Second Five Year Review Report
Hudson River PCBs Superfund Site

APPENDIX 6

EVALUATION OF PCB AMBIENT AIR CONCENTRATION ESTIMATES AND MONITORING

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SECOND FIVE YEAR REVIEW REPORT
HUDSON RIVER PCBs SUPERFUND SITE

TABLE OF CONTENTS

SECOND FIVE YEAR REVIEW REPORT
HUDSON RIVER PCBs SUPERFUND SITE

LIST OF TABLES

SECOND FIVE YEAR REVIEW REPORT
HUDSON RIVER PCBs SUPERFUND SITE

LIST OF FIGURES

1 OVERVIEW

EPA has reviewed the available polychlorinated biphenyl (PCB) ambient air concentration baseline/background data collected or estimated at the Hudson River PCBs Superfund Site. The data reviewed includes the following:

- Monitoring data collected by General Electric Company (GE) (GE 2005a) and the New York State Department of Environmental Conservation (NYSDEC) (NYSDEC 2007) along the Upper Hudson River prior to the initiation of Phase 1 dredging activities in 2009. In combination, the data obtained by GE and NYSDEC provide an estimate of ambient air background concentrations of PCBs in close proximity to the Upper Hudson River prior to remedial activities.
- PCB ambient air concentration data obtained throughout Phase 1 and Phase 2 remedial activities at a pre-designated background location approximately 0.4 miles from the Upper Hudson River (General Electric 2009b, 2012-2016.)
- While post-dredging ambient air monitoring data are not available, using the water-to-air transfer coefficients established in the Revised Human Health Risk Assessment (HHRA) (EPA 2000) in combination with the currently available post-dredging water column PCB concentration data allows for the calculation of estimated post-dredging PCB ambient air concentrations resulting from the river.

The data from these various studies were compared to the results of the HHRA, which estimated PCB ambient air concentrations from the Upper Hudson River prior to remedial activities and concluded that they did not pose an unacceptable cancer risk or a non-cancer health hazard. Nonetheless, the 2002 Record of Decision (ROD) (EPA 2002) required that the remedy include performance standards for air quality consistent with state and federal law. NYSDEC and the EPA did not have specific standards, therefore the Quality of Life Performance Standard (QoLPS) for Air Quality (EPA 2004, updated December 13, 2010), summarized herein, was established to ensure remedial activities would not produce PCB air emissions that would result in an unacceptable increase in the risk to human health. This report includes a summary of PCB ambient air monitoring data collected during Phase 1 and Phase 2 remedial activities, as specified in the Remedial Action Monitoring and

Quality Assurance Project Plan (RAM QAPP) for Phase 1 (General Electric 2009a) and Phase 2 (General Electric 2011, 2012b).

2 BACKGROUND

2000 Revised Human Health Risk Assessment

As part of the HHRA (EPA 2000), EPA estimated and evaluated PCB ambient air concentrations in close proximity to the Upper Hudson River, reviewing various available sampling measurements and conducting modeling calculations in accordance with widely used transport equations to estimate the release of PCBs to air. Consistent with accepted transport methodologies, these calculations assumed that at equilibrium, the chemical release to the air is linearly proportional to the chemical concentration in water. Using this principle, the empirical transfer coefficients provide one means of estimating the PCB concentration in air that corresponds to the PCB concentrations in the water column.

