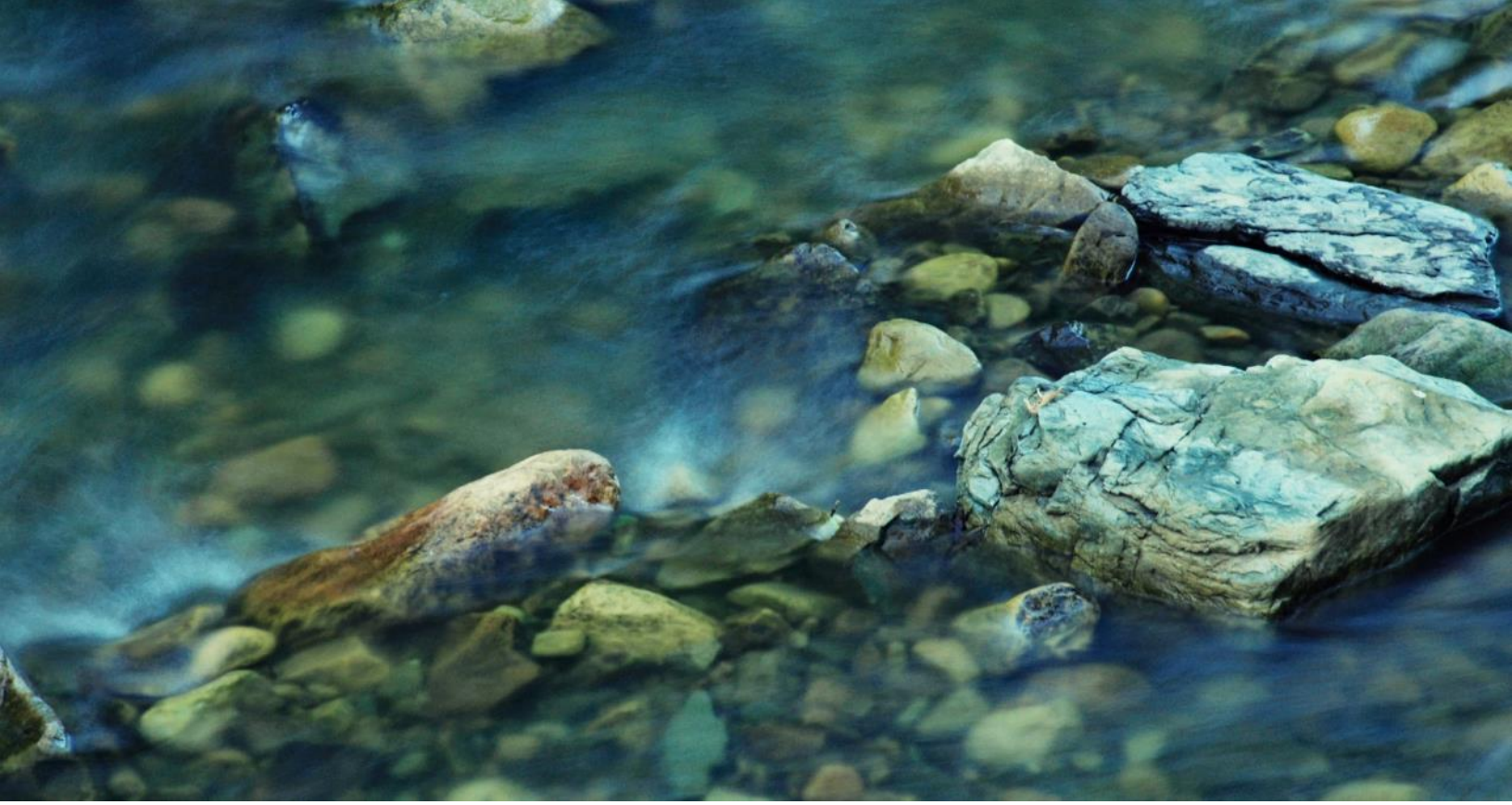

April 2020
Neal's Landfill Site

ANCHOR QEA

Post-Remediation Fish Sampling Data Analysis Report

Prepared for CBS Corporation

April 2020
Neal's Landfill Site

Post-Remediation Fish Sampling Data Analysis Report

Prepared for
CBS Corporation
Pittsburgh, Pennsylvania

Prepared by
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Project Number: 150564-01.01
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ABBREVIATIONS

µg/g	microgram per gram
CB	Commonwealth Biomonitoring
CBS	CBS Corporation
CDA	Consent Decree Amendment
DQO	Data Quality Objectives
HASP	Health and Safety Plan
mg/kg	milligram per kilogram
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PCB	polychlorinated biphenyl
ppm	parts per million
QAPP	Quality Assurance Project Plan
RCC	Remedy Confirmation Clause
ROD	Record of Decision
SD	standard deviation
SDAP	sampling and data analysis plan
USEPA	U.S. Environmental Protection Agency

1 Introduction

On behalf of CBS Corporation (CBS), Anchor QEA, LLC, has developed this fish sampling and data analysis report to evaluate the post-remedial changes in fish tissue polychlorinated biphenyl (PCB) concentrations in Conard's Branch and Richland Creek, adjacent to the Neal's Landfill Site in Bloomington, Indiana. The sampling and data analysis plan (SDAP) for this work (see Appendix A of this report; see also Appendix A of CBS 2017a) was based on the requirements set forth in the Consent Decree Amendment (CDA) issued by the U.S. District Court for the Southern District of Indiana (No. 1:81-cv-0448-RLY-KPF; U.S. District Court for the Southern District of Indiana 2008), as well as the guidance issued by the U.S. Environmental Protection Agency (USEPA) in its Data Quality Objectives (DQO) guidance document (USEPA 2006).

1.1 Remediation Performed

Remediation of the Neal's Landfill Site has included the following:

- Design, construction, and operation of a new element of the spring water collection system, which captures water from springs and seeps located downstream of the historical collection system and conveys this water to the water treatment plant.
- Design and installation of a new effluent line for the water treatment plant. This new effluent line discharges the treated water farther downstream to bypass areas with more significant residual PCBs.
- Cleanup of the PCB-contaminated in-stream sediments, bank soils, and floodplain soils in and along Conard's Branch. The cleanup standard applied was 1 part per million (ppm) for in-stream sediments and banks and 5 ppm for floodplain soils.

1.2 Evaluation of Remedy Success

Section IX of the CDA (Remedy Confirmation Clause [RCC] for Neal's Landfill; see Appendix A to the SDAP, which is Appendix A to this report) presents the target fish tissue PCB concentrations determined by USEPA to be protective of human health and the environment for two locations in Richland Creek and one location in Conard's Branch (Section IX.A.1). The parties to the CDA believe that the remedial actions selected by USEPA in the Neal's Landfill Record of Decision (ROD) Amendment for Operable Unit (OU) 2/3 would be adequate to achieve the target concentrations within a period of 10 years (or less) from the date of the completion of construction of the Remedial Action (CDA Section IX.A.2; see Appendix A). Toward this end, USEPA planned to evaluate the remedy every 5 years after completion of construction to determine whether the mean concentration of PCBs in fish is statistically greater than or less than the risk-based target concentrations (CDA Section IX.A.4.; see Appendix A).

The remedy was accepted as complete by USEPA in 2012, and the sampling described in this report was performed in May and November 2017.

1.3 Objective

The objective of the fish sampling and data analysis was to evaluate whether the mean fish tissue PCB concentrations in Conard's Branch and Richland Creek meet the targets set forth in the RCC of the CDA (Section IX.A.1; see Appendix A). This document describes the results of the 2017 sampling and an evaluation of whether the targets have been met.

1.4 Overall Approach

The overall approach to meeting the objective described in Section 1.3 was to collect and analyze fish tissue samples at the three locations specified in the CDA 5 years post-construction. The CDA called for evaluation of the mean fish tissue PCB concentration of the samples collected at each location using statistical hypothesis testing to evaluate the following:

- Whether the mean fish tissue PCB concentrations are significantly less than or greater than target concentrations set forth in the RCC
- Whether the mean fish tissue PCB concentrations are significantly greater than the mean concentrations measured in pre-remedy samples collected in 2003 through 2005

The statistical methodology was based on the guidelines specified in USEPA's DQO guidance document (USEPA 2006). Specific null and alternative hypotheses used in the statistical testing are presented in Section 3.2.

Section 2 describes the sampling program. Section 3 presents the results, including analyses of species guild distribution within the data set, body size distribution for each guild, statistical properties of the PCB data, results of statistical hypothesis testing, and comparison with pre-remediation data.

2 Sampling Program

2.1 Sampling Locations

Fish were collected at the following three locations:

- **Location B in Conard's Branch:** Upstream of the Vernal Pike Crossing, but not within 1,000 feet of the outlet of the new effluent line
- **Location D in Richland Creek:** From a location 200 feet downstream of the confluence with Conard's Branch down to a location approximately 2,500 feet below the Vernal Pike Bridge
- **Location F in Richland Creek:** At the State Route 43 Bridge

These locations are shown in Figure 1. For Location F, fish sampling was to be conducted no more than 100 meters upstream of the bridge before moving downstream (if insufficient fish were available upstream) within 100 meters of the bridge to be consistent with the sampling practices used during the historical sampling events.

2.2 Frequency and Timing

The CDA states that the data collection should include an equal number of samples from spring and fall periods (Section IX.H.5). Sampling was performed in May and November 2017.

2.3 Fish Sampling Collection Procedures

The field collection strategy was detailed in the long-term groundwater monitoring plan (CBS 2017b) and was the same procedure that was used in the 2005 sampling event. Lengths and weights were measured and recorded in the field for each individual fish collected. Individual fish that met the size requirements (as per the SDAP) were grouped in the field into three fish composites for each target population for homogenizing in the laboratory. The field sampling was performed by Commonwealth Biomonitoring (CB) of Indianapolis, Indiana. USEPA provided full-time oversight of the field activities. The field sampling reports prepared by CB are included in the final data validation reports (CBS 2018a, 2018b).

