use for residents, and in some cases, providing for safe human consumption of fish and/or shellfish (USACE).

Stream restoration is an increasingly well established field. Biologists, ecologists, environmental engineers, and other professionals have been building upon their shared knowledge to great effect. The Society for Ecological Restoration has published, *Restoration Ecology*, a journal on stream restoration since the early 1990s. As the field becomes more commonplace and understood, scientists and non-scientists alike are recognizing the importance of stream restoration. Policy makers have adopted much from the field. Watershed and stormwater management plans are now common practice as local governments and other organizations put in place preemptive regulations on stormwater runoff. Similarly, many cities have started implementing Best Management Practices (BMPs) for stormwater, or techniques used to manage the quantity and quality of stormwater runoff (EPA 2014). The goal of BMPs is to reduce the volume of runoff from impermeable surfaces and to reduce or eliminate the contaminants in the runoff. While BMPs and other techniques aim to prevent stream degradation, not every stream is at a point where preemptive action can be taken; some waterways are too far degraded and require restoration. The Housatonic River is one such example.

Stream Restoration in Action
The expanding history of stream restoration means that there are now a number of concrete examples of successful restoration projects. While stream restoration is practiced around the world, we will focus on examples that share biological and geological characteristics with the Housatonic.

Many stretches of the Housatonic are similar in nature to other New England sites where stream restoration has been successfully completed. The state of Massachusetts has extensive experience with stream restoration due to a long list of recent dam removal projects. From 2010 to 2013, the state removed dams and restored habitat at fifteen sites (American Rivers). In 2011, Massachusetts was declared second in the nation for most dams removed (Massachusetts Municipal Association). Although restoration of the Housatonic will not require dam removal, several dam removal restoration projects have occurred in nearby areas that share the same geology and ecology with the western section of the Housatonic River. One such example is the Hathaway Brook restoration project in Pittsfield, MA.

Hathaway Brook, only a few miles away from the banks of the Housatonic, was restored in the fall of 2010 after the City of Pittsfield voted to remove the Upper and Lower Hathaway Brook Dams. The presence of the abandoned dams resulted in a loss of aquatic habitat, stream continuity, and natural sediment transport throughout Hathaway Brook. Construction crews demolished both dams, thus restoring access to 3,000 feet of stream and allowing the migration of brook trout and other aquatic organisms from the Housatonic to the upper reaches of Hathaway Brook. Riparian habitat along the stream banks was restored through the planting of native shrubs, trees, and grasses. The project also created small pool habitats to encourage brook trout spawning in the area. Restoration efforts were made possible through a partnership between the Central New England Fishery Resources Complex and the Eastern Brook Trout Joint Venture, under an agreement with the City of Pittsfield (Massachusetts Executive Office of Energy and Environmental Affairs).

Hathaway Brook streambed near the end of restoration activities (Photo credit: City of Pittsfield)

A second example of stream restoration on the Housatonic is the Great Barrington River Walk. In cooperation with local volunteers and the town of Barrington, the Great Barrington Land Conservancy constructed a public greenway trail along the river. The trail was recently designated as a National Recreation Trail, and was constructed with the help of over 2000 volunteers. Restoration along the river walk was designed to enhance biodiversity, improve degraded riparian conditions, and increase public access to the Housatonic River. Volunteers planted over fifty varieties of native trees, shrubs, vines and herbaceous plants along the stream banks. Restoring riparian zones improved both groundwater and surface water quality (gbriverwalk.org)

Great Barrington Housatonic River Walk (Photo credit: americantrails.org)

There are also a number of stream restoration success stories from western Connecticut, near the Housatonic. The Naugatuck River, which starts in northwest Connecticut and empties into the Housatonic in Derby, CT, is one such example. In 2000, the U.S. Army Corps of Engineers replaced large in-stream structures that were once used to channelize the river with a series of boulders. The boulders provide overhead and lateral cover for fish and other organisms, as well as relocating fine sediments throughout the stream, rather than allowing sediment to build up in one spot. The Corps installed a total of 450 large boulders throughout a ¾ mile section of the Naugatuck. Photo evidence in the years since construction shows a dramatic improvement in instream and riparian habitat (Connecticut Department of Energy & Environmental Protection, 2005a).

The Norwalk River flows through southwestern Connecticut and empties into the Long Island Sound. Like the Housatonic, the Norwalk flows through heavily populated areas, and heavy development in the Norwalk watershed caused serious deterioration of the southern stretches of the river. In 1999, the USDA and the Natural Resources Conservation Agency (NRCA) conducted streambank stabilization and fish habitat restoration in the Norwalk River near the town of Wilton. Streambanks were stabilized with boulders and backfilled with organic soil. The banks were then seeded with grass mix and covered with biodegradable erosion control fabric. Live stake planting were later installed to keep soil in place. A rock deflector was placed in the river to redirect the center of the channel away from the eroding streambank. To create more fish habitat, a timber structure was installed to replicate an undercut bank, providing overhead cover. Boulders were also placed throughout the stream channel to enhance fish habitat (Connecticut Department of Energy & Environmental Protection, 2005b).

Stream Restoration in the Housatonic River

The Housatonic is presently severely degraded due to years of PCB contamination. It is well understood that cleanup of the river, while necessary for the removal of contaminants, will disrupt the river ecosystem and its surrounding habitat. However, this disruption is not sufficient reason to avoid cleanup entirely. The current cleanup plan relies on MNR in large areas of the river designated as core habitats to avoid disturbance of ecosystems that support several state-listed species. The consensus remains that this methodology is inadequate as the long-term consequences to these fragile ecosystems outweigh any short-term disruption caused by a more effective cleanup.

