By Electronic Mail

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Subject: Technical Comments on EPA's Proposed Second Five-Year Review Report for Hudson River PCBs Superfund Site, May 31, 2017

In a letter to non-government organizations, the U.S. EPA (2012) committed to continue "to consult with the Trustees including on the scoping, data collection, and preparation of the second Five Year Review." Subsequently, \in 2016, NOAA was invited as technical experts to participate in EPA's Second Five Year Review (FYR) Team to provide review and feedback on a variety of FYR topics. NOAA accepted this offer (Brosnan et al. 2016a) and throughout the process provided detailed analysis and feedback that was intended to improve EPA's technical analyses and transparency, so that EPA would have an informed basis for evaluating the effectiveness and protectiveness of the remedy, based on the best available science. NOAA's feedback was provided at several FYR meetings as comments, presentations and follow up letters (*e.g.*, Field et al, 2016; Field and Rosman 2016; Brosnan and Jahn 2016, Brosnan *et al*. 2016b)[1]. NOAA's technical comments on the FYR report follow.

The primary objective of EPA's Proposed Second FYR for the Hudson River PCBs Superfund Site is "*to determine whether the remedial actions at the Hudson River PCBs Superfund Site (Site) are protective of public health and the environment and functioning as designed*."[2] Based on our review of the report and the underlying data NOAA believes that certain Record of Decision (ROD) assumptions (*e.g.* sediment surface PCB concentrations and mass, impact of remedy on lower Hudson, and PCB recovery rates in water, sediment and fish,) are not being met), and, as a consequence, the protectiveness expected in the ROD will be substantially delayed. A summary of NOAA's comments and recommendations follow:

[1] These submittals should be included in Appendix 12 to the FYR list of correspondence provided to EPA by NOAA or the Hudson River Natural Resource Trustees.
[2] Executive Summary pg. 1

1. **Significant amounts of elevated PCB contamination have been left in Upper Hudson River (UHR) sediments following remedy implementation which will further delay recovery of Trustee resources:**

    a. **The Upper Hudson in-river remedy leaves highly elevated PCBs in the sediment surface and at depth in the immediate vicinity of dredged areas in River Sections (RS) 2 and 3 (i.e., incomplete PCB sediment deposit removal)**

    b. **PCB mass remaining outside of dredged areas is underestimated in RS2 and RS3**

    c. **FYR estimates of monitored natural attenuation (MNA) recovery rates appear to be higher than supported by data and analyses for PCBs in water, sediment, fish, and PCB load to the LHR. Overestimation of the rate of recovery reduces the ability of EPA's models to discriminate among remedial alternatives.**

        i. **Assessment of remedy effectiveness and protectiveness should be based on measured post-dredging PCB concentrations per the ROD and not an overreliance on percent reduction in PCBs and PCB decay rates**

        ii. **The FYR reliance on retroactive data adjustment adds significant uncertainty to temporal projections of PCBs for fish and sediment**

    d. **Underestimation of Total and Tri+PCBs in sediment based on recent EPA Method 1668 split-sample analysis is not addressed in FYR**

2. **The ROD assumption that PCB loading from UHR to the LHR plays a major role in LHR recovery appears to be rejected with little technical basis provided**

3. **The 2016 surface sediment monitoring plan does not provide an appropriate baseline for evaluating sediment recovery**

NOAA's recommendations for improving the FYR are as follows:

- When calculating mass, Sediment Sampling and Analysis Program (SSAP) cores with an "unclassified" sediment texture should be treated as fine-grained sediments rather than gravel or bedrock as many of these cores most likely represent undredged PCB deposits.
- The post-source control period from 2005 to 2008 should be used as baseline when calculating HUDTOX-generated MNA PCB decay rates for water.
- Calculation of MNA decay rates for water should only use PCB monitoring data from the baseline monitoring sampling period because of major changes in sampling location and sample collection method.

- PCB load from the UHR to the LHR should continue to be measured in a consistent manner and a more robust analysis is required to assess the impact of the UHR on the LHR.
- The MNA period for fish should begin in 1997 rather than 1995, which is consistent with prior practice. (*i.e.*, use consistent data).
- For evaluating temporal trends in fish, use the long-term monitoring species (or species groups) and stations established by NYSDEC and restrict the size range and time of year to be consistent with NYSDEC monitoring and EPA's food web models.
- Assess the impact of using a single correction factor to adjust year(s) of fish data on the uncertainty of the temporal PCB trend analysis.
- Conduct rib-in vs rib-out comparative study for other fish species that were previously incorrectly processed using non-NYS Standard Fillet protocols.
- Increase sample size, sampling segmentation (0-2, 2-6, 6-12 inches) and spatial resolution of post-remediation sediment sampling design sufficient to create a surface weighted average concentration (SWAC) for cohesive sediment in each river pool in order to capture the highly contaminated unremediated cohesive sediment areas in RS2 and RS3 sampled in the SSAP, and treat these as a separate stratum from the non-cohesive sediments.
- Measured PCB concentrations should be the primary measure of remedy success as defined by the 2002 ROD rather than decay rates or percent reduction.
- For future PCB sample analyses, switch to EPA Method 1668 entirely (preferred option) or use a higher percentage (*i.e.*, at least 25%) of split-sample PCB congener Method 1668.
- Incorporate Hudson River Reference Material into future fish PCB analyses.
- For past data adjustments, analyze archived sediment and fish samples (or sample homogenates for fish) by PCB congener Method 1668 that had previously been analyzed using PCB Aroclor Method 8082 or the modified Green Bay Method (mGBM).

DETAILED TECHNICAL COMMENTS ON THESE POINTS FOLLOW:

Remedy leaves highly elevated PCBs in the surface and at depth in the immediate vicinity of the dredged areas in RS2 and RS3 that will significantly delay recovery of the river.