2.4 Laboratory Analysis

The laboratory homogenized the three fish composites prior to analysis. As required by the CDA, the fish samples were analyzed using the same total congener PCB and lipid methods as were used in 2005. As before, the information reported by the laboratory included length, weight and lipid content. The laboratory that performed these analyses was SGS Analytical Laboratories of Wilmington, North Carolina. This is the same facility used in 2005, although it was then known as Paradigm Analytical.

2.5 Data Validation

The laboratory data were independently validated by Trillium, Inc., of Downingtown, Pennsylvania. Their reports were included with the formal transmittal of the validated data that included the field sampling report in two letter transmittals to USEPA. The spring data report was sent to USEPA on September 21, 2018 (CBS 2018a), and the fall data were transmitted to USEPA in a letter dated September 26, 2018 (CBS 2018b). USEPA reviewed the validation reports and concurred that the data were usable as reported (Hahne 2018).

3 Results

3.1 Fish Species, Sample Size and Body Size

The fish species that have been collected historically have been grouped into top predators, omnivores, and bottom feeders, as shown in Table 1.

Table 1
Fish Species Groupings

Species	Grouping
Sunfish	Top Predators
Rock Bass	
Smallmouth Bass	
Creek Chubs	Omnivore
Golden Redhorse	Bottom Feeders
Northern Hogsucker	
White Suckers	

The CDA set forth a specific mix of these groups that was to be included in the calculation of average PCB concentration for each location (see Table 2; CDA Section IX.A.3).

Consistent with the CDA Section IX.H.2, prior to laboratory analysis, composite samples were prepared. Each composite sample included three individual fish of the same species or feeding guild for each of the groups listed in Table 1. Fish samples were analyzed for total PCB congeners; tissue samples were prepared as whole-body samples at locations B and D and as fillets at Location F (CDA Section IX.A.1).

As indicated in Table 2, the program met the sampling requirements for species/guild distribution and number of samples. In some cases, the number of samples exceeded the target number, resulting in a guild distribution slightly different from the target. All data were kept in the analysis in the interest of using all available information; therefore, proportions of each guild were slightly different from the targets specified in Table 2. A complete listing of the post-remediation data is provided in Appendix B.

Table 2
Number of Post-Remedial Fish Sample Composites Targeted and Collected

Location	Species/Guild Breakdown Targeted (number of composites)	Number of Fish Collected	Number of Composites Analyzed
B	Omnivores (18) If not available, then creek chub (9) and green sunfish (9)	Creek chub (Omnivore): 60	20
D	Top predators (6) Omnivores (6) Bottom feeders (6)	Rock bass (Top predator): 12 Longear sunfish (Top Predator): 6 Creek Chub (Omnivore): 21 White Sucker (Bottom feeder): 18 Hogsucker (Bottom feeder): 3	Top predator: 6 (30%) Omnivore: 7 (35%) Bottom feeder: 7 (35%)
F	Top predators (12) Bottom feeders (4)	Rock bass (Top predator): 15 Longear sunfish (Top predator): 24 Golden redhorse (Bottom feeder): 6 White sucker (Bottom feeder): 9	Top predator: 13 (72%) Bottom feeder: 5 (28%)

Note:
A number of additional fish were collected and archived (see Appendix B).

As per the requirements of the CDA, the body sizes of the fish collected at each location were evaluated for representativeness. "Representative" was defined in the CDA as samples having lengths within one standard deviation (SD) of the historical mean from the corresponding species, based on the data collected historically by CBS or USEPA at that location (CDA Section IX.H.4). Data collected from 2003 through 2005 were used to calculate these statistics (see Tables 3, 4, and 5). The SDAP stated that in the event that sufficient numbers of fish in this size range were not available, then the ranges were to be expanded: fish within two SDs of the historical average size would be collected, with the goal of collecting equal numbers above and below the average size. Both weight and length were to be evaluated, but weight was to provide the overriding criterion.

Targeted and collected fish body size information is provided in Tables 3, 4, and 5. The body sizes of the collected fish generally overlapped the targeted size range, although some fish sizes were outside of the targeted range. Numbers of fish below and above the historical average are also presented in the tables. In some cases, only one historical measurement was available, so the targeted size range could not be determined. In addition, in some cases, fish were collected at a location for which no historical fish of that species were available. Historical data for that species from another location are provided in the tables for qualitative comparison. All data were used in the analysis.

Table 3
Fish Length and Weight Range Targeted for Post-Remedial Sampling and Collected in 2017 – Location B

Fish Metric	Feeding Guild	Fish Species	Average	SD	Size Range for Post Remedial Sampling	Extended Size Range (average +/- 2 SD)	2017 Data Range	2017 Number Below Average	2017 Number Above Average
Length (in centimeters)	Omnivore	Creek Chub	13.1	1.3	11.8 – 14.4	10.5 – 15.7	10.0 – 20.0	44	16
Weight (in grams)	Omnivore	Creek Chub	23.7	5.7	18.0 – 29.4	12.3 – 35.1	12.0 – 43.0	44	16

Note:
See Anchor QEA (2017) for discussion of historical data used to estimate mean and standard deviation (SD).

Table 4
Fish Length and Weight Range Targeted for Post-Remedial Sampling and Collected in 2017 – Location D

Fish Metric	Feeding Guild	Fish Species	Average	SD	Size Range for Post Remedial Sampling	Extended Size Range (average +/- 2 SD)	2017 Data Range	2017 Number Below Average	2017 Number Above Average
Length (in centimeters)	Top Predator	Longear Sunfish	11.4	1	10.4 – 12.4	9.4 – 13.4	11 – 13	2	4
		Rock Bass	16.7	1.8	14.9 – 18.5	13.1 – 20.3	11 - 20	8	4
	Omnivore	Creek Chub	16.1	1.8	14.3 – 17.9	12.5 – 19.7	12 – 18	15	6
	Bottom Feeder	White Sucker	17.4	2.2	15.2 – 19.6	13 – 21.8	12 – 28	4	14
		Hogsucker[1]	26.6	0.6	26.0 – 27.2	25.4 – 27.8	21 – 22	3	0
Weight (in grams)	Top Predator	Longear Sunfish	29.3	8.3	21.0 – 37.6	12.7 – 45.9	26 – 42	1	5
		Rock Bass	88.5	23.3	65.2 – 111.8	41.9 – 135.1	27 – 169	7	5
	Omnivore	Creek Chub	49.5	22.7	26.8 – 72.2	4.1 – 94.9	15 – 69	14	7
	Bottom Feeder	White Sucker	60.4	19.7	40.7 – 80.1	21 – 99.8	25 – 157	6	12
		Hogsucker[1]	207.5	16.3	191.2 – 223.8	174.9 – 240.1	124 – 142	3	0

Notes:
1. Hogsucker was not a Location D species specified in the SDAP (see Appendix A). Historical size ranges are taken from Location F for qualitative comparison.
See Anchor QEA (2017) for discussion of historical data used to estimate mean and SD.

Table 5
Fish Length and Weight Range Targeted for Post-Remedial Sampling and Collected in 2017 – Location F

Fish Metric	Feeding Guild	Fish Species	Average	SD	Size Range for Post Remedial Sampling	Extended Size Range (average +/- 2 SD)	2017 Data Range	2017 Number Below Average	2017 Number Above Average
Length (in centimeters)	Top Predator	Rock Bass	17.9	2.1	15.8 – 20.0	13.7 – 22.1	11 – 20	4	11
		Small Mouth Bass	28.9	0	28.9	28.9	NA	NA	NA
		Longear Sunfish[1]	11.4	1	10.4 – 12.4	9.4 – 13.4	10 – 15	11	13
	Omnivore	Creek Chub	19	1.6	17.4 – 20.6	15.8 – 22.2	NA	NA	NA
	Bottom Feeder	Hogsucker	26.6	0.6	26.0 – 27.2	25.4 – 27.8	NA	NA	NA
		Golden Redhorse	31.9	0	31.9	31.9	31 – 34	3	3
		White Sucker	24.6	0	24.6	24.6	20 – 30	4	5
Weight (in grams)	Top Predator	Rock Bass	119	33.9	85.1 – 152.9	51.2 – 186.8	20 – 198	5	10
		Small Mouth Bass	335	0	335	335	NA	NA	NA
		Longear Sunfish[1]	29.3	8.3	21.0 – 37.6	12.7 – 45.9	15 – 66	9	15
	Omnivore	Creek Chub	83.3	17.2	66.1 – 100.5	48.9 – 117.7	NA	NA	NA
	Bottom Feeder	Hogsucker	207.5	16.3	191.2 – 223.8	174.9 – 240.1	NA	NA	NA
		Golden Redhorse	391	0	391	391	334 – 488	4	2
		White Sucker	163	0	163	163	110 – 275	4	5

Notes:

1. Longear Sunfish was not a F species specified in the SDAP (see Appendix A). Historical size ranges taken from Location D for qualitative comparison.

See Anchor QEA (2017) for discussion of historical data used to estimate mean and SD.
NA: No historical data available/no fish collected in 2017

3.2 Comparison with Target Concentrations

The CDA calls for the comparison of fish tissue total PCB concentrations with target concentrations and with pre-construction concentrations. At locations B and D, the concentration used was a whole-body, wet-weight basis for comparison to the target. At Location F, the concentration used was a fillet wet-weight basis. The target PCB concentrations in fish at each location, as determined by USEPA, are shown in Table 6 (CDA Section IX.A.1).

Table 6
Locations for Fish Sampling and Target Concentrations

Location	Target Concentration
B	2.3 mg/kg wet (whole body)
D	0.9 mg/kg wet (whole body)
F	0.2 mg/kg wet (fillet)

Note:
mg/kg: milligram per kilogram

The CDA requires the use of standard statistical hypothesis testing methods as laid out in the CDA and USEPA's DQO guidance document (USEPA 2006). The CDA calls for the evaluation of the following hypotheses. First, following CDA Section IX.C.2:

H_0: Average PCB concentration greater than or equal to target
H_a: Average concentration less than target (burden of proof)

Second, following CDA Section IX.D.1.a:

H_0: Average PCB concentration less than or equal to target
H_a: Average concentration greater than target (burden of proof)

The second test is only required if the first test does not reject the null hypothesis (i.e., if the data cannot be shown to be significantly lower than the target concentration). The first test was performed at all three locations.