During the HHRA, there were limited data available that provide site-specific information necessary to estimate future PCB concentrations in air that are attributable to PCB releases from the Upper Hudson River. Therefore, in addition to a review of existing studies of PCB ambient air concentration data (including those collected during the Remnant Deposit Remediation in 1991), EPA evaluated PCB concentrations in air using published PCB flux and ambient air concentration modeling approaches. Two approaches were used to estimate the PCB flux from the river: a two-film resistance model and an empirical modeling approach based on field studies. The PCB emission estimates provided the PCB source term for the Industrial Source Complex air dispersion model that was used to estimate PCB concentrations in air in the vicinity of the Upper Hudson River. The modeling analysis yielded much lower estimated concentrations of volatilized concentrations in the air compared to empirical data. Therefore, the Reasonable Maximum Exposure (RME) value is based on the empirical air and water data collected during the Remnant Deposit Remediation in 1991. The HHRA estimated an empirical water-to-air transfer coefficient (i.e., K_{aw}, micrograms per cubic meter [µg/m3] per micrograms per liter [µg/L]) between 0.02 to 0.4 (mean and median of 0.15 and 0.09, respectively).

The HHRA assessment of emissions from the Hudson River assumed a mean PCB concentration in the water column of 0.024 µg/L, or 24 nanograms per liter (ng/L).

Applying this value and the median K_{aw} (0.09) from the Remnant Deposit Remediation data, an empirical estimate of the PCB ambient air concentration of 0.002 μg/m^3, or 2 nanograms per cubic meter (ng/m^3), was calculated. A high-end estimate of the PCB concentration in air is 0.017 μg/m^3 (17 ng/m^3), which is based on the 95th percentile estimate of the water column PCB concentration of 0.042 μg/L (42 ng/L) and the highest value K_{aw} of 0.4. This value (17 ng/m^3) was the highest of the empirical and modeling values estimated in the HHRA and was therefore chosen as the exposure point concentration (EPC) to evaluate RME. Based on this conservatively assumed annual average PCB ambient air concentration of 17 ng/m^3, EPA determined that PCB emissions did not pose an unacceptable cancer risk (less than 1 in a million [10^6]) or a non-cancer health hazard (less than a hazard index of 1.0).

Record of Decision and Quality of Life Performance Standards

As part of the Record of Decision, the White Paper - *PCB Releases to Air* (EPA 2002 (Part 3, Book 2) describes the methods used for estimating the PCB flux from the dredging corridor and sediment processing facility, and the potential risks to workers and nearby residents. The cancer risks and non-cancer health hazards due to the inhalation of volatilized PCBs in the air to project personnel and residents (young child and adult) living near the dredge corridor or the sediment processing facility were found to be below *de minimis* levels of regulatory concern (*e.g.*, below a cancer risk of 1 in a million [10^{-6}] and a non-cancer hazard index of 1.0).

Nonetheless, the EPA established the QoLPS to protect the health and safety of the public during the remedial action of the Upper Hudson River (EPA 2004). New York State agencies, the public, and the federal Natural Resource Trustees were consulted throughout the development of the QoLPS. The Air QoLPS for residential areas was established at 110 ng/m^3 over a 24-hour monitoring period to be protective of a young child (six years and younger) and is based upon the assumption that this average PCB ambient air concentration occurs 350 days per year for the assumed duration of the remedial activities (7 years). The standard is protective of residential exposures for young children and adults,