The field of stream restoration provides a suite of effective tools to both mitigate habitat disruption as well as facilitate a return to equilibrium post remediation. However, the current plan fails to acknowledge the full extent of these tools and resorts to an insufficient cleanup. Both Mass Audubon and the Berkshire Regional Planning Commission (BRPC) have expressed concern with the logic in avoiding cleanup in core habitats. In their 2009 comments in response to the General Electric Work Plan Evaluation of Additional Remedial Alternatives, Mass Audubon states that short term remediation related disruption is acceptable in exchange for a long-term improvement and health of habitat. Mass Audubon compares the decades required for natural PCB degradation to the well documented expedience seen in habitat recovery. Similarly, remediation projects on sections of The Hudson River as well as on the Housatonic River around Pittsfield provide evidence of the resilience of habitats post remediation.

Many of the state-listed species on which EPA bases the need for limited cleanup also exhibit remarkable responses to restoration. The National Remediation Review Board (NRRB) Site Information Packet evaluates each of the plausible effects of the cleanup plan on the habitats found within the Rest of the River. In discussing the effects of bank stabilization and other aspects of the current plan, the NRRB describes both the need for restoring plants and wildlife but also the natural tendency for habitats to recover. As the EPA region response to the NRRB's report states, ten of the state-listed plant species are affiliated with habitats prone to natural and anthropogenic disturbance and are early succession species, and therefore quick to return given the right circumstances. The EPA's response also states that many of the listed wildlife have alternative habitats and could likely move and return after remediation. As both the Mass Audubon and the NRRB have suggested, the most vulnerable state-listed plants could be removed, cultivated and returned post-remediation. The removal and restoration of the submerged aquatic vegetation (SAV) and native plants on the Hudson during PCB remediation provides an example of the viability of such a process.

The Housatonic is a naturally meandering river that has changed significantly over the last 100 years in response to both natural and anthropogenic causes. Mass Audubon's map of the river's shifting banks (below) provides ample evidence of this. The Housatonic shifts within its oxbow sections by as much as .9 feet per year. On such a river, dramatic changes will disrupt habitat inevitably. Furthermore, such bank shifts tend to accelerate when dramatic measures such as channel straightening are employed as the river attempts to restore equilibrium. Shifting river morphometry eventually jeopardizes the viability of caps as long-term solutions. As such, a more complete cleanup is warranted and can be achieved without long-term damage provided appropriate stream restoration practices are employed.

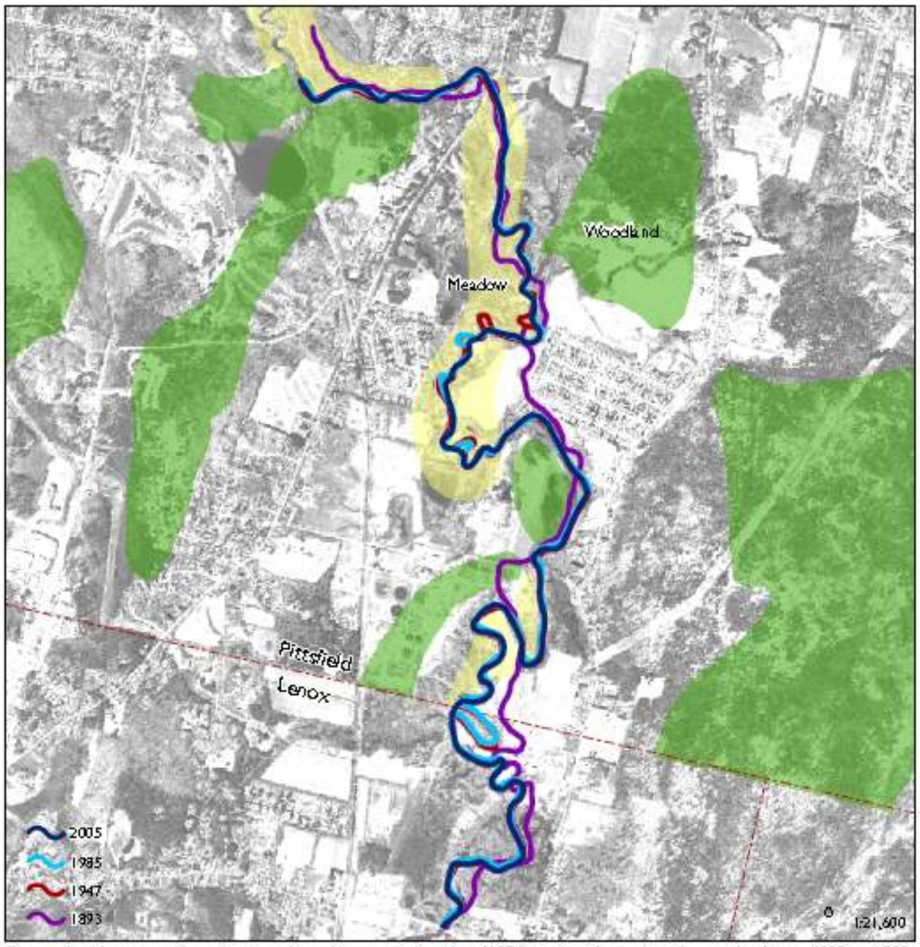

Figure 1. Housatonic River historic channel migration based on USGS quadrangles and modern orthophotos, 1893 to 2005, Pittsfield and Lenox, Massachusetts. 1893 and 1947 USGS quads from University of New Hampshire collection of historic USGS maps of New England and New York. 1988 USGS quads, 2005 half-meter orthophotos, and municipal boundaries from MassGIS. Historical quads were georeferenced by Mass Audubon to approximately 20 meter accuracy; stream centerlines heads-up digitized by Mass Audubon. Historic land cover from Harvard University 1830's Land Cover Project*; areas not shown as woodland were likely cleared; Lenox data missing.