Before statistical hypothesis testing for CDA Section IX.C.2 was performed, data were checked for parametric assumptions of normality (by location) and equal variance (by location and by sampling event). This was done qualitatively by examining quantile and box plots and quantitatively using a Shapiro-Wilk test and equal variance test. Raw data from Locations B and D met both assumptions (normality and equal variance for both the May and November sampling), whereas raw data from Location F did not. Examination of quantile plots indicated that the Location F data were likely lognormally distributed; therefore, the Location F data were natural log transformed and retested.

After transformation, Location F data met assumptions of normality and equal variance across the two sampling events. Quantile and box plots are provided in Appendix C.

As required by CDA Section IX.C.2, a one-sided Student's t-test (α = 0.05) against target PCB concentrations was performed for each location, using combined May and November sampling event data, and employing the pooled variance for two independent samples (Equation 1; Bancroft and Han 1983; Cohen 1988; IUPAC 1997; Ruxton 2006)[1]. The one-sided Student's t-test then employs the accepted calculation for standard error of the mean in the denominator (Equation 2; EPA 2006; Gotelli and Ellison 2004). For all three locations, PCB concentrations from sample event data were significantly less than target PCB values. That is, H_0 was rejected, and H_a was accepted (Table 7).

Equation 1

$$s_p^2 = \frac{(n_{May} - 1)s_{May}^2 + (n_{Nov} - 1)s_{Nov}^2}{n_{May} + n_{Nov} - 2}$$

where:

s_p^2 = the pooled sample variance
s_{May}^2 = May sample variance
s_{Nov}^2 = Nov sample variance
n_{May} & n_{Nov} = May and November sample size, in this case $n_{May} = n_{Nov}$

Equation 2

$s_{\bar{Z}} = \frac{s_p}{\sqrt{n}}$ where:

$s_{\bar{Z}}$ = the standard error of the sample means
s_p = the pooled sample standard deviation
$n = n_{May} + n_{Nov}$ = sample size of the combined sample

[1] Equations 1 and 2 are shown for clarity but can be simplified to Equation 4 of the SDAP.

Table 7
Fish PCB Data Summary and Results of Statistical Hypothesis Testing

Location	Sample Size		Data Transformation	PCB (µg/g wet weight)					p-value[3]	t-statistic[3]
	n_{May}	n_{Nov}		Mean	Pooled Sample Variance,[1] s_p^2	Pooled Sample Standard Deviation, s_p	Standard Error of the Sample Mean,[2] $s_{\bar{Z}}$	Target		
B	10	10	None	1.9	0.41	0.64	0.14	2.3	0.005	2.8
D	10	10	None	0.24	0.025	0.16	0.035	0.9	5.0e-14	18.8
F[4]	9	9	None	0.047	0.0020	0.044	0.010	0.2	NA	NA
			Natural Log	-3.48	0.55	0.74	0.175	-1.6	2.9e-09	10.7

Notes:
1. Pooled sample variance was calculated from Equation 1.
2. Standard error of the mean was calculated from Equation 2.
3. The test statistic was calculated as t = (Mean – Target)/(S_p/√(n_{May} + n_{Nov}) for the combined sample. Data values in the table have been rounded. To calculate the test statistic, unrounded values were used.
4. Analysis for Location F was performed on the natural log transformed data and target concentrations.
µg/g: microgram per gram
NA: indicates that the analysis was performed on the transformed data

3.3 Comparison with Historical Data

As required in the SDAP, graphical comparisons with historical data (collected in 2003 through 2005), along with the target concentrations, are presented in Figure 2a (Location B), Figure 2b (Location D) and Figure 2c (Location F). Median concentrations in post-remediation data are lower than in pre-remediation data at all three locations, indicating recovery of fish tissue PCB concentrations.

4 Conclusions

In conclusion, average fish tissue PCB concentrations at all sampled locations were tested against the CDA target concentrations using the appropriate statistical techniques and were found to be less than the target with greater than 95% confidence in all cases. Therefore, as per CDA Section IX.C.2, CBS has demonstrated that the remedy has been successful. No further statistical analysis is necessary for any locations.

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Figures

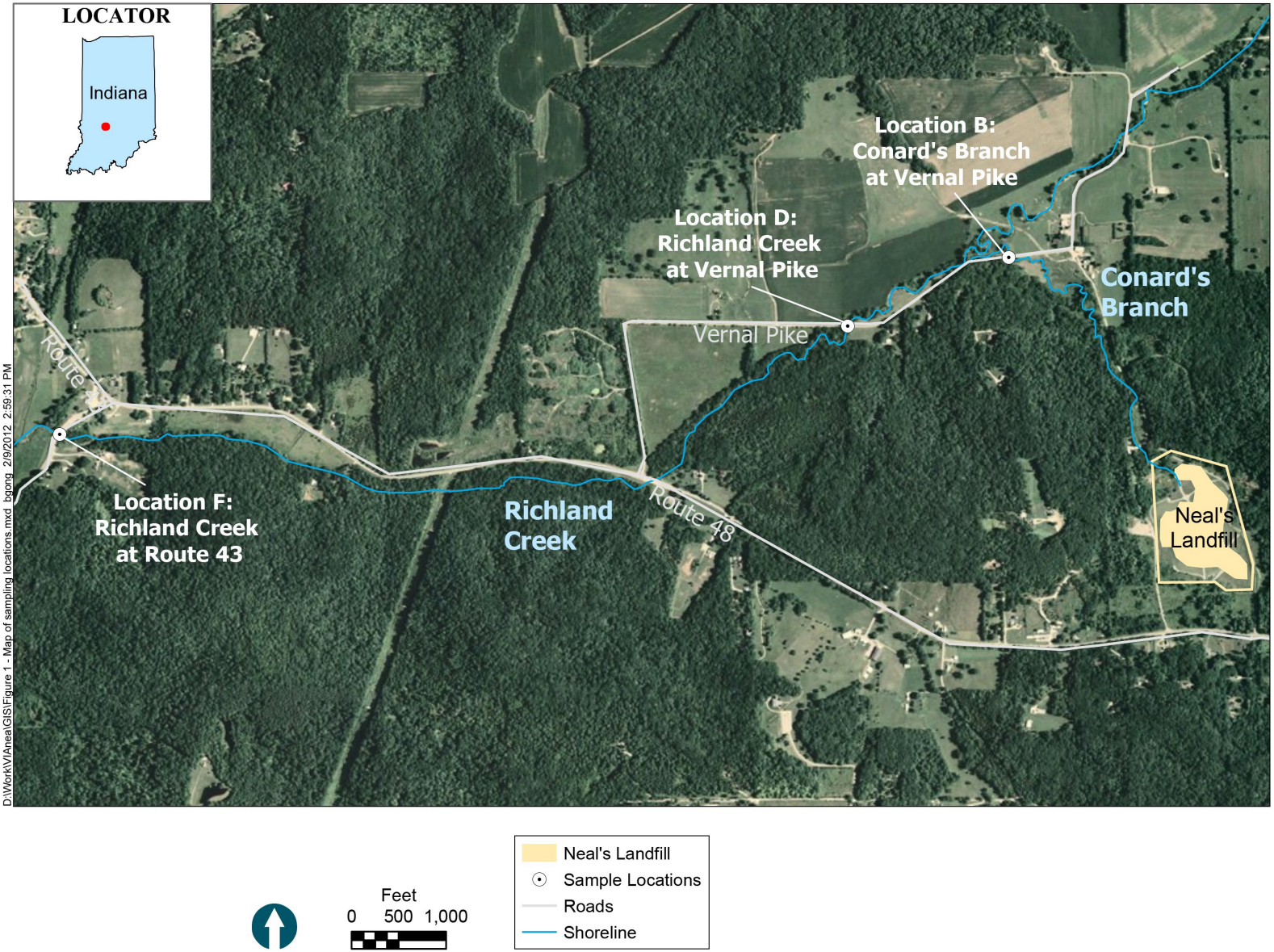

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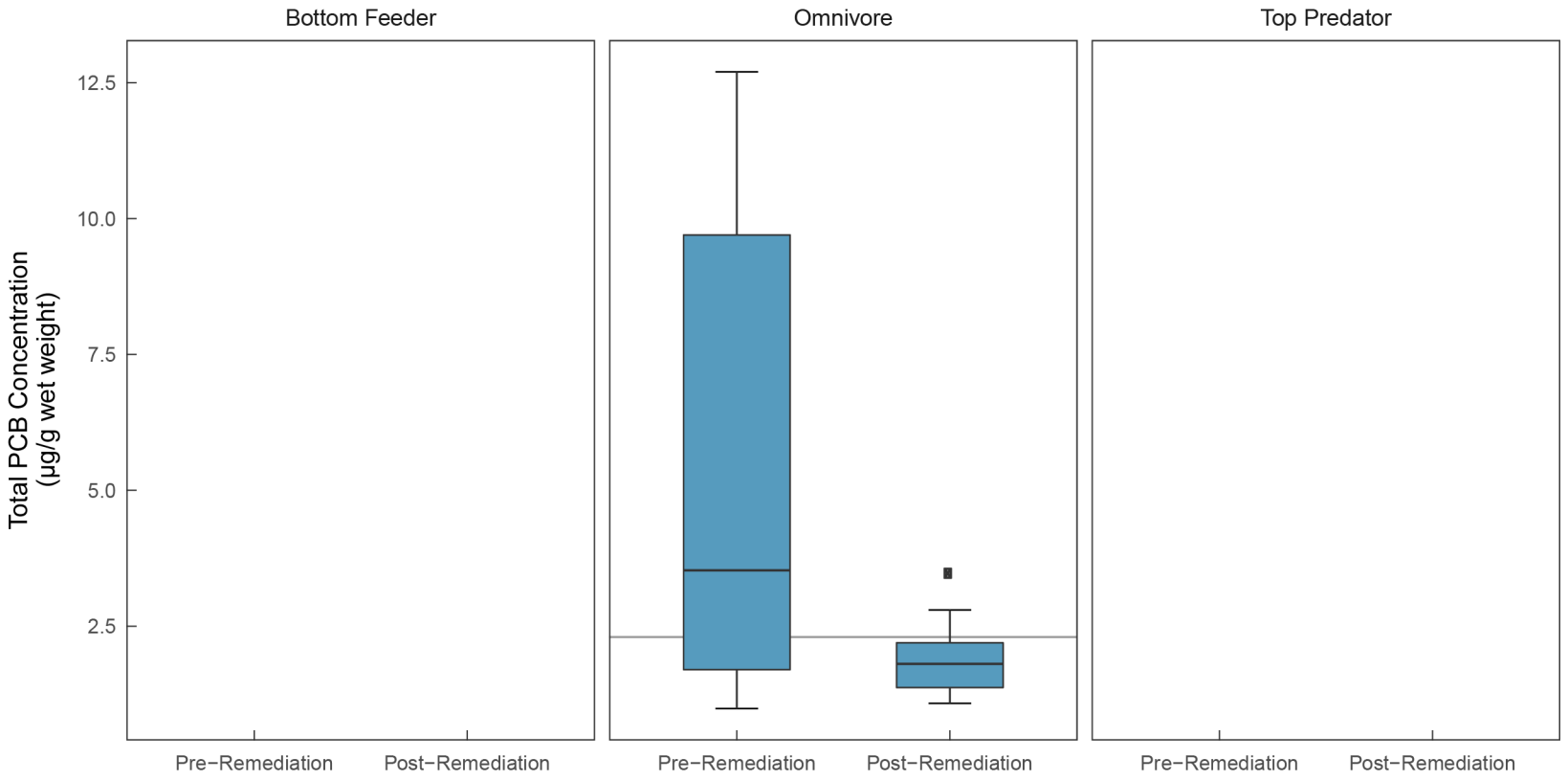
Figure 1