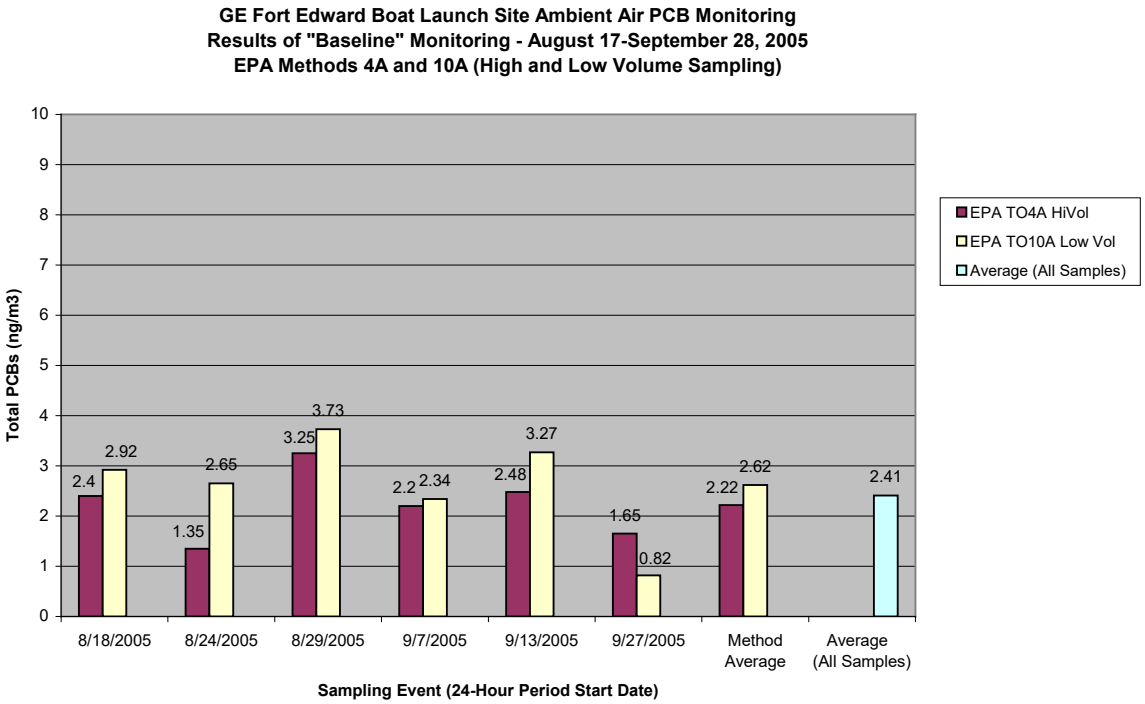
considering the long-term and short-term toxicity of PCBs and the potential risk of cancer from PCB air emissions.

To develop the Air QoLPS, EPA employed EPA risk assessment methodologies, based on the chronic Reference Dose for Aroclor 1016 that is available on EPA's consensus database for toxicity information, the Integrated Risk Information System (IRIS). The exposures to young children and adults living near the river during the remedial action were evaluated by considering their Average Daily Dose of exposure including age-specific inhalation rate and body weight, a potential residential exposure period, and averaging time. In the residential area, the young child was identified as the most sensitive receptor and the standard was calculated to meet the goal of protection of a Hazard Index (HI) = 1. In addition, the proposed standards were evaluated based on potential cancer risks. The resulting cancer risks for both the young child and adult were shown to be within the acceptable risk range identified within the Superfund program of 10^{-4} (one in ten thousand) to 10^{-6} (one in a million) (EPA 2004).

3 BACKGROUND AMBIENT AIR STUDIES

Before remedial activities began, two studies were conducted that were used to measure PCB ambient air concentration along the dredge corridor. The data collected during these studies further support the conclusion of the HHRA that the PCB ambient air concentrations near the river prior to remedial activities were below the concentrations in air for the residential RME individual utilized in the HHRA (17 ng/m^3) (see Table 1).

In the summer of 2005, GE performed an equipment shakedown and analytical method verification study to compare high-volume and low-volume air sampling methods. The location of the study, the Fort Edward boat launch, was chosen to also provide a representative background sample of the dredge corridor (GE 2005a). The study used high-volume (EPA Method TO-4A) and low-volume (EPA Method TO-10A) samplers at the same location, collecting 24-hour samples on 6 days between August 18, 2005, and September 27, 2005. The summary of the results of this study are shown in Figures 1 and 3, below.