The extensive SSAP coring for the dredge area design demonstrated that surface sediment PCB concentrations were considerably higher, shallower, and more widespread than EPA expected, especially in RS2 and RS3 (Field *et al.* 2009; USEPA 2012). The majority of the highly elevated PCBs in surface sediment and PCB mass were found immediately adjacent to defined dredge areas (Field *et al.* 2011a; Field *et al.* 2011b). Approximately 175 acres surrounding the dredged areas in RS2 and RS3 exceeded the more stringent cleanup levels for RS1 for PCB mass (MPA) or surface (top 12 inches) PCB concentration (Field et al 2016). The FYR (USEPA 2017) confirmed that PCB mass within PCB contaminated sediment deposits was dramatically higher than the 2002 ROD expected. Because target cleanup levels for RS2 and RS3 were approximately 3X higher for PCB mass and surface concentrations than in RS1, the dredge areas for RS2 and RS3 surgically removed a portion of larger sediment PCB deposits, essentially removing the hole, but leaving the donut of contamination un-dredged.

FYR underestimates PCB mass outside of dredged areas.

> ***Recommendation: Treat SSAP cores with "unclassified" sediment types differently when calculating post-dredging mass, as these SSAP cores most likely consist of fine-grained sediments representative of PCB deposits.***

The FYR confirmed that PCB mass within PCB contaminated sediment deposits was dramatically higher than the ROD expected. According to Table A8-2 (USEPA 2017, Appendix 8), the ROD substantially underestimated the PCB mass in all three river sections. Overall, the observed total PCB mass removed under the Remedial Action was 223% greater than the ROD estimate from approximately the same number of acres. Total PCB mass was underestimated by 45% and 220% for RS2 and RS3, respectively. PCB mass per acre was underestimated by 26% and 349% for RS 2 and RS3, respectively. This implies that the PCB deposits had significantly more PCBs than the ROD expected. The FYR attributes the reason for these differences to "*earlier estimates … based on cores that did not fully characterize the vertical extent of contamination*"[3], but provides no documentation that this was the primary explanation for the differences from the ROD expectations in RS2 and RS3. According to NYSDEC, underestimation of the depth of contamination associated with inadequate core penetration was observed in RS1 but was limited in RS2 and RS3. Therefore, it is reasonable to assume that the un-dredged PCB deposits adjacent to the dredged areas in RS2 and RS3 also had higher PCB mass than the ROD expected. Further evidence is provided by our observation that sediment samples exceeding RS1 target cleanup levels in all three river sections had similar average surface (top 12 inches) PCB concentrations (19-25 mg/kg Tri+PCBs) and MPA (8-9 g/m^2 Tri+PCBs).

[3] Appendix 2, Section 4.5, pg. 4-8

The FYR generalized assumption that "*unclassified areas within River Section 3… were predominately comprised of gravel and bedrock substrate*"[4] increases the uncertainty of EPA's estimates of PCB mass remaining in the river. Most of the areas with multiple "unclassified" SSAP cores (without a sediment type classification) are located in shallow nearshore or backwater areas. These 'unclassified" shallow nearshore and backwater areas are often adjacent to dredge areas and represent unremediated PCB sediment deposits. The 240 "unclassified" cores in RS3 had an average MPA of greater than 7 g/m^2 Tri+PCBs, and 148 (62%) of those cores exceeded the target cleanup levels for RS1. However, the FYR assigns the average MPA for gravel (2.5) or bedrock (0.00) as upper and lower bounds, respectively, in the calculation of PCB mass outside the dredged areas. Using a lower average MPA for "unclassified" cores than was actually measured leads to an underestimation of PCB mass. At a minimum, the unclassified areas represented by SSAP cores (~30 acres) should be treated as cohesive fine grain sediment in the calculation of mass remaining in un-dredged areas.

FYR estimates of MNA recovery rates appear to be higher than supported by data and analyses for PCBs in water, sediment, fish, and PCB load to the LHR.

> ***Recommendation: Consistent with prior practice, the MNA period should begin in 1997 rather than 1995.***

The FYR relies on estimated recovery rates for water, sediment, fish, and PCB load to LHR to confirm model estimates of approximately 8% per year. In most cases, as discussed below, the FYR uses data treatment approaches that result in elevated rates of recovery.

The FYR incorrectly defines 1995 as the beginning of the MNA period. Previously, EPA recognized that PCB releases from the failure of the Allen Mill gate structure and from the migration of PCB oil through the bedrock were not mostly controlled by remedial measures until 1997 (USEPA 2000a). For that reason, it has been customary to use 1997 as the starting point for pre-dredging temporal analyses. For example, for fish, the time period of 1997-2008 was used as the basis for development of pre-dredging temporal models (USEPA 2010b; Greenberg *et al.* 2010; Greenberg *et al.* 2011; Greenberg 2013).

Water

> ***Recommendation: Calculation of MNA decay rates for water from the HUDTOX model should use the post source control period from 2005 to 2008. Calculation of MNA decay rates from PCB monitoring data should only use data from the baseline monitoring sampling because of major changes in sampling location and sample collection method.***

The FYR reports that "revamped" HUDTOX model MNA predictions based on updated hydrologic conditions (but not updated surface sediment concentrations) forecast PCB decay rates between 9.9% and 11.7% for the four stations (Thompson Island Dam, Schuylerville,

[4] Appendix 2, Section 4.4, pg. 4-6

Stillwater, Waterford) considered (USEPA 2017, Appendix 1, Table A1-7). These estimated PCB decay rates are considerably higher than the reported data-based rates for Stillwater and Waterford for the same 1995-2008 time period. Unfortunately, neither the MNA predicted decay rates nor the data-based decay rates should be taken at face value. The HUDTOX model incorporated a 6-fold drop in upstream water concentration (from 0.16 kg PCB/day to 0.0256 kg PCB/day) occurring January 1, 2005 (USEPA 2002). Calculating a decay across that step-wise drop in PCB input concentration provides more information on source control at the two GE plant sites than on natural recovery of UHR sediments (Field and Rosman 2016). Between 2005 and 2008, a period of natural recovery, NOAA calculated PCB decay rates for the four stations using data from the revamped model (USEPA 2017, Table A1-7) that are considerably lower than reported in the FYR, ranging from 0.01% to 5.5%.