Map of Sampling Locations

Post-Remediation Fish Sampling Data Analysis Report
Neal's Landfill Site



Notes: Of the 25 pre-remediation Location B samples, 22 are individual fish and three are composites. All post-remediation Location B samples are three fish composites (20). Complete pre-remediation data, including source, year, and sample type, are provided in Appendix C of the sampling and data analysis plan. Complete post-remediation data are provided in Appendix B of this report, with a statistical summary provided in Appendix C. Blue boxes correspond to the 25% and 75% quantiles, and the middle line corresponds to the 50% quantile (median). The vertical lines extending up and down from the blue boxes indicate the range of data lying within 1.5 times the interquartile range. Any data outside this range are represented as black dots. Target remediation values are shown as grey lines.

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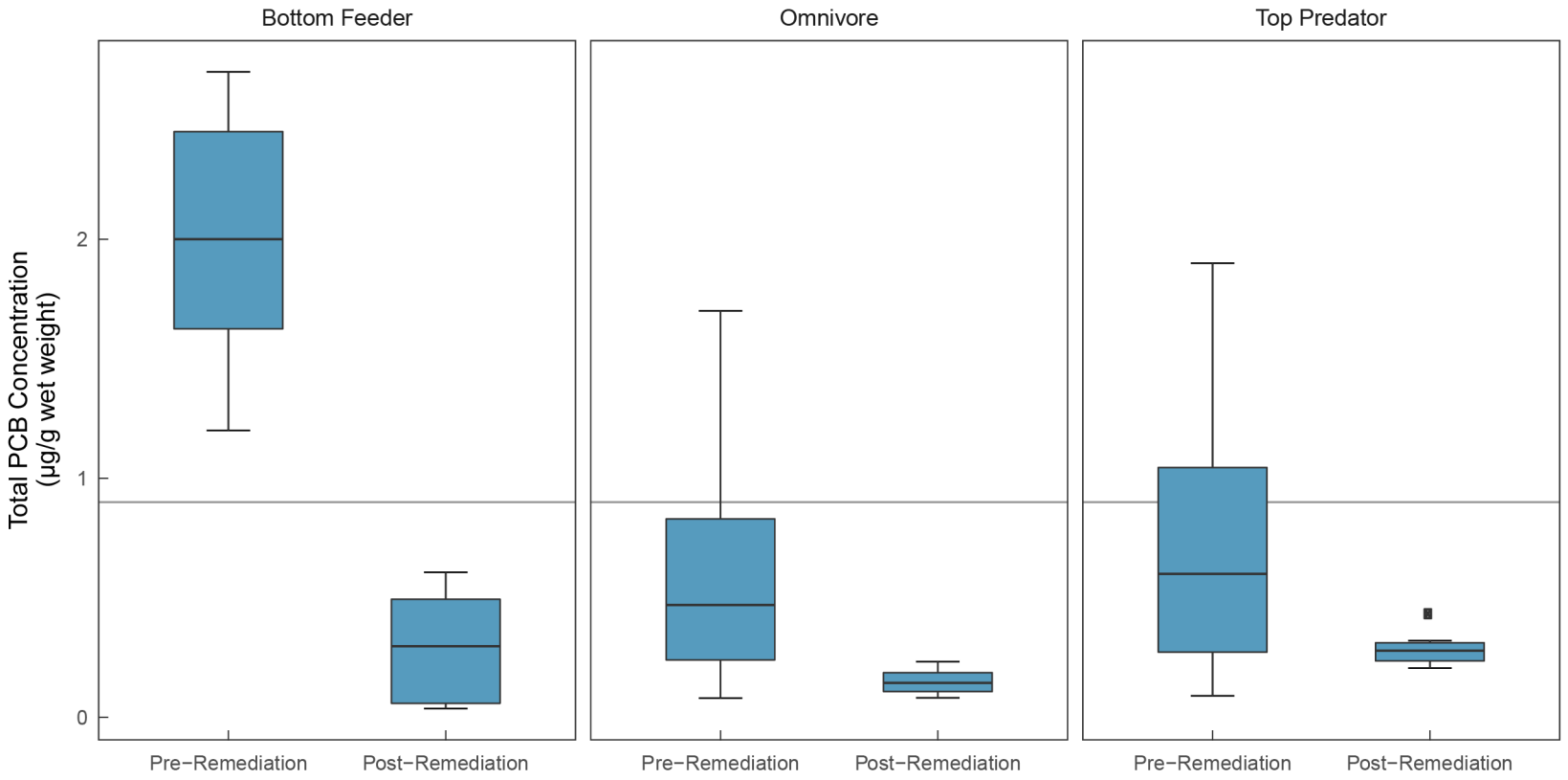
Figure 2a

Location B Comparison of Historical and Post-Remedy PCB Concentrations

Post-Remediation Fish Sampling Data Analysis Report
Neal's Landfill Site



Notes: Of the 53 pre-remediation Location D samples, 49 are individual fish and four are composites. All post-remediation Location D samples are three fish composites (20). Complete pre-remediation data, including source, year, and sample type, are provided in Appendix C of the sampling and data analysis plan. Complete post-remediation data are provided in Appendix B, with a statistical summary provided in Appendix C. Blue boxes correspond to the 25% and 75% quantiles, and the middle line corresponds to the 50% quantile (median). The vertical lines extending up and down from the blue boxes indicate the range of data lying within 1.5 times the interquartile range. Any data outside this range are represented as black dots. Target remediation values are shown as grey lines.

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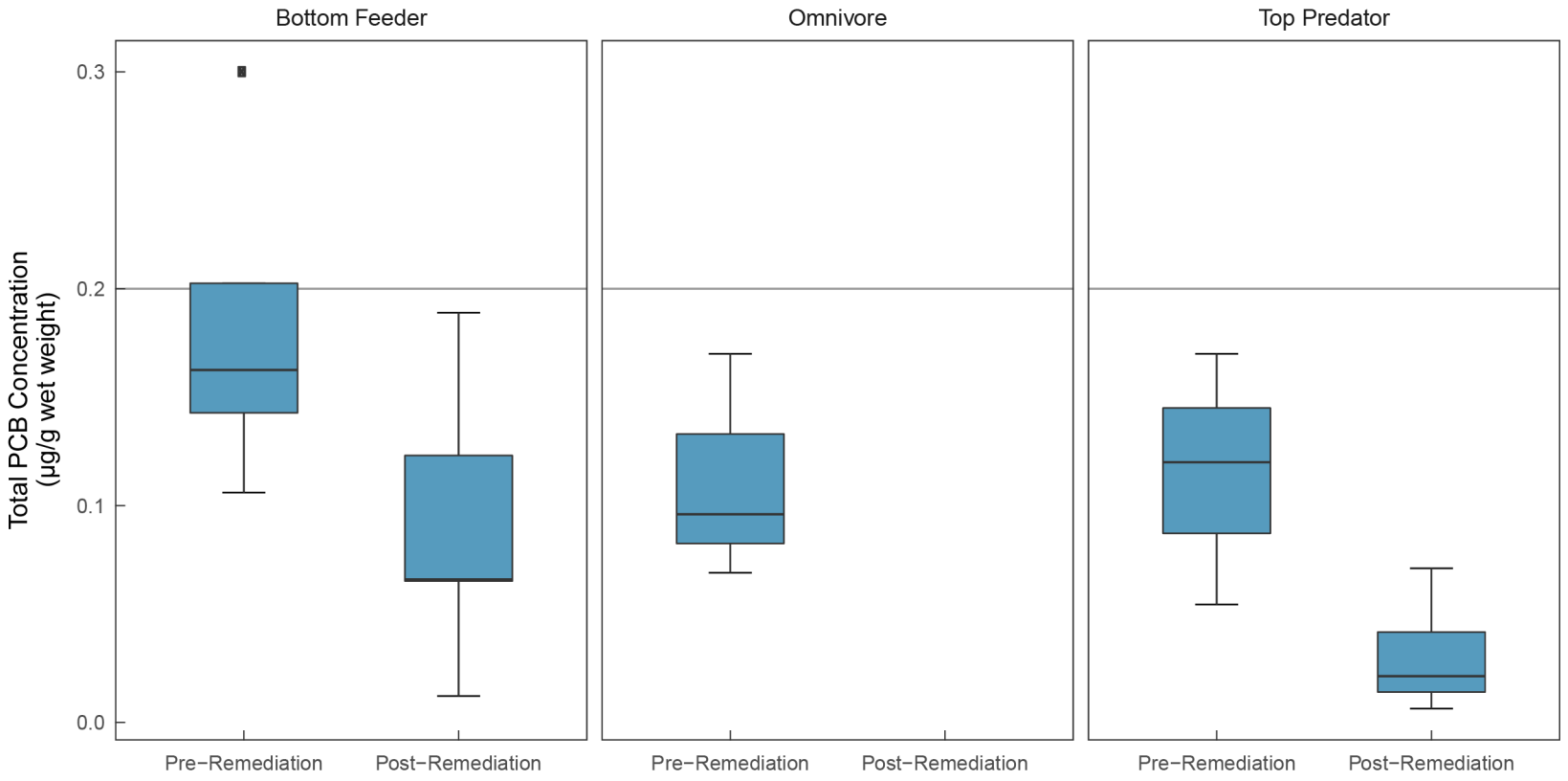
Figure 2b