* Hall B., G. Motzkin, D. R. Foster, M. Syfert, and J. Burk. 2002. Three hundred years of forest and land-use change in Massachusetts, USA. Journal of Biogeography 129: 1319-1135.

Mass Audubon
Protecting the Nature of Massachusetts

Finally, the entire Housatonic River will not require stream restoration. The plan should account for each reach on a case by case basis based on river morphometry and cleanup measures. Stretches of the Housatonic with lower flow rates and higher silt accumulations tend to accumulate more contaminants than high velocity areas of the river. Thus the lower velocity sections of the river, such as Reach 5B, tend to be contaminant hot spots (see below). Such areas make good candidates for stream restoration, due to both the elevated contaminant levels and the ease of in-river construction in low flow areas.

A section of Reach 5B of the Housatonic River, directly below the New Lennox Road bridge (Photo credit: Berkshire Eagle)

While initial costs for stream restoration construction may seem unnecessary, the long term benefits of stream restoration far outweigh the financial costs. For the Housatonic, stream restoration in select sections will be an affordable option that will help the river recover from both the initial contamination as well as the cleanup process. Restoration projects throughout the area and around the country are proof that stream restoration is a mature and technical field with an impressive track record. Stream restoration along the Housatonic is not only a sustainable and efficient cleanup option, but a necessary one.

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6) Adpative Management

Introduction

Adaptive management is a process in which the management decisions involving the restoration and/or maintenance of an ecological system are modified over time in response to how those decisions affect the system. This type of management is most useful in projects with high uncertainty that make it difficult to select a more traditional management framework. This type of uncertainty is often seen at Superfund sites because of the unknown or uncertain distribution of contaminants, large scale and time frame. These uncertainties could range from the frequency and magnitude of major storm events to the interactions among trophic levels, and ultimately affect the potential success of any remediation project. This situation can be particularly true when managing major cleanup operations, which may rely on the interactions between a number of remediation procedures and technologies. No matter the final remedy, adaptive management requires coordinating multiple procedures, and could include new methods.

On the Housatonic River, the EPA has made clear that they intend to make adaptive management a part of the remediation process. If so, adaptive management actions must be clearly defined and tailored to the specific biotic and abiotic factors within the Housatonic ecosystem.

Conditions for Using Adaptive Management

According to the Department of the Interior's Adaptive Management Applications Guide (Williams & Brown, 2012), there are five primary conditions that a site should meet to be considered an appropriate candidate for adaptive management. These conditions are:

1. Management action is needed
2. Decisions are based on clear measurable objectives
3. A range of management options exist
4. Monitoring will be conducted and can reduce uncertainty
5. Managers and stakeholders must commit to adaptive management

These conditions are explained below.
First, managers must determine that some type of management action is necessary in spite of substantial uncertainty. The Housatonic River meets the threshold whereby, in doing nothing, the risk to human health and the environment is greater than the risk posed by acting on a management plan with uncertain consequences. The PCBs in sediments throughout the river must be addressed despite some uncertainty in how the proposed management alternatives will affect the river system.

Second, there must be clear and measurable objectives around which to base management decisions. Without these goals and metrics, it can be difficult to determine if the actions taken are effectively improving the conditions of a site. For example, preliminary remediation goals (PRGs) for PCBs take into account how sediment concentrations affect fish tissue concentrations, as well as the human cancer risk of consuming different numbers of fish meals per year. These PRGs provide the basis for clear objectives that can be measured via sediment and animal tissue concentrations to present a clear picture of the remediation's effectiveness.

Third, there must be a range of possible management alternatives from which to choose and the flexibility to change management approaches if the initial alternative proves to be less effective than anticipated. New alternatives can also be considered. It is this condition that distinguishes adaptive management from other management frameworks, and the use of adaptive management is counter-indicated if there is not a clear willingness to discontinue ineffectual management alternatives. For example, while an Explanation of Significant Differences (ESD) or a Record of Decision (ROD) may technically allow for flexibility, neither is appropriate for allowing modifications during the remedial process. The process of formally changing the ROD may not be responsive enough to fully enter into the spirit of an adaptive management framework. Language will need to be inserted in the ROD to allow methodological or procedural modifications based on monitoring data or other information.

Fourth, there must be types of monitoring conducted during the remedial process that can reduce the level of uncertainty. The intent of the adaptive management framework is to use knowledge gained during the management action to better inform future decisions and adjustments in management. This modification is impossible without some type of monitoring that can provide information on the response of the site to the remedial actions. The long-term information would allow site managers to determine if PCB concentrations are behaving as modeled, and when certain goals have been achieved. Water column monitoring allows for modifications of in-water activities to reduce the input of contaminants.

Fifth, there must be an active and sustained commitment by the stakeholders to the principles of adaptive management and the complex role they play in remediating sites. Many large remediation projects require decades to complete, and the stakeholders must be able and willing to invest time and resources over the full course of the project. For the best possible outcome, there need to be committed community advocacy groups, responsible parties dedicated to the cleanup, and extensive involvement of both state and federal environmental regulators to ensure the adaptive management framework is used over the life of the remediation project.