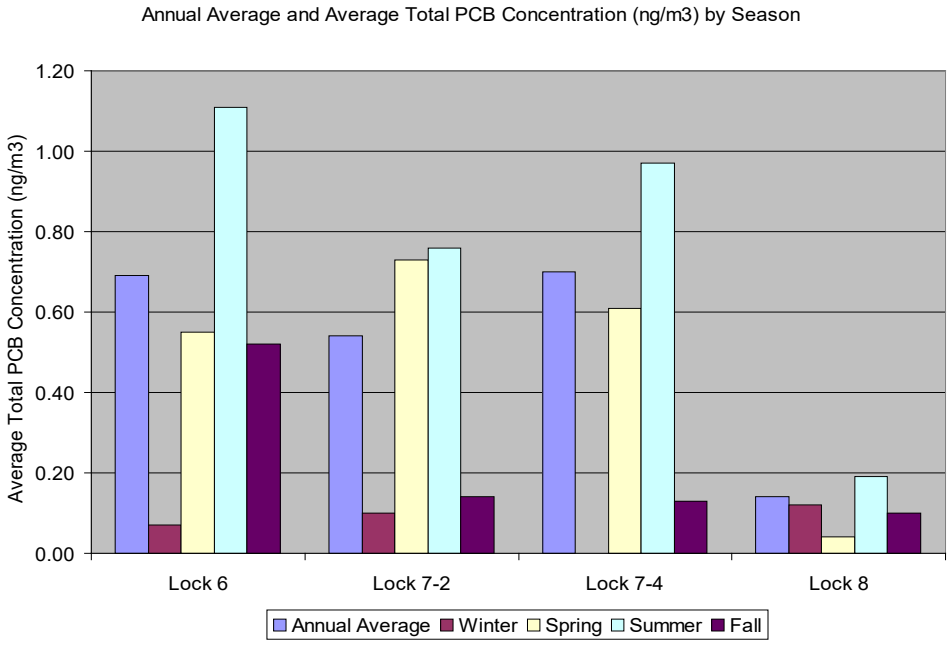
Source: Slide #4, GE Presentation "Equipment Shakedown and Analytical Method and Verification Study, GE 2005b

Figure 1: GE Fort Edward Boat Launch Site Ambient Air PCB Monitoring Results of "Baseline" Monitoiring August 17 - September 28, 2005 EPA Method 4A and 10A (High and Low Sampling)

Between November 2005 and November 2006, the NYSDEC conducted an ambient air monitoring study at three samples sites (Locks 6, 7 and 8) on 41 sampling days, specifically to establish baseline concentrations of PCBs prior to the start of remedial activities. The PCB concentrations ranged from 0.03 to 2.8 ng/m^3, and the overall average of PCB samples was 0.6 ng/m^3. NYSDEC noted that PCB concentrations were lowest at Lock 8, which is located on the Champlain Canal 1.7 miles from the closest point of the Hudson River. NYSDEC concluded that:

- "Baseline PCB concentrations are well-below the EPA Quality of Life Performance Standard,
- Median concentration was less than 0.34 ng/m3, which is below the QoLPS, and
- Ambient air concentrations are comparable to previous ambient air concentrations measured by the New York State Department of Health (NYSDOH) in the Fort Edward and Hudson Falls areas as part of the 'PCBs and Health: The Hudson River Community Project' [(NYSDOH 2006)]." (NYSDEC 2007)

Figures 2 and 3 provides a summary of the NYSDEC study results.



Source: Slide #8, NYSDEC Hudson River Baseline PCB Air Monitoring Study. NYSDEC 2007

Figure 2: Annual Average and Average Total PCB Concentration (NG/m3) by Season

Table 1 and Figure 3 provide a summary of both GE and NYSDEC results.

Table 1: GE and NYSDEC Pre-dredging, Background Monitoring Results

Study	Location	Year	Dates	Range (ng/m^3)	Average (ng/m^3)
GE	Fort Edward Boat Launch	2005	August 17 – September 28	0.82 – 3.73	2.41
NYSDEC	Lock 6	2005-2006	November 2005 – November 2006	0.3 - 2.8	0.64
NYSDEC	Lock 7 (2)				0.47
NYSDEC	Lock 7 (4)				0.65
NYSDEC	Lock 8				0.07

Source: GE 2005b; NYSDEC 2007.