Location D Comparison of Historical and Post-Remedy PCB Concentrations

Post-Remediation Fish Sampling Data Analysis Report
Neal's Landfill Site



Notes: All pre-remediation Location F samples are individual fish (10). All post-remediation Location F samples are three fish composites (18). Complete pre-remediation data, including source, year, and sample type, are provided in Appendix C of the sampling and data analysis plan. Complete post-remediation data are provided in Appendix B, with a statistical summary provided in Appendix C. Blue boxes correspond to the 25% and 75% quantiles, and the middle line corresponds to the 50% quantile (median). The vertical lines extending up and down from the blue boxes indicate the range of data lying within 1.5 times the interquartile range. Any data outside this range are represented as black dots. Target remediation values are shown as grey lines.

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Figure 2c

Location F Comparison of Historical and Post-Remedy PCB Concentrations

Post-Remediation Fish Sampling Data Analysis Report

Neal's Landfill Site

Appendix A
Sampling and Data Analysis Plan

NEAL'S LANDFILL SITE
POST-REMEDIATION FISH SAMPLING AND DATA ANALYSIS PLAN

Prepared for

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April 2017

NEAL'S LANDFILL SITE
POST-REMEDIATION FISH SAMPLING AND DATA ANALYSIS PLAN

Prepared for

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Pittsburgh, Pennsylvania

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April 2017

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
Anchor QEA	Anchor QEA, LLC
CBS	CBS Corporation
CDA	Consent Decree Amendment
cm	centimeter
DQO	Data Quality Objectives
EPA	U.S. Environmental Protection Agency
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
mg/kg	milligrams per kilogram
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PCB	polychlorinated biphenyl
ppm	parts per million
QAPP	Quality Assurance Project Plan
RCC	Remedy Confirmation Clause
ROD	Record of Decision

1 INTRODUCTION

On behalf of CBS Corporation (CBS), Anchor QEA, LLC (Anchor QEA) has developed this fish sampling and data analysis plan to evaluate the post-remedial changes in fish tissue polychlorinated biphenyl (PCB) levels in Conard's Branch and Richland Creek, adjacent to the Neal's Landfill Site in Bloomington, Indiana. The scope of this sampling effort is based upon the requirements set forth in the Consent Decree Amendment (CDA) issued by the U.S. District Court for the Southern District of Indiana (No. 1:81-cv-0448-RLY-KPF), as well as the guidance issued by the U.S. Environmental Protection Agency (EPA) in its Data Quality Objectives (DQO) guidance document (EPA 2006).

1.1 Background

The CDA provides the basis for evaluating the remedial actions selected by EPA. Additional remediation has included the following:

- Design, construction, and operation of a new element of the spring water collection system, which captures water from springs and seeps located downstream of the historical collection system and conveys this water to the water treatment plant.
- Design and installation of a new effluent line for the water treatment plant. This new effluent line discharges the treated water farther downstream to bypass areas with more significant residual PCBs.
- Cleanup of the PCB-contaminated in-stream sediments, bank soils, and floodplain soils in and along Conard's Branch. The cleanup standard applied was 1 part per million (ppm) for in-stream sediments and banks and 5 ppm for flood plain soils.

Section IX of the CDA (Remedy Confirmation Clause [RCC] for Neal's Landfill; Appendix A) presents the target fish tissue PCB concentrations determined by EPA to be protective of human health and the environment for two locations in Richland Creek and one location in Conard's Branch (Section IX.A.1). The parties to the CDA believe that the remedial actions selected by EPA in the Neal's Landfill Record of Decision (ROD) Amendment for Operable Unit (OU) 2/3 are adequate to achieve the target concentrations within a period of 10 years (or less) from the date of the completion of construction of the Remedial Action (CDA Section IX.A.2; Appendix A). Towards this end, EPA will evaluate the remedy every 5 years after completion of construction to determine whether the mean concentration of PCBs in

fish is statistically greater than or less than the risk-based target concentrations (CDA Section IX.A.4.; Appendix A).

1.2 Objectives

The objective of the fish sampling and data analysis is to determine whether the mean fish tissue PCB concentrations in Conard's Branch and Richland Creek meet the targets set forth in the RCC of the CDA (Section IX.A.1; Appendix A). This document describes the methodology for sampling and data evaluation to perform such a determination.

1.3 Approach

The overall approach to meeting the objective described previously is to collect and analyze fish tissue samples at the three locations specified in the CDA 5 years post-construction. The mean fish tissue PCB concentration of the samples collected at each location will be analyzed using statistical hypothesis testing to determine:

- Whether the mean fish tissue PCB concentrations are significantly less than or greater than target concentrations set forth in the RCC
- Whether the mean fish tissue PCB concentrations are significantly greater than the mean concentrations measured in pre-remedy samples collected in 2003 through 2005

The statistical methodology will be based on the guidelines specified in EPA's DQO guidance document (EPA 2006).

2 SAMPLING PROGRAM DESIGN

2.1 Sampling Locations and Concentration Targets

The CDA requires monitoring at three locations:

- Location B in Conard's Branch upstream of the Vernal Pike Crossing, but not within 1000 feet of the outlet of the new effluent line
- Location D in Richland Creek from a location 200 feet downstream of the confluence with Conard's Branch down to a location approximately one half mile below the Vernal Pike Bridge
- Location F in Richland Creek at the State Route 43 Bridge

These locations are shown on Figure 1. Fish will be collected at these same locations. For Location F, fish sampling will be attempted no more than 100 meters upstream of the bridge before moving downstream (if insufficient fish are available upstream) within 100 meters to be consistent with the sampling practices used during the historical sampling events.

The target PCB concentrations in fish at these locations, as determined by EPA, are shown in Table 1 (CDA Section IX.A.1).

Table 1
Locations for Fish Sampling and Target Concentrations

Location	Target Concentration
B	2.3 mg/kg wet (whole body)
D	0.9 mg/kg wet (whole body)
F	0.2 mg/kg wet (fillet)

Note:
mg/kg - milligrams per kilogram

2.2 Frequency and Timing

The CDA states that the data collection should be "balanced" to include an equal number of samples from spring and fall periods (Section IX.H.5), and it allows for calculation of averages from data collected over 1 or 2 years (Section IX.H.5). In order to limit the possibility of significantly affecting the size of the population of fish in Conard's Branch, sampling will be

performed over spring and fall periods in year 5 post-construction (discussed further in the following subsections).

2.3 Fish Species and Size Requirements

The fish species that have been collected historically have been grouped into top predators, omnivores, and bottom feeders, as shown in Table 2.

Table 2

Fish Species Groupings

Species	Grouping
Sunfish	Top Predators
Rock Bass	
Smallmouth Bass	
Creek Chubs	Omnivore
Golden Redhorse	Bottom Feeders
Northern Hogsucker	
White Suckers	

The CDA sets forth a specific mix of these groups that is to be included in the calculation of average PCB concentration for each location (Table 3; CDA Section IX.A.3). As per the requirements of the CDA, fish from each group will be selected to be representative of the sizes at each location. "Representative" has been defined in the CDA as samples having lengths within one standard deviation of the mean from the corresponding species, based on the data collected historically by CBS and/or EPA at that location (CDA Section IX.H.4).

As stated in the CDA Section IX.H.2, prior to laboratory analysis, composite samples will be prepared. Each composite sample will include not less than three individual fish of the same species or feeding guild for each of the groups listed in Table 3. For example, a composite sample of top predator will have at least three individual top predators. Fish samples will be analyzed for total PCB congeners; tissue samples will be prepared as whole body samples at locations B and D and as fillets at Location F (see Table 1; Section IX.A.1 in CDA).

Table 3

Proportional Contribution of Different Fish Populations to the Overall Sample

Location	Population/Group Breakdown
B	50% creek chub and 50% green sunfish, or 100% creek chub (if insufficient sunfish available). Note 100% creek chubs will be targeted.
D	Equal proportions of top predators, omnivores, and bottom feeders
F	75% top predators, 25% bottom feeders

2.4 Sample Size Requirements

2.4.1 Requirements Set Forth in the Consent Decree

The CDA requires evaluation of progress towards achieving the target fish tissue PCB concentrations through statistical hypothesis testing (Section IX.C.1; Appendix A) based on fish samples collected from the locations in Table 1 (Section IX.A.3; Appendix A). To demonstrate the success of the remedy, CBS is required to test whether there is a statistically significant decline in fish tissue PCB concentrations at all three sampling locations. The null and alternative hypotheses for this test are described in Sections IX.C.2 of the CDA (Appendix A). To demonstrate that the remedy is not successful, EPA is required to determine through hypothesis testing that the fish tissue PCB concentration at any given location is greater than the target concentration, and that the mean fish tissue PCB concentration at that location has shown no improvement relative to the pre-remedy data collected between 2003 and 2005 at the same location (CDA Section IX.D.1; Appendix A). The 2003 to 2005 pre-remedy sampling events are listed in Table 4. The null and alternative hypotheses for these tests are described in CDA Sections IX.D.1.a.i and IX.D.1.a.ii (Appendix A), respectively.