The FYR evaluation of the water column data-based decay rates does not account for the PCB releases from the failure of the Hudson Falls Allen Mill gate structure in 1991 and from the migration of PCB oil through the bedrock. Although not as marked as during the initial period of GE's Allen Mill release, the continuing impact to PCBs in the water column is evident from the Rogers Island water column monitoring data (see Attachment, Figure 1---plot of Rogers Island water data provided by NYSDEC with the period between 1995 and 1997 highlighted for emphasis). Additionally, the FYR analysis does not account for major changes in sampling location (*e.g.*, Thompson Island station moved from nearshore to mid-channel) and method (shift to automated samplers) beginning in June 2004 with the initiation of GE's baseline monitoring program. The high variability, compounded by differences in sampling location and methods, makes the currently available surface water data an unreliable measure of temporal change in PCBs.

PCB load to LHR

Recommendation: NOAA supports the recommendation of the Hudson River Foundation report (Farley et al 2017) to re-instate the USGS suspended sediment monitoring at Waterford and to collect additional high flow samples to improve evaluation of PCB loading to the LHR.

The measured PCB load to the LHR between 2004 and 2008 was 2 to 3 times greater than the original HUDTOX projections (USEPA 2010a; Hydroqual 2010). In the FYR, EPA updated the HUDTOX model projections with observed flows and estimated tributary flows and solids loads through 2008, but did not update the sediment concentrations with SSAP data. The updated HUDTOX model projections in the FYR (USEPA 2017, Appendix 1, Table A1-8) improved the model-data comparison, but still underestimates the measured 2004-2008 PCB loads by 8-41%, with the difference increasing with time. Based on data provided in the FYR (USEPA 2017, Appendix 1, Table A1-8), the updated HUDTOX model predicts PCB load to the LHR between 2004-2008 will decrease at a rate of 9.2%, while the estimated decay rate from the measured PCB load has a decay rate of 2.8% [Attachment 1, Figure 2]. This shows that, prior to dredging, PCB loading to the LHR was declining at a much slower rate than the updated HUDTOX model predicted.

Sediment

Recommendation: The comprehensive sediment sampling data from the SSAP should be treated as the baseline for evaluating recovery of PCB-contaminated cohesive sediment in un-dredged areas. Studies conducted since the SSAP (Downstream Deposition study 2011-3 and 2016 post-dredging sediment study)* mostly do not address the *highly PCB-contaminated cohesive sediment areas adjacent to dredged areas in RS2 and RS3 and should not be used as a measure of sediment recovery without significant caveats. Sediment grain size data should be used to reduce the uncertainty in defining cohesive sediment areas.

EPA's 2002 ROD assumed that implementation of the selected remedial alternative REM 3/10/S would result in post-dredging surface sediment concentrations in RS2 and RS3 less than or equal to 1 ppm Tri+PCBs in cohesive sediment, comparable to post-dredging surface sediment concentrations in RS1. EPA (USEPA 2010b) confirmed the finding of Field *et al.* (2009) that pre-dredging surface sediment concentrations were "*much higher than model predictions*"[5] and "*exceed the upper bound of model predictions*."[6] As discussed earlier, the highly elevated PCBs in surface sediment in the SSAP samples were mostly immediately adjacent to dredge areas. Unfortunately, the surface sediment surveys conducted since the SSAP data collection (Downstream Deposition Study (DDS) 2011-3 and 2016 post-dredging sediment study) provide data that are not directly comparable to the SSAP data (very limited data collected from the highly contaminated cohesive sediments surrounding the dredge areas and only sampled the top 2 inches and not the top 12 inches of surface sediment used to define dredge areas). In addition, the analysis of split sediment samples in 2016 using the current EPA standard method for PCB congener analysis (Method 1668) indicates that the PCB Aroclor analysis (Method 8082) for those studies significantly underestimated Tri+ and Total PCBs.

The surface sediment PCB concentrations for cohesive sediment in RS2 and RS3 estimated from the DDS sediment survey and 2016 sediment monitoring survey should be considered to be biased low. The DDS survey used a biased sampling design to specifically focus on the downstream edge of dredge prisms. According to EPA (USEPA 2016), "*If assessing changes in conditions for the entire river section were the DQO, then care would have been taken to ensure that the distribution of the PCB concentrations targeted by the DDS program would have been a representative subset of the SSAP program*." This was clearly not the case for RS2 and RS3. The sample locations selected for comparison to nearby (within 20ft) SSAP locations outside of dredge areas represented locations that had PCB concentrations that were "significantly higher than the results for all SSAP locations" for RS2, and the median PCB concentration was higher than the 95% UCL for all SSAP locations in RS3. Attempting to re-sample high concentration

[5] USEPA (2010b), pg. I-53
[6] Ibid.

samples from a lognormal distribution has a high statistical probability that the re-sample result will be lower than the original sample (Field et al. 2015).

The FYR uses the side-scan sonar results from 1992 to classify the UHR bottom sediment type, rather than using the GE results from the SSAP. Because the Reassessment bottom type mapping did not cover RS3, EPA chose to create a model to predict sediment type in RS3 from the GE data. The 2016 samples are classified into cohesive and non-cohesive samples based on this predictive model, which adds considerable uncertainty to the classification, in spite of the fact that sediment grain size analysis on the 2016 samples was available for classification. In the baseline modeling report (USEPA 2000b), samples with at least 25% fines (silt + clay) were classified as cohesive sediment. Only about 1/3 of the samples identified as cohesive by the predictive model for RS3 had at least 25% fines and more than 20% had sediment texture classified by the field samplers as "coarse" or "rock." Including samples with a much lower percentage of fines likely underestimates the PCB concentration in cohesive sediments. For example, identifying cohesive sediment based on grain size analysis in RS3, the arithmetic mean Tri+ PCB concentration is 1.3 (mg/kg) compared to 0.8 as reported in the FYR (USEPA 2017, Appendix 4, Table A4-3). These concentrations do not take into account the underestimation of PCB concentration by the Aroclor Method (discussed elsewhere in this document). The adjusted mean cohesive sediment Tri+ PCB concentration in RS3 is 4.2 (mg/kg), based on the correction factor from the split-sample Method 1668 analysis.