According to the National Research Council (2007), the size, long time-frame, and complexity of Superfund dredging projects demand the flexibility that adaptive management can offer. However, the typical Superfund process, in which a single remedial alternative is selected from those identified in the feasibility study and rarely modified significantly, remains largely incompatible with the spirit of adaptive management. In order for a remediation project to achieve its stated goal of using an adaptive management framework, sometimes significant alterations to the Proposed Plan are needed. The Hudson River PCB remediation project offers a simple example of modifications in the operational changes that yielded much success for the project as a whole. Modifications to the cleanup plan for the Hudson were made to reduce airborne PCBs and to increase the rate of sediment removal to shorten the project duration. The Hudson River cleanup project is now one year ahead of schedule due to these changes in the sediment removal plan.

Using Adaptive Management in the Remediation of a River

Adaptive management is typically depicted as a cyclical process consisting of six primary steps in which monitoring provides the feedback necessary to initiate each iteration of the cycle (NRC, 2005). The six steps are presented below.

Step 1: Assessing the Problem

The first step in adaptive management is to assess the problem. This includes establishing measurable goals and the metrics to measure progress towards those goals, as well as assessing any predictive models or forecasts to anticipate site-response to remedial actions (NRC, 2007). Within the Superfund process, this may begin in the early stages during the preliminary assessment (PA) and site investigation (SI), but is primarily accomplished during the remedial investigation (RI) and feasibility study (FS). Conceptual modeling may be used to predict how PCBs move through the river system in each of the remedial alternatives. Management goals may be set via the remedial area objectives and PRGs. However, in order for this step to be complete, all relevant information should be collected prior to finalizing a plan for remediation.

Step 2: Designing a Management Plan

The second step in adaptive management is to design a management plan. This step includes comparing and selecting remedial actions. This includes selecting indicator values which may trigger changes in the selected remediation plan. The remedial alternatives are compared based on likelihood of meeting management goals, cost, and other factors. Adaptive management plans from this step can be either passive or active. In active adaptive management, multiple competing remedial alternatives are implemented in order to compare their actual effects on the resources being managed (NRC, 2005). This type of experimental design ideally leads to a better understanding of the impacts of the various alternatives, but is typically impractical for remediation projects of the size and scope of most Superfund projects. Passive adaptive management is more typical of the Superfund process, and involves selecting a single remedial alternative that is determined to be the most appropriate for the site.

Once a remedial alternative has been selected, it is important to determine what indicator values should trigger a change in the management action. In other words, if the preferred alternative does not perform as anticipated, there should be a clear and specific plan for modifying the management plan or using one of the other identified alternatives.

Step 3: Implementing the Plan

The third step in the adaptive management process is simply to implement the plan as designed in Step 2. This includes making modifications to the plan according to the specific criteria agreed upon prior to implementation, with appropriate documentation and engagement with the stakeholders.

Step 4: Monitoring

The fourth step in adaptive management is to monitor for quantifiable data that will indicate if the plan is being effective at achieving the remedial objectives. This monitoring should be designed in such a way as to assess whether the actions taken at the site were in compliance with the plan, whether the plan is meeting the remedial objectives, and whether the conceptual site model is using the correct parameters and relationships between variables.

Step 5: Evaluating Results Obtained from Monitoring

Once monitoring data have been collected, those results are compared to the models from Step 1 of the management process. The difference between the modeled outcomes and the results of the monitoring can provide greater insight into the dynamics of a complex system and reduce the level of uncertainty in making management decisions. This step is key in the utility of the adaptive management framework because it allows new information to create a better understanding of the remediation site and refine management decisions. Unfortunately, the Superfund process is not designed to provide an expedient and agile method of evaluating and responding to new information. The five-year review process can be used as a platform for performing this type of evaluation, but more informal, short-term evaluations may be more effective at identifying potential problems or faulty information in the models.

Step 6: Adjusting the Management Plan in Response to the Monitoring Results
Once the new monitoring data has been evaluated and integrated into the site model, adjustments must be made to the management plan to account for any significant improvements in understanding. This involves updating models to reflect the new information, reviewing the remedial objectives to determine if they are still reasonable, and updating any management actions as appropriate. Under the current Superfund process, this would be accomplished during the five-year review.

Once Step 6 is complete, the cycle continues back to Step 1 for another round of problem assessment. This allows the stakeholders to determine if the new information gathered in the previous cycle has illuminated additional aspects of the remediation site, or altered the understanding of a previous problem. With each iteration of the adaptive management cycle, uncertainty is reduced and management actions are refined to better target the problem. A river cleanup, with its large scale and high levels of complexity and uncertainty, is an excellent candidate for adaptive management. However, the cleanup documents must advocate for an adaptive management approach that is fully engaging in each step of the process. Without a very clear strategy for how management actions may be modified, including contingencies for the possible failure of the preferred alternative, the cleanup is simply an attempt at management, not adaptive management.

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Specific Comments on the Proposed Plan

River Sediment and Banks

The "Long Term Biota Benchmark" values are in line with EPA recommendations, at present, and will not be current when new toxicology data are taken into account. Nevertheless, the terms here are not defined and there seems to be no point in time by which the long term levels shall be achieved.