For the test performed by CBS (CDA Section IX.C.1; Appendix A), a false positive is an incorrect conclusion that the fish tissue PCB concentrations are below the target when additional data would have revealed that not to be the case. Similarly, for the tests performed by EPA (CDA Section IX.D.1.a.i and IX.D.1.a.ii; Appendix A), false positives are conclusions that post-remedial fish tissue PCB concentration is greater than the target at a location, and that the post-remedy average fish PCB concentration has shown no

improvement relative to the pre-remedy data when, in fact, additional post-remedy data would have revealed the opposite. The CDA requires collection of a sufficient number of samples to minimize the risk of false positives. For the comparison of post-remediation data with the target concentrations, the CDA specifies the following conditions for determining sample sizes (CDA Sections IX.C.4 and IX.D.1.b; Appendix A):

- The probability of a false positive conclusion (i.e., incorrectly rejecting the null hypothesis [see Section 4.2.1], represented by the parameter α), should be less than 5 percent.
- The width of the gray region (i.e., the region where there is a high probability of a false positive or a false negative) shall be set equal to 20 percent of the target concentrations determined by EPA (Table 1).
- The probability of a false negative conclusion (i.e., incorrectly accepting the null hypothesis, represented by the parameter β) shall be set at 20 percent.

For comparisons of post-construction and pre-construction mean concentrations, the CDA specifies the following (CDA Section IX.D.1.c; Appendix A):

- The probability of a false positive conclusion (i.e., incorrectly rejecting the null hypothesis, represented by the parameter α), should be less than 5 percent.
- The gray region (i.e., the region where there is a high probability of a false positive or a false negative) shall extend from a value equal to 20 percent of the mean of the pre-remedial concentration to zero (corresponding to the case that there is no difference between the pre- and post-construction means).
- The probability of false negative conclusion (i.e., incorrectly accepting the null hypothesis, represented by the parameter β) shall be set at 20 percent.

2.4.2 Determination of Sample Sizes

The EPA DQO guidance document (EPA 2006) provides an equation for estimating sample sizes by assuming a normal distribution for the underlying population[1]:

[1] This equation assumes that the post-remedial standard deviation is known, which is not true (as discussed in the subsequent sections, only an estimate is available). A more appropriate equation would use the percentiles of the student-t distribution. However, since the student-t distribution also depends on the sample size (i.e. the left-hand side of the equation) it is not possible to solve the equation using student-t percentiles. Hence, the z-percentiles have been used as an approximation.

$$n = \left[\frac{(z_{1-\alpha}+z_{1-\beta})\sigma}{d}\right]^2 + \frac{z_{1-\alpha}^2}{2} \quad (1)$$

where:

$z_{1-\alpha}$; $z_{1-\beta}$	=	the standard normal percentiles corresponding to the probabilities of not causing Type I and Type II errors, respectively
d	=	the width of the gray region (in this case, 20 percent of the target concentrations at each location)
σ	=	the post-remedial standard deviation
n	=	estimated sample size assuming a normal distribution

The post-remedial standard deviation is not known *a priori*, and therefore has to be estimated. For the purpose of estimating sample sizes at each location, the CDA recommends the use of pre-remedial data collected by CBS and EPA from 2003 through 2005 (CDA Section IX.D.1.a.iii; Appendix A). Table 4 shows the pre-remedial sampling events. Table 5 summarizes the sample counts of the pre-remediation data collected at each location from 2003 through 2005. The pre-remediation data consist predominantly of individual fish samples with only a few composites for each group. At Location B, only creek chub (an omnivore) was collected. At locations D and F, all required groups were collected, albeit in proportions that were different from those specified in Table 3 for post-remediation sampling. Furthermore, at Location F, most data were analyzed for total PCB Aroclors rather than total PCB congeners. Therefore, the Aroclor and congener data were combined for this analysis at Location F.

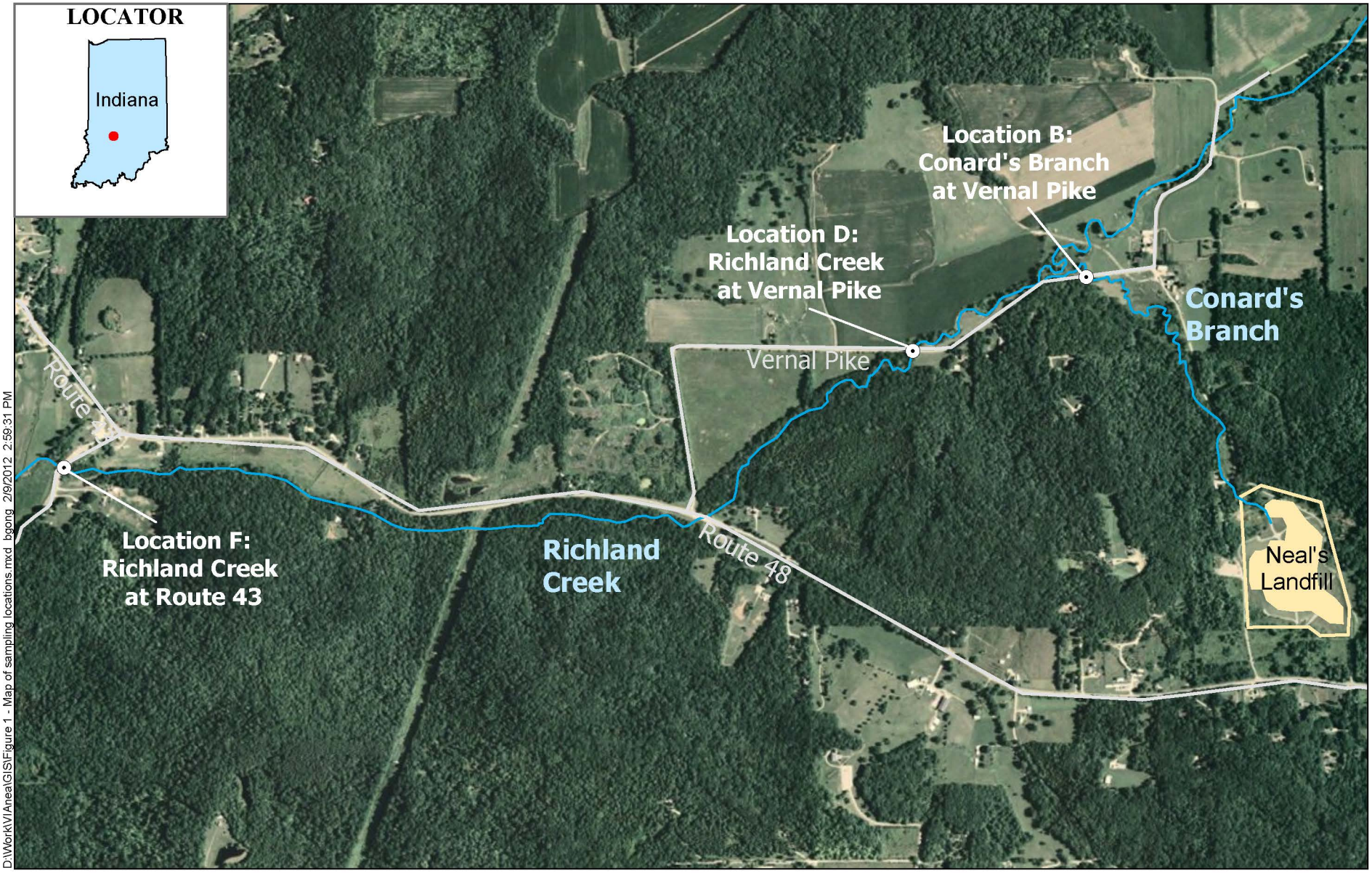

Figure 1
Map of Sampling Locations
Neal's Landfill Post-Remediation Fish Sampling Plan
Neal's Landfill Monitoring Program

Table 4

Pre-Remedial Sampling Events Completed Between 2003 and 2005

Location	Events
B	May and November 2003; November 2005
D	May and November 2003; September 2004; November 2005
F	June 2004

Table 5

Sample Counts in Pre-Remedial Data Collected from 2003 through 2005

Group	Location B		Location D		Location F	
	Individuals	Composites	Individuals	Composites	Individuals	Composites
Top Predators	0	0	20	2	3	0
Omnivores	22	3	24	1	3	0
Bottom Feeders	0	0	5	1	4	0

Notes:
Duplicates were averaged and are represented as a single measurement in the counts.
For locations B and D, only fish data reported on a whole body basis were included; for Location F, only fish data reported on fillet basis were included.
The reported numbers of individuals in each composite range from 2 to 7. Numbers were not reported for a few composites.

Scatter plots of the annual average versus the annual standard deviation of the fish tissue total PCB concentrations were developed. For this plot, a paired average and standard deviation were calculated for each species, for both Locations B and D[2], and for each year within the period 2001 through 2005 (Figure 2). For the purposes of this calculation, no distinction was made between individual and composite fish in their contribution to the average and standard deviation. Figure 2 shows that the standard deviation of fish PCB concentration is correlated with the annual average at both locations B and D. This suggests that as PCB concentrations decline post-remedy, the standard deviation will decline as well.

The post-remediation standard deviation (S_{post}) of each target population mix was estimated from the projected post-remediation mean concentration ($\hat{\bar{X}}_{post}$) for each species (which was

[2] At Location F, this calculation was not possible due an insufficient number of samples (less than three) from each species within each year.

estimated using the mechanistic modeling of PCB fate, transport, and bioaccumulation [QEA 2007]), and the mean ($\bar{X}_{pre}$) and standard deviation (S_{pre}) of the pre-remediation population mix as follows:

$$S_{post} = S_{pre} \frac{\hat{\bar{X}}_{post}}{\bar{X}_{pre}} \quad (2)$$

This analysis is based on the assumption that the coefficient of variation (equal to the standard deviation divided by the mean) will remain relatively constant over time. This is supported by the data at Location D, which exhibit a linear relationship with intercept near zero. $\bar{X}_{pre}$ and S_{pre} were estimated from a bootstrap analysis of the 2003 through 2005 data, described as follows.