Fish

> ***Recommendation: For evaluating temporal trends, use the long-term monitoring species (or species groups) and stations established by NYSDEC and restrict the size range and time of year to be consistent with NYSDEC monitoring and EPA's food web models. Use only lipid-normalized data to evaluate temporal trends and for comparison to food web model projections use wet weight values adjusted to the standard lipid content for each fish species used in the modeling. Assess the impact of using a single correction factor to adjust year(s) of PCB data on the uncertainty of the temporal fish trend analysis. Conduct rib-in vs rib-out comparative study for other fish species incorrectly processed using non-NYS Standard Fillet protocols. Collect sufficient spatial data to analyze fish concentrations on a pool by pool basis, rather than river section basis.***

Evaluation of temporal trends in fish PCBs requires consistent sampling for fish species from specific sampling locations over time. Because PCBs in fish are strongly associated with lipid content and lipid content has decreased in spring-collected resident species, analyzing temporal trends should take into account lipid content and not rely on wet weight concentrations. Prior to the GE's implementation of the baseline monitoring plan (BMP) in 2004, all fish data were collected by NYSDEC from 2 regular monitoring stations in the UHR Thompson Island Pool (RS1) and Stillwater (RS3) for spring-collected resident species (bullhead, black bass, yellow perch) and fall-collected forage fish (yearling pumpkinseed). In the LHR, 3 regular monitoring locations (Albany/Troy, Catskill, and Poughkeepsie) for the same species with the addition of white perch. These species/locations represent the most robust and consistent dataset to evaluate

temporal trends. In contrast, the BMP sampled multiple locations in each river section in the UHR. By including all BMP sampling locations from RS1 and RS3, the FYR overweighs the data from the BMP (2004-8) and adds significant uncertainty by including the additional stations. The variability among stations within river sections is clearly evident in Greenberg *et al.* (2010, 2011). The other species used in the FYR fish trend analysis were inconsistently sampled throughout the time period and not suitable for long-term PCB temporal trend analysis.

The FYR temporal analysis does not account for rib-on /rib-off difference for lipid-normalized PCBs. Based on an unpublished special study for black bass (largemouth and smallmouth bass), the FYR minimizes the effects of GE's change in fillet processing protocol by excluding the 2007-8 fillet samples from temporal trend analysis for wet weight PCBs. Lipid-normalized results were assumed to be unaffected by this change, in spite of the fact that average lipid-normalized concentrations for "rib-on fillets" in black bass were ~22% higher (13-31% 95% confidence interval) than the "rib-off " samples and would require a "correction factor" analogous to the FYR homologue adjustment factors. Additionally, the FYR assumes, with no supporting data, that the special study results for black bass apply equally to all other fillet species (*e.g.*, bullhead, yellow perch, white perch, catfish, and striped bass) (Brosnan *et al.* 2015; Brosnan and Jahn 2015; Brosnan *et al.* 2016). Including the 2007-8 lipid-normalized fillet data, which is biased low by an unknown degree, results in an inflated temporal decay rate for those species.

The homologue "correction" factor used in the FYR for NYSDEC data from 1999-2011 uses the wet weight adjustment factor for the lipid-normalized results, in spite of the fact that both NY and GE labs analyzed lipid along with PCBs and the correction factors for the lipid-normalized concentrations were different. NYSDEC data during the MNA (pre-dredging) period from 1999-2003, before GE began sampling in 2004 for the baseline monitoring program, was inflated by this approach, because the wet weight correction factor used by EPA was 1.17 compared to a lipid-normalized correction factor of <1 (0.96). This inflates the NYSDEC data during the period from 1999-2003 before GE began sampling in 2004 for the baseline monitoring program and effectively increases the estimated temporal decay rate.

Using only the lipid-normalized PCB data from the principal monitoring stations, species or species groups, and MNA time-period from 1997-2006 (excluding data from 2007-8 when GE incorrectly processed fillet samples), NOAA calculated exponential decay rates using the original (unadjusted) data, the FYR-adjusted data, and modifications to the FYR adjustment factors for NYSDEC fish data that incorporated the lipid-normalized adjustment factors (discussed above) (Table 1). The PCB decay rates vary somewhat among the 3 data approaches, but the overall conclusions are much the same. In the UHR, only black bass and yellow perch from the Thompson Island Pool monitoring station show PCB decay rates greater than 8%. Bullhead (the species most closely associated with the sediment) and yearling pumpkinseed from that same location have PCB decay rates of less than 5% and 0%, respectively. At the other UHR long-term monitoring locations in the Stillwater Pool, all species had PCB decay rates less than 5%.

At the Albany/Troy location all species except pumpkinseed had PCB decay rates of 4% or less. Pumpkinseed showed a very high PCB decay rate at Albany/Troy, but the sampling location was changed several times during the time period. Because pumpkinseed are known to show high site fidelity, the changes in sampling location makes those results for pumpkinseed highly unreliable. Other locations in the LHR (Catskill and Poughkeepsie) showed similarly low PCB decay rates. Overall those results were very consistent with findings of Field et al (2016) based on emulation of the HUDTOX-FISHRAND models for the LHR applying updated surface sediment concentrations.

The sampling program was designed to determine PCB concentrations in fish by river section rather than each river pool. The river pool sampling approach for fish (sediment and water) is essential to establishing a post-dredging baseline for evaluations of fish exposure in the UHR and LHR. Resident fish tend to remain within a river pool, which means they integrate their exposure within pools or smaller areas, and not over much larger river sections (Field and Kern 2009b).

FYR appears to reject ROD assumption that PCB loading from UHR to the LHR plays a major role in LHR recovery

Recommendation: Need a more robust analysis of impact of UHR on LHR.

The FYR appears to disregard prior conclusions and modeling results in the ROD (USEPA 2002) that the UHR PCB load to the LHR is the primary factor in the recovery of LHR fish. The FYR cites slower recovery of LHR fish as evidence that the UHR does not play an important role in LHR and speculates about "other sources". Based on high-resolution core sampling data and modeling (Thomann *et al.* 1989, Farley *et al.* 1999, USEPA 2000a, Hydroqual 2007, Rodenburg and Ralston 2017), the primary source of PCBs to the LHR is the result of past and continued loading of PCBs originating from the Hudson Falls and Fort Edward plant sites and sediments within the UHR.