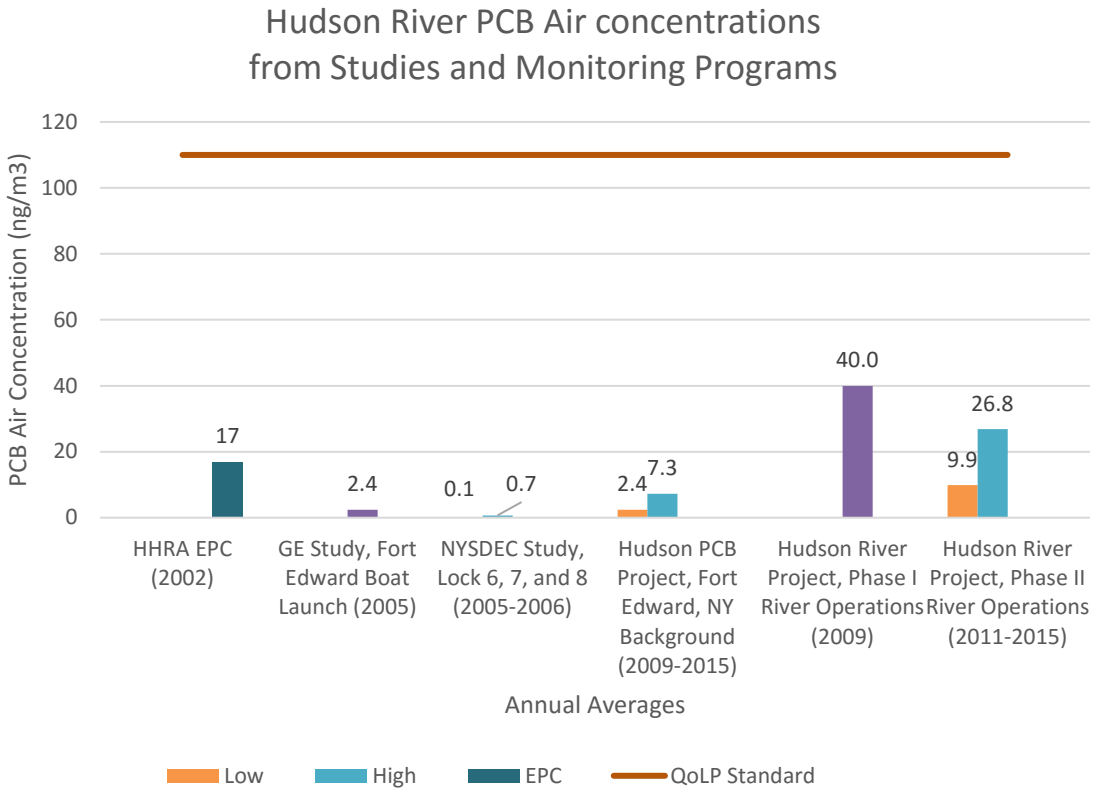


Figure 3: Hudson River PCB Air concentrations from Studies and Monitoring Programs

4 HUDSON RIVER PCBS SUPERFUND SITE PCB AIR MONITORING PROGRAM

In accordance with the QoLPS and the RAM QAPP, GE conducted a comprehensive monitoring program to monitor PCB emissions during remedial activities at the processing facility and along the dredging corridor. Throughout Phase 1 and Phase 2, the PCB air quality monitoring program collected a total of 10,334 samples to quantify PCB air concentrations from 248 monitoring locations along the dredging corridor between 2009 and 2015.