The CDA requires analysis of composite samples. To determine the appropriate mean ($\bar{X}_{pre}$) and standard deviation (S_{pre}) from the pre-remediation data set, a procedure was developed to combine individual samples from the pre-remediation data to form "pseudo-composites," from which the mean and standard deviation were estimated. The pseudo-composites were formed by randomly selecting with replacement from the available pool of data (a statistical procedure called bootstrapping). The CDA requires the use of three or more fish per composite in the post-remedial sampling. Hence, the pseudo-composite samples were generated by including three fish per composite. Historical samples that were reported as composites were used as such without combining with individual fish. Thus, the total number of pseudo-composite samples that can be generated from the data is equal to one third of the number of individual samples plus the number of composites. At Location B, the total number of pseudo-composites that can be generated from the number of samples in Table 5 is ten (seven from individual fish plus three composites).

For locations D and F, an additional level of complexity in the bootstrapping procedure was necessary to accommodate the proportions of each species group required by the CDA (Table 3). The bootstrap samples were generated by repeatedly resampling with replacement from the pre-remediation dataset, performed separately for predators, bottom feeders, and omnivores (each such sample is referred to as a bootstrap realization). The algorithms used for the bootstrapping procedure at Location B, and locations D and F are described further in

Appendix B. The fish tissue data that were used in the bootstrapping analysis are shown in Appendix C. The distributions of the mean and standard deviation at each location estimated from the bootstrap simulations are shown in Appendix D. The pre- and post-remediation means and standard deviations are summarized by location in Table 6.

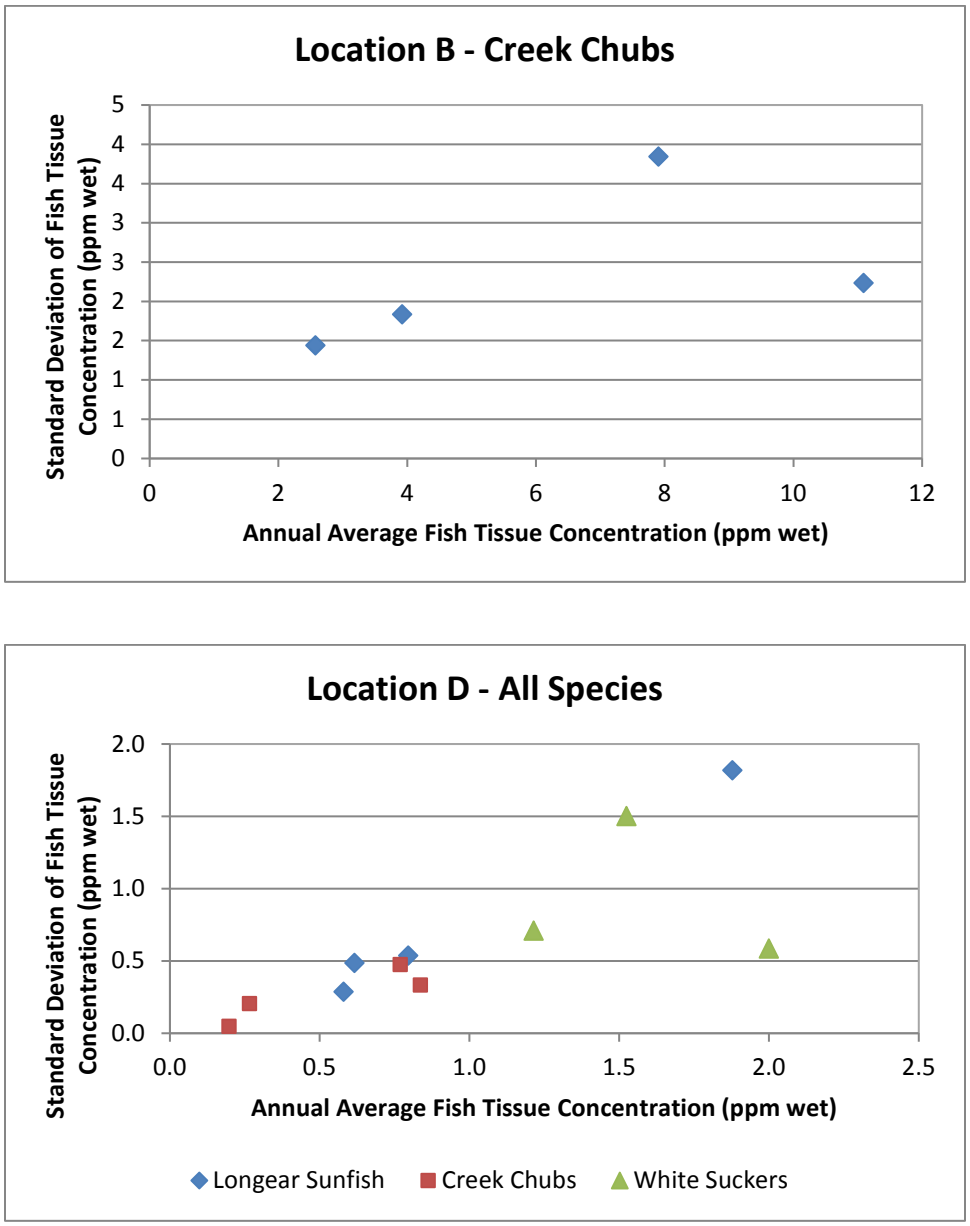

Figure 2

Relationship between the Annual Average and Annual Standard Deviation of the Fish Tissue PCB Concentration Exhibited in the Historical Data

The average standard deviation from Table 6 was used in Equation 1 to derive the post-remediation sample size; the estimated minimum sample sizes required at each location that meet the risk tolerance parameters specified in the CDA are shown in Table 7. To illustrate the calculation, the required number of omnivore samples at Location B is calculated as follows (rounded up to the nearest integer):

$$18 = \left[\frac{(-1.64-0.84)*0.74}{0.2*2.3}\right]^2 + \frac{(-1.64)^2}{2} \quad (3)$$

At Location F, a model estimate of the post-remediation concentration was not available. Hence, the pre-remediation standard deviation (from Table 5) was used in estimating the sample size.

The CDA requires that the fish collected be comparable in size to the pre-remedy data (CDA Section IX.H.4; Appendix A); because no top predators (specifically, sunfish) were collected pre-remedy between 2003 to 2005 at Location B, it is not possible to obtain a reference sample size for post-remedial sampling events for sunfish. Therefore, at Location B, only omnivores (Creek Chubs) are proposed. Moreover, the CDA allows for collection of 100 percent omnivores if insufficient top predators (sunfish) are available (see Table 3). For Location D, equal proportions of top predators, omnivores, and bottom feeders are proposed consistent with the CDA requirements described in Table 3 (33 1/3 percent each). For Location F, the top predators and bottom feeders are split 75 to 25 percent (12 top predators and 4 bottom feeders) consistent with the CDA requirements described in Table 3.

The calculated number of composite samples estimated for locations B, D, and F will require collection of 54, 54, and 48 individual fish, respectively. From 2003 through 2005, 35, 75, and 8 of the appropriate fish species were collected at locations B, D, and F, respectively, including duplicates and individual fish that were used in composites. During the 2005 fish data collection effort, Normandeau Associates (2006) reported fish densities in the vicinity of Location D for every 100-meter reach of the channel as approximately 59 top predators (fish groups listed in Table 2), 359 omnivores (creek chub and bluntnose minnow) and 16 bottom feeders (white suckers). Based on these results, it may be possible to catch the number of fish specified in Table 7 (note that Table 7 provides the number of composites; the number of fish is three times these amounts). Populations at locations B and F are not known; however,

based on stream characteristics, it is anticipated that there will be fewer fish in Conard's Branch (Location B) and more fish in Richland Creek at Route 43 Bridge (Location F) relative to Location D.

Table 6
Estimated Pre- and Post-Remediation Mean and Standard Deviation

	Pre-Remediation		Post-Remediation	
Location	Mean	Standard Deviation	Mean	Standard Deviation
B	6.34	2.95	1.58	0.74
D	1.09	0.73	0.41	0.28
F	0.13	0.06	--	--

Notes:
Pre-remediation mean and standard deviation estimated from bootstrap analysis (see Figure D-1 in Appendix D).
Post-remediation mean estimated from mechanistic modeling (QEA 2007).
Post-remediation standard deviation estimated from Equation 2.
For Location F, an estimate of post-remediation mean and standard deviation was not available from mechanistic modeling.

Table 7
Number of Post-Remedial Fish Sample Composites Required to Meet Risk Tolerance Criteria in Consent Decree

Location	Top Predators	Omnivores	Bottom Feeders	Total
B	0	18	0	18
D	6	6	6	18
F	12	0	4	16

Note:
Because each sample is a composite of three or more fish within each group, the total number of individual fish for each group is three times the values in the table.

At all three locations, two sampling events will be conducted in Year 5 (i.e., 2017): one in spring and one fall, targeting approximately half the number of fish in Table 6 during each event. At the first event, even if the targeted number of fish cannot be collected, extraordinary collection efforts will not be employed in order to minimize the effect on the population as a whole. If, within a couple of days fishing effort, the targeted numbers of fish

are not collected, fishing effort will nonetheless cease. Fishing effort will be recorded in field notes. During the second event, additional effort will be employed if the overall total target is not reached. Such effort may include sampling within a wider reach of Richland Creek. The target ranges for collections are as follows:

- Location B: in Conard's Branch from 1,000 feet downstream of the outlet of the new effluent line down to just upstream of the Vernal Pike culvert
- Location D: in Richland Creek from a location 200 feet downstream of the confluence with Conard's Branch down to a location approximately one half mile below the Vernal Pike Bridge
- Location F: in Richland Creek 100 meters upstream of the SR43 bridge to 100 meters downstream of the State Route 43 Bridge, with initial sampling targeting areas upstream of the bridge

Table 7 contains the minimum targeted sample numbers. Upon collecting the minimum number of samples in Table 7, if the fish population in the Conard's Branch and Richland Creek is sufficiently abundant, additional samples may be collected.