- Reach 5A: The removal of PCB contaminated sediment and riverbank is intended for a concentration > 5 ppm PCBs, without explanation or documentation.
- Natural Channel Design and Bioengineering: "The Housatonic River is currently recovering from these past disturbances, and over time, the river will approach sustainable dynamic equilibrium."
  - What evidence supports this conclusion? Even a reference would be a help. In truth, the data do not support this conclusion, but a different one-PCB levels are no longer declining.
- Reach 5B: "excavation and restoration of areas of river bed and banks that exceed the reach-specific Performance Standard of 50 mg/kg PCBs."
  - 50 ppm PCBs in sediment, soil, riverbanks, etc. is inadequate to protect wildlife, human health or to prevent downstream contamination of MA and CT waters, sediments and animals.
- Reach 5B: The Basis: "pilot study regarding Enhanced Monitored Natural Recovery"…"using sediment amendments such as activated carbon"
  - While the idea of pilot studies to demonstrate the effectiveness of new methods or the application of methods in new circumstances is common, pilot studies should be well defined to serve the purpose of cleanup.
  - Conducting pilot studies on activated carbon will likely further delay the cleanup, when removal is the best option in many areas of the river.
  - This section plans to leave in place a PCB load that is enough to continue the contamination of the 100 miles of the Housatonic for many years to come, if not forever.
- Figure 3: Outlines 10 year floodplain
  - The current models for flood plains, flow, and storm events are proving to be inadequate to account for the rapidly changing and severe weather. More realistic is the 100 year floodplain, which is more likely due to climate change and increased likelihood of larger storms.
- Reach 5C:
  - No PCB ppm level is set or proposed for sediment/floodplain removal.
- Backwaters Adjacent to Reaches 5 and 7
  - Capping over sediment with > 1 ppm PCB is not a permanent solution.
  - "Some portions of backwater designated as having high-quality habitat for state-listed species (known as Core Area 1 habitat) will not be remediated except in discrete area with PCB concentrations greater than 50 mg/kg PCBs."

        - There is no explanation or substantive justification why a sensitive area will be less protected, at a PCB level of 50 ppm, instead of <1.0 ppm.
        - There is no definition or documentation of Core Area 1 Habitat.
- Woods Pond Reach 6: removal and capping here; EPA is looking for comments on other options for Woods Pond cleanup
    - Our suggestion is the use of bioremediation via BioTech Restoration's modified bacteria.
- Reach 7b, 7c, 7e, 7g Impoundments: removal of sediment > 1 ppm before capping
- Reach 8: removal of sediment > 1ppm prior to capping; but also mentions "in lieu of capping" – excavate the sediments to meet 1 ppm PCBs throughout pond
    - We suggest chosing to excavate anyway, and no capping
- Flowing sub-reaches Reach 7 and 9-14: MNR; "…MNR typically relies on physical, chemical, and biological processes to isolate, **destroy**, or otherwise reduce exposure…"
    - MNR as a remediation method does not destroy any PCBs or other persistent chemicals
- Engineered Cap Design: "EPA has proposed Engineered Cap Performance Standards that do not specify particular thickness and are flexible enough to allow for construction of caps that are protective, permanent, and implementable and are suitable under conditions that may be associated with climate change, while still being designed to minimize cap thickness."
    - The term "flexible" is concerning; there are other alternatives to capping, no matter how thin.

Floodplains and Vernal Pools

- The phrase "frequently used subareas" needs further definition.
- Vernal pool/sediment cleanup level of 3.3 ppm, followed by active restoration
    - What is the basis for 3.3 ppm?
- Core Area 1 habitat will be excluded from initial set of vernal pools
    - They should not be excluded; they demonstrate the most in-need scenario and should be treated immediately with the most effective remedy. The entire set of assumptions is inadequately documented here and not at all explained. The public has to see the entire record and documentation that has led EPA to reach this conclusion.
- Additional pilot study on vernal pools and using activated carbon
    - Concerned by the number of pilot studies on the same thing, i.e. activated carbon; can't we rely on published research that already indicates its best use?
    - Concern over whether or not multiple pilot studies will continue in delayed cleanup
- Third group of vernal pools will use a currently unnamed innovative method
    - ESC's suggestion: bioremediation by BioTech Restoration
    - Make sure the public gets to comment on this and see what new technologies are available

Restoration

- "A restoration program will be required to address the impacts of the cleanup on state-listed species and their habitats and on the floodplain, river bottom and banks, impoundments, and vernal pools with the broad objective to return, to the extent feasible and consistent with the remediation requirements, the functions, values, characteristics, species use, and other ecological attributes existing prior to remediation."
    - If a restoration program will already be required for the areas to be remediated, these efforts need to be extended to the areas determined to be too sensitive to remediate. Many of the same restoration methods will work in both areas and ultimately more PCBs will be removed to not further threaten sensitive species.

Off-site disposal of Contaminated Sediment and Soil

- All contaminated soil and sediment will be disposed of off-site
    - This should be a major consideration with the potential for increased dispertion of contaminants, even with the maximizing of rail transport

Monitoring, Maintenance, Inspections, Periodic Reviews, and ICs

- "In all areas where unrestricted use is not achieved, institutional controls will be put in place to restrict or place conditions on activities that would cause unacceptable risks, such as disturbance of caps, excavation in flooplain areas, or future maintenance or removal of dams."
    - These ICs will have to be inforced in perpetuity; not a permanent, protective solution.
- "…periodic reviews will be required every 5 years to evaluate effectiveness and adequacy of the remedial measures…"
    - When selecting a cleanup that utilizes a large amount of capping and MNR, these reviews will likely demonstrate a nessicity for additional cleanup in the future.