Fort Edward Background Sampling Results

A stand alone, high-volume background monitoring station was established in Fort Edward, New York, located 0.4 miles from the Upper Hudson River and 0.7 miles from the processing facility. Table 2 and Figure 3 provide a summary of data collected at the Fort Edward background monitoring station. The intent of this location was to provide insights into region-wide phenomena that may be affecting the PCB ambient air concentrations during the remedial activities, hence the siting of this location far from both the dredge corridor and the processing facility. While comparison of the background and operational datasets collected may produce differing results, all of these datasets can be favorably compared to the RME of the high-end empirical transfer coefficient estimate of 17 ng/m^3 chosen as the EPC utilized in the HHRA.

Table 2: Fort Edward NY, Background Monitoring Results

Year	Number of Samples	Number of Exceedances	Range (ng/m^3)	Average (ng/m^3)
Phase 1 (2009)	200	0	0.40 – 42.09	6.82
2011	210	0	0.07 - 37.3	4.38
2012	220	0	0.06 - 62.84	7.28
2013	195	0	0.38 – 54	5.6
2014	199	0	0.05 - 50.1	6.06
2015	201	0	0.01 - 13.93	2.35
All Phase 2	**1025**	**0**	**0.01 - 62.84**	**5.13**

Source: General Electric 2009b, 2012-2016;

Dredging Corridor Sampling Results

Low-volume samplers were used to provide continuous monitoring of PCB ambient air concentrations near the dredging activities between residents and the dredging operations, using 24-hour samples. While there were some daily exceedances of the Air QoLPS, considering the average of the data collected over the course of the dredging season[1], the project operated well below the Air QoLPS established to protect the public during dredging. Daily exceedances were typically the result of air samples collected in close proximity to high PCB concentrations sediments prior to best management practices (BMPs) being implemented in that area. Air concentrations typically decreased to previous levels after BMPs were implemented.

At the dredge corridor in Phase 1, there were 81 exceedances of the QoLPS out of a total of 1,846 samples over the 166-day dredging season (4.4%). The overall average PCB ambient air concentration recorded during Phase 1 for compliance purposes near dredging operations was 0.04 $\mu g/m^3$, or 40 ng/m^3, which is below the QoLPS standard of 110 ng/m3.

Additional mitigation strategies and monitoring requirements were established during the review of the data obtained during Phase 1 and refinement of the Air QoLPS prior to the start of Phase 2. Table 3 and Figure 3 provide a summary of the data collected along the Hudson River during Phase 2 in the proximity to active dredging and transfer operations. During Phase 2, less than 2% of samples exceeded the Air QoLPS, and the average of all the compliance samples obtained each year did not exceed 27 ng/m^3 (below the QoLPS of 110 ng/m^3).

[1] The averages for each year represents the average of all compliance samples collected during dredging operations at a specific location. These data represent the average of all locations, and actual average concentrations at each location will vary. This data would also represent an annual average, as ambient air concentrations on days without nearby dredging operations or in the off-season would likely be similar to background estimates.

Table 3: Phase 2 RAMP PCB Air Concentration Samples within Dredging Corridor

Year	Number of Samples	Number of Exceedances of 110 ng/m3	Range (ng/m^3)	Average (ng/m^3)
2011	1069	7	2.1 – 205.8	18.3
2012	2263	81	2.4 – 635	26.8
2013	1987	41	2.4 – 514.9	22.2
2014	2330	2	2.6 – 150.6	9.9
2015	836	0	2.57 – 68.2	11.0
All Phase 2	8485	131	2.1 – 635	18.5

Source: General Electric 2010, 2012-2016

The data collected and experience gained during Phase 1 and the Phase 1 review allowed for the design of more effective BMPs during Phase 2, such as covering sediment with water, expediting processing of barges containing highly contaminated sediments, and rotating dredging operations based on contaminate levels. BMPs were implemented when the potential for air emissions was expected to be high or in reaction to unexpected circumstances (*e.g.*, shallow backwater areas requiring transfer of sediments from barge to barge). Continuous PCB ambient air concentration monitoring allowed for the continuous evaluation of the implementation of BMPs and an understanding of the operating conditions that would or would not impact PCB ambient air concentrations. Largely as a result of improved BMPs, post-dredging PCB ambient air concentrations generally decreased following dredging.