EPA concluded in their Phase 1 report (p. I-4) that,

> *The observed baseline loads to the Lower Hudson prior to dredging were substantially greater than the model forecast of Monitored Natural Attenuation (MNA) and show very little decline. The loads to the Lower Hudson River under MNA will be substantially greater than those forecast by the model by approximately 6,000 kg over 25 years. Also the surface sediment concentrations in the Upper Hudson River remain elevated despite the passage of time and continue to provide a greater reservoir of contaminated sediments for transport to the Lower Hudson than was envisioned when the remedy was selected.*

Post-dredging, as pointed out previously, most of the remaining sediment PCB contamination is found in RS2 and RS3. Based on GE's modeling, Connolly *et al.* 2000 pointed out the importance of sediment remediation in RS2 and RS3 in reducing PCB loading to the LHR: "*Sediment remediation in the TIP would be less effective at reducing PCB flux to the Lower Hudson River in the short term than would remediation of sediments downstream of the TIP*."

There appears to be little basis to reject the ROD's assumption that UHR sediment PCBs are a major factor in the recovery of LHR fish, given the higher than expected PCBs in surface sediment and the much slower decline of PCB loading to the LHR.

2016 surface sediment monitoring plan provides inadequate baseline of PCBs for evaluating sediment recovery.

> ***Recommendation: The sediment monitoring program should be modified to adequately address the highly contaminated sediments in RS2 and RS3, which will remain a major source of PCBs to Upper Hudson food webs and provide continued PCB loading to the LHR. The highly contaminated cohesive sediment areas sampled during the SSAP should be treated as a separate stratum from the non-cohesive sediments and more samples are needed within those cohesive areas per river pool to establish a surface sediment baseline for evaluations of fish exposure, PCB loading to the Lower Hudson River, and the rate of recovery of the system. Core samples should be collected and analyzed from 0-2, 2-6, and 6-12 inch intervals consistent with the definition of "surface" as the top 12 inches in the ROD (USEPA 2002) and confirmed in the Final Dispute Resolution (July 26, 2004).***

EPA's 2016 sediment sampling plan is intended to provide a baseline for future monitoring to determine the rate of recovery in surface sediment. The underlying premise assumes that a SWAC for each entire river section is the best metric for evaluating recovery. The modeling done by EPA to support the ROD (and by GE) is based on the understanding that cohesive (fine-grained) sediment provides the foundation for the food web (NOAA 2016). However, the 2016 sediment sampling, by virtue of the design, provides only minimal information on the known highly contaminated unremediated areas (mostly cohesive sediments) surrounding the RS2 and RS3 dredge areas that were identified in the SSAP. Therefore, the 2016 sediment sampling provides an inadequate post-dredging baseline.

Cohesive sediments represent the primary source of exposure to the benthic food web and fish species, but most of the 2016 samples were collected from non-cohesive sediment areas. The highly contaminated cohesive sediment areas sampled during the SSAP should be treated as a separate stratum from the non-cohesive sediments and more samples are needed within those cohesive areas to properly characterize them.

The sampling program was designed to determine the PCB SWAC by entire river sections rather than the smaller river pools (=river reach). The river pool sampling approach is essential to establishing a surface sediment baseline for evaluations of fish exposure, PCB loading to the Lower Hudson River, and the rate of recovery of the system. Resident fish tend to remain within a river pool, which means they integrate their exposure within pools or smaller areas, and not over much larger river sections (Field and Kern 2009b).

The 2016 sediment sampling only collected the top 2 inches of surface sediment, but it is important to measure PCBs in the top 12 inches of sediment. Surface sediment was defined in the 2002 ROD and in the Final Dispute Resolution (July 26, 2004) as 0-12 inches. The PCBs in

the top 12 inches represent a more complete accounting of the PCBs biota are or may be exposed to in the future, as well as the mass that may be transported to the lower river. In the dispute resolution EPA acknowledged that "*The Agency selected a remedy that targeted dredge areas based on, among other things, PCB concentrations representing the top 12 inches of sediment in order to account for all processes – whether physical, chemical or biological - that can make PCBs bioavailable*."

According to the FYR: "*One year of post-dredging data indicate a reduction in exposures consistent with EPA's expectations at the time of the ROD.*"[7] EPA's 2016 sampling plan, which is proposed to serve as the baseline for future sediment sampling to assess temporal change, only minimally addresses areas of known highly contaminated sediments in cohesive sediments adjacent to dredge certification units (*see* NOAA 2016 comments on plan). Consequently, the sediment monitoring program will not adequately address these highly contaminated sediments in RS2 and RS3, which will remain a major source of PCBs to Upper Hudson food webs and provide continued PCB loading to the LHR. The 2016 sediment monitoring plan also provides an inadequate basis to "*…indicate a reduction in exposures consistent with EPA's expectations at the time of the ROD.*"

NOAA's 2016 comments on the Operation, Maintenance, and Monitoring Plan (OMM) 2016 summarize the concern:

> Both EPA's and GE's bioaccumulation modeling recognized that fine-grained (cohesive) sediments were a major source of exposure for PCBs entering the food web. For example, the EPA bioaccumulation modeling assumed that fish were primarily exposed to cohesive sediment (75%) while in GE's bioaccumulation models [QEA 1999], PCB concentrations in the food web were based entirely on exposure to cohesive sediments. Most vegetation in the Upper Hudson is found associated with fine-grained sediments.
>
> The OMM Plan is not comparable to any historical data, and does not provide sufficient sampling power to address individual reaches in RS2 & RS3, which will provide necessary spatial resolution to measure recovery. Using statistical analysis of DDS data as the basis for sample density underestimates number of samples required for RS2 & RS3 because it doesn't take into account composite sampling in the DDS in RS2 and RS3.
>
> Focusing exclusively on the top 5 cm instead of the bioactive zone of 30 cm (as defined in the EPA-GE Dispute Resolution) provides limited information on the PCBs in the surface that will be available to biota and at potential immediate risk of recontamination of dredged areas and transport to the LHR.