Why EPA is Proposing this Cleanup Plan

- "…certain areas in the river and floodplain will be left undisturbed including a large part of Reach 5B."
    - The contamination is too great in this area to leave it unremediated.

Expected Outcome of the Proposed Remediation

- "…cleanup is expected to result in reductions in biota concentrations to allow increased human consumption of fish and other biota taken from the river within a short time after remediation is completed."
    - Why is this the goal? Even with capping, fish tissue will take a while to reduce, so why not go with a longer term solution and a complete remediation?

Site Description

- "Eroding contaminated riverbanks are a significant source of PCBs in Reach 5, currently contributing an estimated 45% of the PCB load to the river…"
  - Then why is a large part of Reach 5B being left undisturbed, as noted above? This process is the reason for cleaning it up, not for leaving it.

Site History

- "PCBs are presently discharged into the Housatonic River from GE's Pittsfield facility and are regulated under a NPDES discharge permit"
  - This constitutes a continued source to the Housatonic; all the more reason to cleanup what is already present.
- "Investigation and cleanup work continues at the groundwater management areas and the two remaining action areas"
  - These constitute a continued source to the Housatonic; all the more reason to cleanup what is already present.

Risk to Humans and Animals

- HHRA (June 2003); ERA (July 2003); Summary of both risk assessments (August 2009)
  - Have these been updated with new numbers and information since 2003?
- For fish: maximum exposure = 50 fish meals per year; average exposure = 7 meals per year
  - Is this information from a survey of local fishermen/recreational/subsistence fishermen? These assumptions will not protect subsistence fishers
- High Cancer Risk: fish = as high as 2×10^{-3}; waterfowl = 1×10^{-3}
- High Non cancer risk: fish = 120; waterfowl = 76
- Unacceptable risk from direct contact with river sediment: HI's as high as 3.5
- Unacceptable risk from direct contact with floodplain soil:
  - 90 separate "exposure areas", 2/3 of them between Reach 5 and 6; each area evaluated for risk due to exposure to PCBs in floodplain soil; amount of exposure depended on the accessibility of the particular area; 13/90 exceed HI of 1, as high as 16; 41/90 cancer risk > 1×10^{-5}
- Consumption of agriculture products: commercial and backyard
  - No cancer or non cancer risk; based on assumption that soil has average PCB concentration of 2 ppm or less, but if higher, risks are likely
  - Based on current land use, no remediation is required; future change in land use is a problem
- Unacceptable Environmental Risk
  - Intermediate to High for all sectors; based on exposure to soil, sediment, and diet

Development of Cleanup Alternatives

- "As part of the site study, a range of potential cleanup goals, known as Interim Media Protection Goals (IMPGs) were developed as one of the factors to use in the comparison of remedial alternatives. In addition to IMPGs, it is important to note that certain specific numerical Performance Standards, which may differ from the IMPGs, are being proposed in the Draft Modification to the Reissued RCRA Permit to be met as part of the remedy."

  - This is a confusing set of criteria; what is the purpose in creating IMPGs when numerical Performance Standards exist?

- Among the alternatives, a better definition is needed of thin layer capping, MNR, and EMNR, particularly the last two which have shown minimal reduction of PCBs.
- What qualifies "certain frequently used areas" to warrant removal of 3 ft vs. 1 ft.?
- The level of removal for PCB concentrations vary across Alternatives and across media, and only starts with Alternative #5; this makes it hard to determine the best cleanup among the alternatives:
  - Alt 5 = >50 ppm
  - Alt 6 = >1 ppm
  - Alt 7 = backwaters: >1 ppm; floodplain: >50 ppm
  - Alt 8 = >13 ppm
  - Alt 9 = riverbank/bank areas: >50 ppm; backwaters: >1 ppm

Treatment/Disposition Alternatives

- Alt TD 2: CDFs, which are impractical and do not meet the long term criteria. Disposal of material that exceeds the capacity of the CDFs (in the river or backwater, two proposed sites) would be disposed of in existing off-site licensed landfills
  - What is the potential for exceeding CDF capacity?
- Alt TD 3: local on-site Upland Disposal Facility; 3 locations proposed; outside 500 yr floodplain
  - Any calculation for their total capacity?
  - EPA made public assurances that no landfill would be located in the County or nearby

Selection of Decision Factors

- #6: Reduction of Toxicity, Mobility, or Volume of Wastes
  - The "or" is a concern if EPA treats them equally, but toxicity is the most important as indicated by past practice, and I think guidance. We should ask of EPA how these three are ranked and compared.
- #7: Short Term Effectiveness
  - This criterion should not play as large a part in the decision as currently seems to be the case; long term effectiveness should be the goal. If long term effectiveness is sacrificed, then resources and human health will be damaged for many times longer than the short period of time that active cleanup is taking place, especially when measures can be taken to control, reduce, or mitigate the harm.

Overall Protection of Human Health and the Environment

- "None of the alternatives analyzed would achieve the federal and state water quality criterion for human consumption of organisms in any of the Massachusetts reaches…"
    - EPA recognizes the Plan is not sufficient to satisfy the law in letter or in intent; other methods and technologies are able to reach water quality criteria and should therefore be considered.
- "While thin-layer capping has been used successfully at other sites across the nation, site-specific conditions (e.g. higher PCB concentrations and higher flows) have raised concerns about its suitability for the Housatonic River."
    - Where has it been successful? EPA needs to give sites and documents and data specifics of where any other site has come close. Other sites have reported success in reducing PCB levels in fish when PCB contaminated sediments are removed, not left in place, as reported by EPA (see Marc Greenberg 2013 on the Hudson).
    - These concerns about site-specific characteristics should be fully evaluated in this process, but EPA does not seem to be conducting such an analysis despite the fact that the majority of the chosen alternative is capping.
- "… Combination Alternatives that require extensive excavation in these ecological resources, including state-listed habitats (such as Combination 6) may result in less overall protection of the environment."