5 POST-DREDGING MONITORING EVALUATION

Post-dredging water PCB concentrations will continue to be monitored under the Operation, Maintenance and Monitoring (OM&M) program. In addition, it is possible to estimate projected post-dredging PCB ambient air concentrations by combining the water-to-air transfer coefficient (K_{aw}) calculated during the HHRA with the available post-dredging water column PCB concentration data.

Water column PCB concentrations were measured weekly at the historic Thompson Island Dam sampling station between March and November 2016 (the current preliminary data are expected to be finalized in GE's Annual Progress Report in the spring of 2017). The mean PCB concentration of the 37 data points was 12 ng/L and the 95th percentile estimate was 23.7 ng/L. Following the approach outlined in the HHRA, combining the median empirical transfer coefficient (0.09) with the average concentration of 12 ng/L results in an estimated PCB ambient air concentration of 1.1 ng/m^3. In addition, combining the highest empirical transfer coefficient from the HHRA (0.4) with the 95th percentile estimate of the water column PCB concentration of 23.7 ng/L results in a more conservative estimated PCB ambient air concentration of 9.5 ng/m^3, which is approximately one-half of the calculated high-end estimate utilized in the HHRA. This projection is consistent with the conclusion of the HHRA that PCB air emissions from the Upper Hudson River do not pose an unacceptable cancer risk nor a non-cancer health hazard, and that ambient PCB air concentrations have likely improved as a result of the remedial activities and will continue to decrease over time due to monitored natural recovery (MNR).

6 CONCLUSIONS

- Prior to the Hudson River PCBs Superfund Project, there was little available data on the potential for emissions from PCB sediment remediation projects at-large nor specifically along the Hudson River.
- In the HHRA EPA estimated PCB emissions from the Hudson River prior to the remedy and the potential for emissions during the remedy, and determined that PCB emissions did not pose an unacceptable cancer risk nor a non-cancer health hazard to the RME resident.
- Background PCB air monitoring studies by GE and NYSDEC before remedial activities began indicated that PCB ambient air concentrations were below estimates calculated during the HHRA.
- NYSDEC determined that:
  - "Baseline PCB concentrations are well-below the EPA Quality of Life Performance Standard,
  - Median concentration was less than 0.34 ng/m^3, which at is below the QoLPS, and
  - Ambient air concentrations are comparable to previous ambient air concentrations measured by the New York State Department of Health (NYSDOH) in the Fort Edward and Hudson Falls areas as part of the 'PCBs and Health: The Hudson River Community Project' [(NYSDOH 2006)]" (NYSDEC 2007).
- GE's PCB air monitoring program monitored PCB air concentrations during remedial activities. Background monitoring collected between 2009 and 2015 in Fort Edward, N.Y., during the project demonstrated that PCB ambient air concentrations were below the estimates calculated during the HHRA. While there were occasional daily exceedances of the Air QoLPS adjacent to dredging operations, when considering the annual average of all data collected along the river, the project operated well below the Air QoLPS established to protect the public during remedial activities.

- The experience gained during dredging operations, continuous monitoring, and BMP implementation during the project support EPA's expectation that post-dredging PCB ambient air concentrations are expected to decrease following dredging.
- While monitoring of the post-dredging PCB ambient air concentrations has not been performed, EPA calculated projected post-dredging PCB ambient air concentrations along the Hudson River. Using average post-dredging water column PCB concentration data, post-dredging PCB ambient air concentration estimates are similar to measured background concentrations prior to dredging.
- Post-dredging PCB ambient air concentration estimates are lower than those estimated during the HHRA.
- As PCB concentrations in water are likely to decrease over time due to MNR, it is expected that the PCB emissions from the river will also continue to decrease over time based on the mass of PCBs removed from the River.

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