[7] Pg. 67.

FYR assessment of remedy effectiveness over-relies on percent reduction and decay rates rather than actual PCB concentrations

> ***Recommendation: Actual PCB concentrations should be the primary measure of remedy success as defined by the ROD rather than decay rates or percent reduction. The FYR should acknowledge that the highly contaminated areas adjacent to the dredged areas in the SSAP have not been re-sampled sufficiently to determine post-dredging PCB concentrations, percent reduction, or decay rates.***

The FYR emphasizes the percent reduction in PCB mass in the river. The success of the remedy does not depend on the percentage or amount removed, but the magnitude and spatial extent of PCBs left behind, which greatly exceeded expectations in the 2002 ROD. The FYR underestimate of ~60,000 kg PCB mass left behind outside of dredged areas is almost equivalent to the 70,000 kg PCBs the 2002 ROD estimated would be removed from the river by the dredging remedy.

The FYR compares SSAP and 2016 surface sediment data from the top 2 inches to estimate reduction in surface area PCB concentration. This is an apples to oranges comparison, as the 2016 data only minimally included samples in RS2 & RS3 from the highly elevated fine-grained PCB sediment deposit areas adjacent to dredged areas. Additionally, 2016 PCB Aroclor analysis significantly underestimated PCB concentrations based on split-sample analyses (see EPA Method 1668A discussion, below).

Important implications of split-sample PCB analysis are not addressed in FYR.

> ***Recommendation: In future PCB analyses switch to Method 1668 entirely (preferred) or use a much higher percent of split-sample EPA Method 1668 (Method 1668). Incorporate Hudson River Reference Material into future fish PCB analyses. For past data adjustments, analyze archived sediment and fish samples (or sample homogenates for fish) that had previously been analyzed using Aroclor and/or mGBM methods.***

The 2016 sediment sampling included analysis of a subset of the samples by a highly qualified independent laboratory using the current standard for PCB congener analysis (EPA Method 1668A) (Anchor QEA 2017). However, the FYR report does not contain an analysis of these results. NOAA's evaluation indicates that Total PCBs (and Tri+ PCBs) measured by EPA Method 1668A congener analysis were more than twice as high as the Arcolor Method 8082 (geometric mean ratio of 2.4) previously used by Pace laboratory (formerly NEA, GE's contractor for laboratory analysis). This implies that recent previous sediment analysis conducted by GE's Pace laboratory (*e.g.*, DDS 2011-3 analyses) (and possibly earlier analyses conducted by NEA such as SSAP) underestimated PCBs in the sediment. The modified Green Bay Method (mGBM) split-extract analysis conducted by NEA during the last 3 years of the SSAP sampling indicated that the Aroclor total PCB concentrations in sediment were higher than reported from the mGBM peak analysis (USEPA 2017). The 2016 results suggest that the mGBM peak analysis may have also underestimated PCB concentrations in sediment.

Although comparable split-sample data from Method 1668 for fish do not exist, it is reasonable to hypothesize that total PCB concentrations for fish may also have been underestimated. This uncertainty could have been avoided if GE had used the Hudson River Reference Material (HRM) prepared by NYSDEC, as required by the Consent Decree. NYSDEC contract labs have been using the HRM routinely since 2009.

To evaluate the potential implications of this major uncertainty, NOAA recommends that EPA send previously analyzed and archived frozen fish samples to the same laboratory that EPA used to analyze the 2016 sediment-samples using Method 1668 (Axys Laboratory) for PCB congener analysis using Method 1668 that have prior PCB analyses by both Aroclor and mGBM methods and include both the Hudson River Reference Material[8] and Standard Reference Material available from the National Institute of Standards and Technology (NIST) or a commercial vendor.

Homologue adjustment of fish PCB data and estimating sediment type for RS3 adds major uncertainty to the FYR evaluations

> ***Recommendation: Assess the impact of using a single correction factor to adjust multiple years of fish PCB data on the uncertainty of the temporal PCB trend analysis. Confirm that Total PCBs in fish from mGBM are comparable to Total PCBs from Method 1668.***

The FYR's "homologue" adjustment of NYSDEC and GE fish data uses a single factor based on a geometric mean of the ratio of Aroclor PCBs to mGBM Total PCBs. In the case of the NYSDEC data, the adjustment factor from 1999-2000 is applied to all subsequent years without any data to document applicability. The NYSDEC adjustment factor applies the factor from wet weight analysis to the lipid-normalized concentrations, instead of more appropriately using the factor from lipid-normalized analyses, which are substantially different for some years. Also, for the 1997 NYSDEC fish data, the FYR relies on a model-estimated factor from Butcher *et al.* .(1998), ignoring the data from the split-sample approach used for subsequent years. Using a single factor ignores the uncertainty/variability of the relationship for different subgroups (e.g., species, location, year) and may not represent the pattern in the underlying data. Additionally, the 2016 split-sample analysis for sediment suggests that both the Aroclor and mGBM PCB analyses may significantly underestimate the total PCB concentration from full congener analysis (Method 1668).

> ***Recommendation: Use direct measurement (i.e., sediment grain size analysis) to determine cohesive/non-cohesive sediment type in monitoring sediment.***

The FYR relies on side scan sonar surveys conducted in 1992 to determine sediment type rather than the side scan sonar surveys conducted by GE in 2004 to design the remedy. Because the

[8] "Performance evaluation (PE) samples for fish tissue, in the form of the Hudson River Reference Material (HRM) developed by New York State, shall be incorporated into the program. EPA will consider removing the MS/MSD samples if the HRM material is incorporated." From Appendix B to the Consent Decree, Hudson River PCBs Site, Statement of Work (SOW) for Remedial Action and Operations, Maintenance and Monitoring, December 2010, Section 2.7.5 Measurements.