    - No explanation as to why they reach this conclusion. The assertion is based on the notion that leaving contamination in a habitat to leach toxic chemicals for decades is less damaging than removal with restoration of the habitat. EPA provides absolutely no evidence to support this contention and no analysis and no data. The state listed habitats will remain poisoned at levels that are toxic to various insects, snails, crustaceans, amphibians, birds, fish and mammals.
    - Furthermore, when the river shifts course and cuts through the buried sediment that is contaminated with PCBs, the release of even higher amounts of PCBs will increase the harm and ecological damage from the contamination.

Control of Sources of Releases

- "A computer model was used to predict the reductions in the mass of PCBs passing Woods Pond and Rising Pond Dams, respectively, and the reductions in the mass of PCBs transported from the river to the floodplain versus today's conditions in Reaches 5 and 6."
    - The name and description of the model used is needed; an appendix supplying the model inputs and results should be included. We must assume that the model referenced here is the one that was part of the assessment 10 years ago.
- … Alternatives 6 and 7 do the most to control releases"

    - Control of source releases is more important than the solids trapping efficiency of Woods Pond
- "Combinations 7, 8, and 9 nearly double the solids trapping efficiency of Woods Pond when compared to the other Combinations."
    - For example, Alt. 6 shows 96%-99% reduction in annual PCB mass passing Woods Pond etc, which is more important than a lower solids trapping efficiency at Woods Pond of 15%.
- "In the event of a serious breach or failure of the dam, the release of PCBs downstream would be less for these alternatives (7 through 9) than for Combinations 1 through 6 that rely primarily on capping or MNR."
    - Alternative 6 does not rely on capping; typo?
- "Combination 6 followed by Combination 7 are expected to provide the highest level of protection of all the combinations during an extreme event as they provide the greatest amount of remediation with corresponding engineering controls. Combination 9 is expected to provide adequate protection in an extreme storm event in all reaches, with the exception of Reach 5B which is subject to MNR and therefore bed sediment and bank soil may erode and be transported downstream."
    - "Adequate" will not be good enough with the increase in storms/severe weather due to climate change. Recent evidence indicates that extreme weather events have already increased in frequency and severity.

Chemical specific ARARS

- "Because the water quality criteria for human consumption of organisms (0.000064 ug/L) is not expected to be met in the River in Massachusetts under any of the alternatives evaluated, EPA is proposing to waive this criterion under both Federal and State ARARS as technically impracticable in Reaches 5 through 9."
    - An Alternative should be presented that does meet the WQ standards in both MA and CT, i.e. an alternative with more active removal, and capping and elimination of MNR.

Long-term Reliability and Effectiveness

- "Combination Alternatives that remove the most contaminated soil and sediment… provide the best long-term reliability and effectiveness because the magnitude of the residual risk that remains is much lower than those alternatives that leave significantly more contaminated material in place."
    - This is the most important consideration in choosing an alternative
- "However, combination Alternatives that fundamentally impact the dynamic, meandering character of the river or require extensive excavation in habitats supporting state-listed species (such as Combinations 6 and 7) may result in reduced long-term effectiveness because of potential long-term adverse effects on the environment."
    - What evidence is there to support the conclusion that a comprehensive cleanup will reduce long-term effectiveness? Long-term adverse effects are guaranteed if removal of PCBs does not take place.

- "Restoration is expected to be effective and reliable, returning habitats to their pre-remediation state for all active alternatives on a timeframe appropriate for the type of habitat being restored (e.g. a floodplain forest will take longer than an emergent wetland)."
    - If restoration is effective and reliable, then why are Alternatives that call for major sediment removal, and subsequent restoration, maligned for their impact on the environment?
- "Combinations 6, 7, and 9 are also more reliable in the long-term based on their removal of a large mass of PCBs from behind Woods Pond dam."

Attainment of IMPGs

- "Current land use in the floodplain no longer includes any agricultural exposures; these IMPGs would be considered if future uses were to change to agriculture."
    - Previous assessment of agricultural exposure (include backyard gardens) in this Statement of Basis relied on the assumption that PCB concentrations were less than 2 ppm; otherwise, the agricultural exposure route should still be under consideration
- "A full evaluation of each alternative's performance regarding fish consumption based IMPGs can be found in the Administrative Record, see Figure 9 for a representative example."
    - Fish consumption is the greatest exposure to PCB for the human consumer. This information should be an appendix, not hidden in an Administrative Record. A full evaluation of its validity should be available for comment within this document.
    - Figure 9, Combination 6 (most removal) is not correct as it would not take the last 5 years in the 50 year span to see a drop in fish tissue; Also, the model should go past 60 years to demonstrate the continued drop in PCB from Combination 6, as it is the only line that extends past the extent of the model.
- "Combinations 6 and 7 are designed to meet the lower-bound (more stringent) ecological IMPGs."