1992 sediment type analysis did not include RS3, the FYR developed a predictive model of sediment type to determine cohesive/non-cohesive areas in RS3. The model was estimated to accurately predict cohesive/non-cohesive locations 76% of the time. As discussed earlier, a number of samples from the 2016 sediment sampling were incorrectly classified as cohesive based on grain size analysis or sediment texture observations, which results in an underestimation of the PCB concentration in cohesive sediment. Given the importance of the cohesive sediment in estimating sediment recovery and PCB mass, using a model rather than direct measurement increases the uncertainty of the estimates.

Conclusion

In conclusion, NOAA appreciated the opportunity to serve on EPA's FYR panel and to provide technical comments on the draft FYR report. NOAA shares the goal of full recovery of the river from PCB contamination in as short a time as is practicable and commend EPA for the significant dredging that has been achieved. Our technical comments are intended to improve EPA's ability to more accurately assess remedy protectiveness and effectiveness, including the time for the river to fully recover, based on the best available science. Our comments include observations that major ROD assumptions are not being met (*e.g.*, levels and amount of PCBs left behind in sediment and other environmental media, rate of recovery, and impact of the remedy on the LHR), that recovery will be significantly delayed from what was anticipated in the ROD, recommendations on how to improve data analysis, and the need for a much more robust monitoring program to assess protectiveness and effectiveness in future. Please do not hesitate to contact us with any questions or comments or if you would like to discuss these recommendations further.

Sincerely,

FIELD.LAWRENCE.J.1365856954 Digitally signed by FIELD.LAWRENCE.J.1365856954
Date: 2017.08.30 11:19:53 -07'00'

Jay Field

ROSMAN.LISA.B.1365827458 Digitally signed by ROSMAN.LISA.B.1365827458
Date: 2017.08.30 18:59:31 -04'00'

Lisa Rosman

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ATTACHMENTS

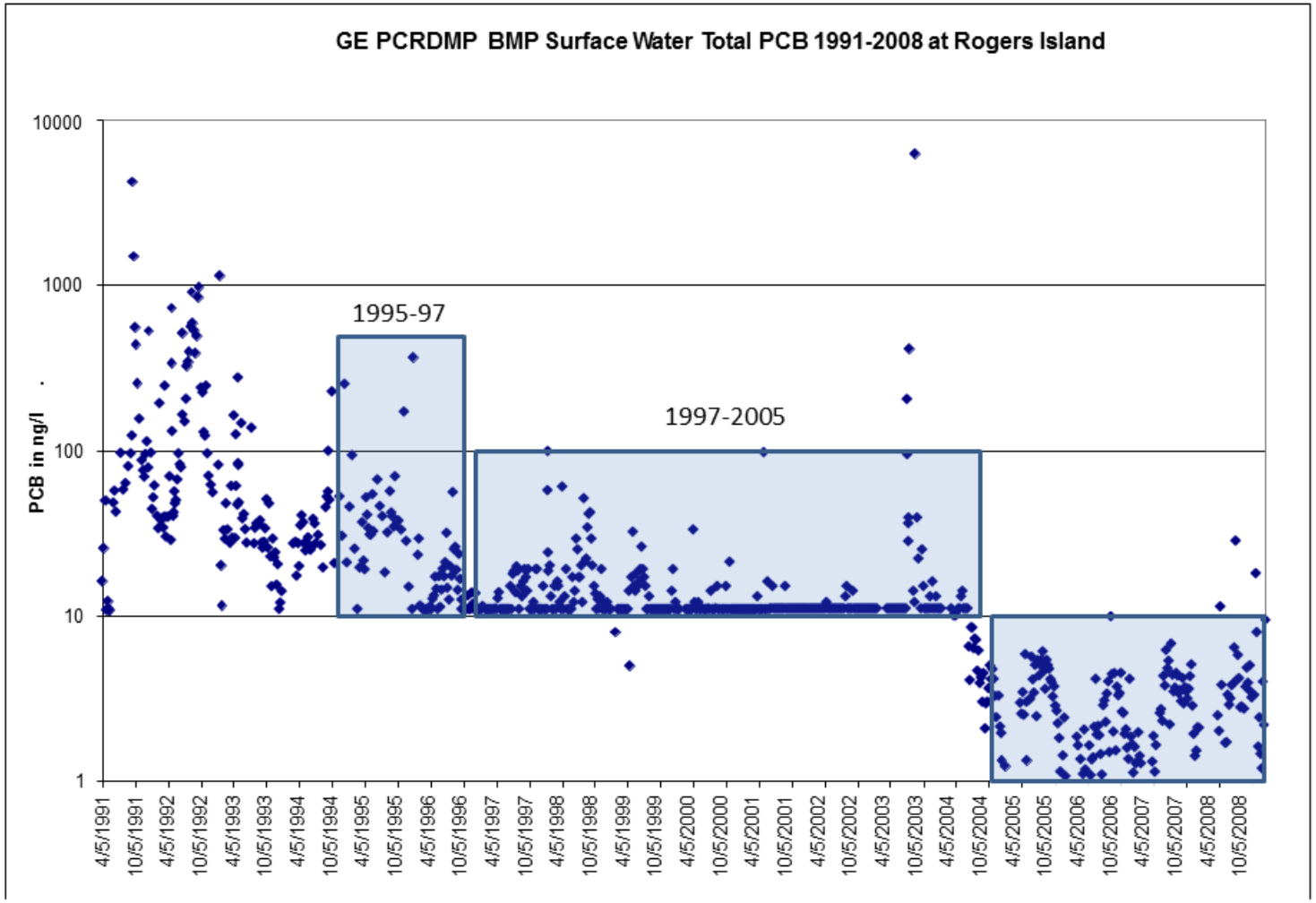

Figure 1. Total PCBs (ng/L) at Rogers Island monitoring station from 1991 to 2008. Data provided by NYSDEC. Emphasis added.

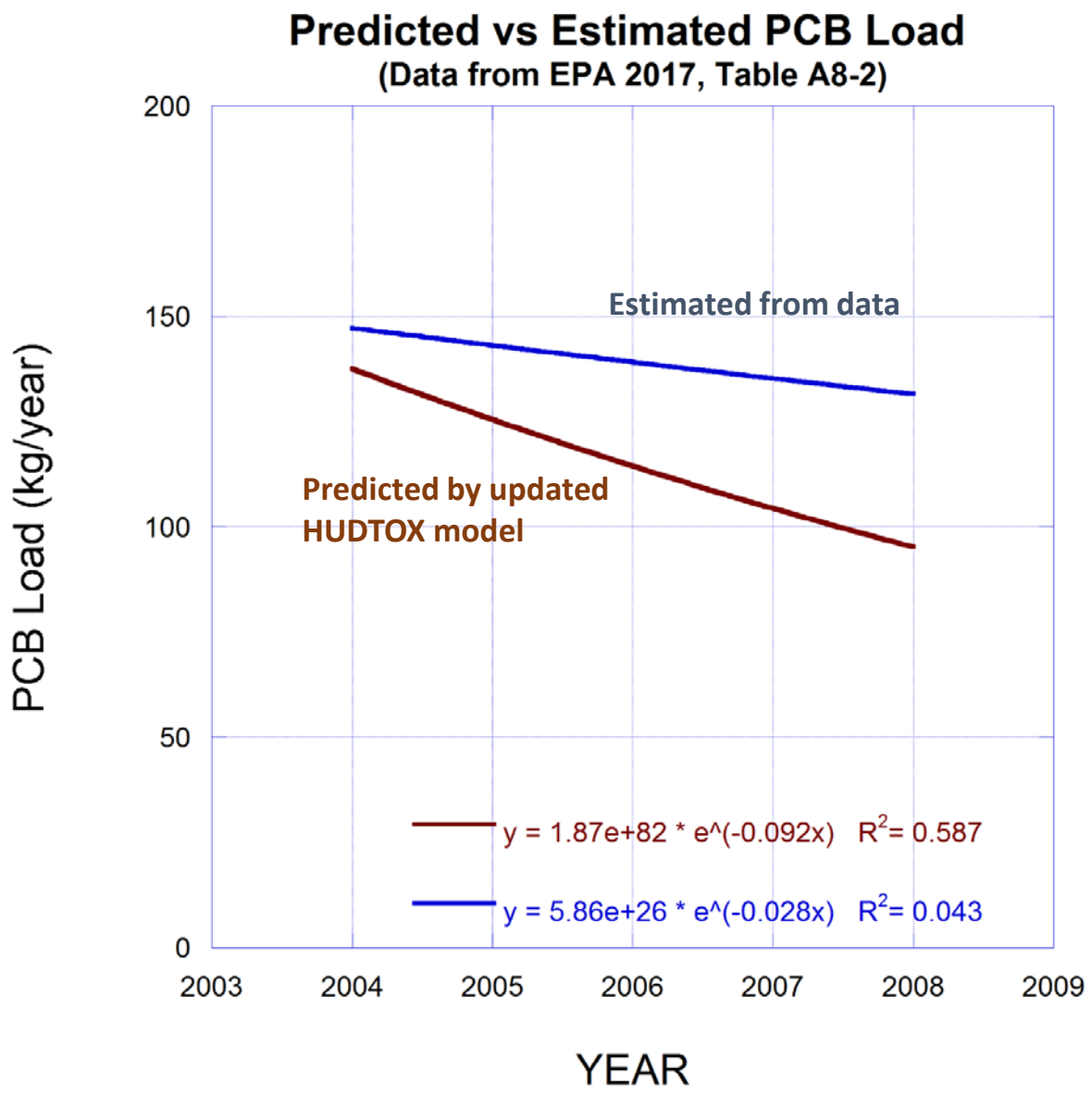

Figure 2. Predicted vs estimated PCB load (kg/year) exponential decay using data from USEPA 2017, Appendix Table A1-8.

Table 1. Exponential decay rate for standard long-term monitoring species and locations between 1997 and 2006.

		1997-2006			
SP_GROUP	RMILE	Unadjusted Data	FYR Adjusted Data	NOAA modified adjusted data	Average
Black Bass	RM189	-0.102	-0.102	-0.089	-0.098
Black Bass	RM176	-0.049	-0.051	-0.039	-0.046
Bullhead	RM189	-0.045	-0.031	-0.038	-0.038
Bullhead	RM176	-0.056	-0.036	-0.048	-0.047
Yellow Perch	RM189	-0.133	-0.131	-0.118	-0.127
Yellow Perch	RM176	-0.007	-0.025	0.001	-0.011
Pumpkinseed	RM189	0.048	0.044	0.052	0.048
Pumpkinseed	RM168	-0.057	-0.046	-0.041	-0.048
Black Bass	RM152	-0.047	-0.042	-0.035	-0.041
Bullhead	RM152	0.017	0.035	0.040	0.031
Yellow Perch	RM152	-0.041	-0.030	-0.017	-0.029
White Perch	RM152	-0.040	-0.027	-0.028	-0.032
Pumpkinseed	RM152	-0.174	-0.153	-0.150	-0.159
Black Bass	RM113	-0.078	-0.041	-0.075	-0.065
Black Bass	RM076	-0.067	-0.016	-0.043	-0.042
Bullhead	RM113	-0.043	-0.001	-0.023	-0.023
Bullhead	RM076	-0.015	0.019	0.000	0.001
White Perch	RM113	0.053	0.094	0.062	0.070
White Perch	RM076	-0.007	0.012	0.002	0.002
Yellow Perch	RM113	-0.007	0.031	0.010	0.011
Yellow Perch	RM076	0.020	0.018	0.019	0.019
Pumpkinseed	RM113	0.056	0.056	0.056	0.056
Pumpkinseed	RM076	-0.050	-0.050	-0.051	-0.051

< 5% decay
> 8% decay

Black Bass includes Largemouth and Smallmouth bass > 250 mm
Bullhead includes Brown Bullhead and Yellow Bullhead >= 175 mm
Yellow Perch > 150 mm

Yearling Pumpkinseed (< 120 mm)

FYR adjusted data provided to NOAA by EPA

NOAA modified adjusted data: uses lipid-normalized adjustment factors for 1997-2011 NYDEC data based on geometric mean ratio

Pumpkinseed Albany/Troy (RM152) sampling location changed over time, which makes temporal evaluation unreliable

Bullhead from Albany/Troy had small sample size