Reduction of Toxicity, Mobility, or Volume of Wastes

- "Reduction of Toxicity: None of the Combination Alternatives with the exception of Combination 9 includes any treatment processes that would reduce the toxicity of PCBs in the sediment or soil. Combination 9 requires the addition of an amendment such as activated carbon in certain components of the remedy…"
    - Reduction of toxicity isn't only achieved by the activated carbon amendment, and this amendment could be tacked on to any of the other Alternatives too, it is not an exclusive technology to Alternative 9; regardless, the best reduction of toxicity is removal and treatment by bioremediation methods
- Reduction of Mobility: "Combination Alternative 6 provides the greatest reductions in mobility followed by Alternatives 7 and 9."
    - Capping does not permanently reduce contaminant mobility, which are part of Alt 7 and 9. Counter to previous references to Alt 6 in this report,

    - which seemed to indicate too much movement/release of contaminants during removal, Alt 6 removes the greatest amount of contaminated sediment.
- Reduction of Volume: "Combination Alternatives 3-9 reduce the volume of PCB-contaminated sediment, bank soil and floodplain soil in the Rest of River through permanent removal of the material."
    - Capping and MNR are not permanent methods of PCB removal.

Short-term Effectiveness

- Time of construction is blown out of proportion, especially 52 years for Alt 7; this has not been the case on the Hudson River.

Implementability

- Combination 9 uses activated carbon and the Adaptive Management Approach
    - These need not be exclusive to Alternative 9; they should be looked at as tools across the alternatives
- This section notes that those alternatives that rely to a greater extent on capping, MNR, and ICs are less reliable than those alternatives that rely more on removal of contamination.

What's the difference between IMPGs and Performance Standards?

- Certain IMPGs EPA adopts as Performance Standards in the draft permit
- Figure 9: Probabilistic IMPGs; EPA selected one point in this range of concentrations = 1.5 mg/kg in fish tissue which is the non-cancer probabilistic risk for average adult fish consumer with the assumption that he eats 14 fish meals/yr, half of those from the River.
    - IMPG based on 14 meals/yr is CTE (average exposure), not MRE (maximum reasonable exposure); why are these possibly used as a Performance Standard?
    - Combination 6: too dramatic a drop at 45-50 years; other Alternatives' data don't indicate a similarly delayed drop in concentration; the graph should follow to the lowest concentration past 60 years
- This section notes that alternatives that have little or no active remediation are less reliable and would require more extensive monitoring; also more ICs where less remediation is performed.

Comparative Analysis of Treatment/Disposition Alternatives

- Only offers off-site disposal, on-site CDF, on-site disposal, chemical extraction, and thermal desorption.
    - Should include bioremediation
- Effective use of a separate evaluation for the removed sediment, rather than making this a part of the Alternatives.
- There is always a possibility for release from CDF, upland disposal, or even landfill.
- Should be more consideration for re-use of soil after treatment.

- Need a further discussion of types of chemical desorption being considered to better evaluate their use on these contaminants.

Short Term Effectiveness

- “Each of the alternatives has the potential for short-term impacts to the community.”
    - As this is the case, then long-term effectiveness should be the number one consideration
- Loss of habitat for areas designated as on-site facilities
- “Since state and local officials have expressed a strong preference for off-site disposal, these alternatives may encounter significant opposition, thus rendering these alternatives [TD 4 and 5] difficult to implement.”
    - All treatment options should be looked at for best results nonetheless; a statement like this shouldn’t be in a PP before public comment has taken place
- “… uncertainties regarding the future availability of the necessary capacity in off-site landfills for the alternatives that have larger volumes and longer durations.”
    - This is a valid consideration going into the future; this makes an argument for sediment treatment.

EPA is asking for public comment on the following proposed regulatory determinations

- Wetland Impacts: EPA is required to conduct the least environmental damaging practicable alternatives
    - The chosen alternative must not pander only to the visible “destruction” of a more complete sediment removal versus keeping PCB contamination in place
- Floodplain Impacts: The activities in the proposed cleanup plan that affect the floodplain are not permanent and would be subject to mitigation following remediation.
    - This needs to be kept in mind for all removal-driven options, i.e. the effects are not permanent because restoration program activities will mitigate and begin the rebuilding of the ecosystem process
- EPA needs to propose an alternative that can meet the federal and state water quality standards, fish tissue standards for human consumption and for wildlife, including rare and endangered species.

Appendix A

Literature Search and References – 2013-2014 Publications on Toxicology of Polychlorinated Biphenyls

The following is a reference list of materials resulting from a literature search conducted in late August 2014 on the toxicology of Polychlorinated Biphenyls (PCBs), its congeners, and frequently associated compounds. The reference list includes primarily publications from 2013-2014 but a few key reports from agencies such as EPA and WHO have been included for background information. Toxicology is loosely defined as those materials documenting the effects of PCBs on both ecological systems as well as human health. While toxicological reports were the primary focus of this search, some related materials describing environmental prevalence, fate, and transport are also included.

This literature search was conducted via the Virginia Commonwealth University Library system using the VCU multi-database search tool, as well as specific databases such as BIOSIS and Science Direct. The majority of these materials are peer reviewed journal articles; however, government/NPO reports and white papers are included where appropriate and relevant.

ESC, LLC makes no claims about the research in these citations in terms of validity and does not necessarily agree with the conclusions within. We note that readers need to confirm that authors of scientific papers are free of conflicts of interest, financial or otherwise. We advise readers to determine if the authors receive funding from the industries or companies that may be affected by the results of their research. References are cited in Chicago format and numbered for convenience.

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Appendix B

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These comments have been funded wholly or partly by the U.S. Environmental Protection Agency under a Technical Assistance Grant to the Housatonic River Initiative. The contents of this document do not necessarily reflect the view and policies of the U.S. Enviornmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.