2.4.3 Targeted Body Sizes

As described in Section 2.3, the body size will be within one standard deviation of the average size for the respective group collected from 2003 through 2005 (Table 8). In the event that sufficient numbers of fish in this size range are not available, then the ranges will be expanded: fish within 2 standard deviations of the historical average size will be collected, with the goal of collecting equal numbers above and below the average size. Both weight and length are to be evaluated, but weight is to provide the overriding criterion.

Table 8

Fish Length and Biomass Range for Post-Remedial Sampling

Location	Feeding Guild	Fish Species	Fish Length (in Centimeters)[1,3]			Weight (in grams)		
			Average	Standard Deviation	Size Range for Post Remedial Sampling	Average	Standard Deviation	Size Range for Post Remedial Sampling
B	Omnivore	Creek Chubs	13.1	1.3	11.8 – 14.4	23.7	5.7	18.0 – 29.4
D	Top Predator	Longear Sunfish	11.4	1.0	10.4 – 12.4	29.3	8.3	21.0 – 37.6
		Rock Bass	16.7	1.8	14.9 – 18.5	88.5	23.3	65.2 – 111.8
	Omnivore	Creek Chubs[2]	16.1	1.8	14.3 – 17.9	49.5	22.7	26.8 – 72.2
	Bottom Feeder	White Sucker	17.4	2.2	15.2 – 19.6	60.4	19.7	40.7 – 80.1
F[4]	Top Predator	Rock Bass	17.9	2.1	15.8 – 20.0	119.0	33.9	85.1 – 152.9
		Small Mouth Bass	28.9	NA	NA	335.0	NA	NA
	Omnivore	Creek Chubs	19.0	1.6	17.4 – 20.6	83.3	17.2	66.1 – 100.5
	Bottom Feeder	Hogsucker	26.6	0.6	26.0 – 27.2	207.5	16.3	191.2 – 223.8
		Golden Redhorse	31.9	0	31.9	391.0	0	391.0
		White Sucker	24.6	NA	NA	163.0	NA	NA

Notes:

1. Average and standard deviation of fish lengths and biomass values estimated from only those samples for which a fish tissue concentration was analyzed.
2. Three samples at Location D were missing length data and were not included for calculating statistics of lengths at Location D.
3. Data for 2003-2005 was used.
4. For location F only sample for which concentrations reported for filets were included.

NA – Not Available

3 SAMPLE COLLECTION AND ANALYTICAL METHODOLOGY

3.1 Fish Sampling Collection Procedures

The field collection will use the same procedures that were used in the 2005 sampling event (Normandeau Associates 2006). Lengths and weights will be measured and recorded in the field for each individual fish collected. Individual fish that meet the size requirements (as per Table 8) will be grouped in the field for each target population for homogenizing in the laboratory.

3.2 Laboratory Analysis

Field samples will be homogenized in the lab prior to analysis. As required by the CDA, the fish samples will be analyzed using the same total congener and lipid methods as were used in 2005. Ideally, the same analytical laboratory will be used, to eliminate uncertainties associated with inter-laboratory comparisons. As before, the information reported by the lab will include length, weight, lipid content, and sex of the fish analyzed.

3.3 Quality Assurance/Quality Control

The Quality Assurance Project Plan (QAPP) developed for the 2005 program will be used (Viacom 2005).

3.4 Health and Safety

The Health and Safety Plan (HASP) developed for the 2005 program will be used.

4 DATA EVALUATION PLAN

4.1 Overall Approach

The CDA calls for the comparison of fish tissue total PCB concentrations with target concentrations and with pre-construction concentrations. At locations B and D, the concentration on a whole body wet weight basis will be used for comparison to the target, and at Location F, the concentration on a fillet wet weight basis will be used.

4.2 Methodology

4.2.1 Comparison to Target Concentrations

The CDA requires the use of standard statistical hypothesis testing methods as laid out in the CDA and EPA's DQO guidance document (EPA 2006). At each location, the following hypotheses will be evaluated. First, following CDA Section IX.C.2.:

H_0: Average PCB concentration >= Target
Ha: Average concentration < Target (burden of proof)

Second, following CDA Section IX.D.1.a:

H_0: Average PCB concentration <= Target
Ha: Average concentration > Target (burden of proof)

The first test will be performed at all three locations. If the null hypothesis is rejected at all locations, then, as per CDA Section IX.C.2, CBS will have demonstrated that the remedy has been successful. In this case, the second test will not be necessary for any locations. Furthermore, as per CDA Section IX.C.3, for a location in Richland Creek (i.e., sample Location D or F), if the null hypothesis is rejected, then CBS shall be relieved of its obligation to implement the sampling plan for enhanced monitoring at that location, and the second test will not be conducted at that location.

The simplest statistical approach would involve standard statistical hypothesis testing. The decision to perform a parametric (t-test or z-test) or non-parametric test will be based on a characterization of the distribution of samples collected.

The spring and fall samples will be combined to produce one average concentration that will be compared with the target concentration. If a t-test or similar is used, then the pooled variance will be used for this comparison. For equal variances and equal sample sizes in spring and fall, the pooled variance will be calculated as follows:

$$\mathrm{VAR}(\overline{Z}) = \frac{s_X^2 + s_Y^2}{4n} \quad (4)$$

where:

X	=	concentration in spring samples (mg/kg)
Y	=	concentration in fall samples (mg/kg)
Z	=	calculated concentration in combined spring and fall samples (mg/kg)
s_X^2	=	sample variance of the spring samples
s_Y^2	=	sample variance of the fall samples
$\mathrm{VAR}(\overline{Z})$	=	variance of the mean composite concentrations
n	=	sample size (assumed in this equation to be the same for spring and fall)

This formula will be adjusted as appropriate for unequal variances and sample sizes in spring and fall. The variance will then be used to calculate the standard error of the mean for use in hypothesis testing.

In the unlikely event that actual numbers of samples collected are relatively small then it may be difficult to estimate population variance. Furthermore, the distribution of species groups (predator, omnivore, bottom feeders) would be unlikely to match the requirements of Table 3 exactly, in which case a significant number of samples may not be usable. (If, for example, there are 10, 10, and 3 fish of each type collected at Location D, one could only combine the data into one composite of three fish for each group to achieve the 33 percent/33 percent/33 percent requirements in Table 3: the remaining seven predators and seven omnivores could not be used.) The CDA allows CBS to propose an alternative

methodology for evaluation of post-remedial concentrations against the target concentrations set forth in the CDA (Section IX.H.3; Appendix A). The fundamental hypothesis tested will remain the same, although in the alternative methodology bootstrap methods will be considered. The bootstrap methodology would be particularly useful if the distribution of species in the collections is very different from the distributions presented in the CDA (Table 3). A bootstrap approach would permit the use of the entire data set in such a circumstance.

A bootstrap analysis might proceed as follows. At each location, the 95th percentile of the population mean would be estimated from the available data as follows:

- **Step 1.** Resample with replacement from available data to produce a bootstrap realization. Use the proportion of top predators, omnivores, and bottom-feeders as specified in the CDA.
- **Step 2.** Estimate mean of the bootstrapped sample. This provides one bootstrap estimate of the population mean.
- **Step 3.** Repeat steps 1 and 2 a large number of times (1,000 to 5,000 times, depending on when the variance of the bootstrap simulations stabilizes).
- **Step 4.** Estimate the 95th percentile of the bootstrap distribution of the mean. This provides an upper bound cutoff value for the population mean.
- **Step 5.** One approach would be to then compare the target concentration with the 95th percentiles: if the target concentration lies outside the 95th percentiles, one would conclude that the post-construction data differ significantly from the target value.

The procedure described above provides a 5 percent probability of Type I error, as required in the CDA. The proposed method is non-parametric and is robust to non-normal distribution of the underlying population. Other variants of bootstrapping (e.g., the Bias Corrected Accelerated bootstrap confidence interval [Efron 1981]) may be considered as well.

Because the most appropriate approach depends on the details of the data, the final statistical approach will be determined once the data are available in consultation with EPA.

4.2.2 Comparison to Historical Fish Tissue Concentrations

For each sampling location where the mean concentrations of PCBs in fish cannot be statistically proven to be less than the target value, the CDA calls for the use of statistical hypothesis testing to determine whether there has been an improvement in the mean concentration of PCBs in fish in comparison to pre-remedy data (Section IX.D.1.a.ii; Appendix A). The tests will be setup as follows:

Ho: Average concentration from current sampling <= pre-remedy average
Ha: Average concentration from current sampling > pre-remedy average

In the event that this test is significant with 95 percent confidence (i.e., the mean concentration of PCBs is greater than the pre-remediation mean) for at least one sample location, it will be concluded that the remedy has not and will not achieve the target concentrations for fish as set forth in Paragraph IX.A.1 of the CDA.

For the purposes of these tests, the CDA requires that the probability of Type I error (α) be set to 0.05 (i.e., 5 percent).

As discussed in Section 2, only a limited number of historical samples are available for statistical hypothesis testing, and the distribution of species does not match the requirements laid out in the CDA. Furthermore, as discussed in Section 4.2.1, the number of post-remedial samples collected in future sampling events could face the same limitations. Therefore, following the reasoning discussed in Section 4.2.1, applicability of classical hypothesis testing may be limited.

An alternative approach based on bootstrapping, similar to the one discussed previously, is proposed for comparison to historical data. The procedure for implementing this test is discussed below:

- **Step 1.** Resample from the post-remedial and pre-remedial samples. Preserve the proportions of each subgroup as set forth in the CDA.
- **Step 2.** Compute the mean and the standard deviation for the two resamples.
- **Step 3.** Repeat steps 1 and 2 5,000 times, and construct histograms of bootstrap

estimates of mean for the pre- and post-remedial simulations.

- **Step 4.** Calculate the standard deviations of the bootstrap pre- and post-construction realizations. This represents the standard error of the data and can be used to perform a standard two sample t-test. If the p-value of this test is lower than 5 percent, then reject the null-hypothesis.

This is one approach to bootstrap testing; alternative approaches, such as using the bias correction will be considered as well.

Because the most appropriate approach depends on the details of the data, the final statistical approach will be determined, in consultation with EPA, once the data are available.

4.3 Presentation of Results

Results from statistical tests will be presented in a tabular format (e.g., p-values and inference from statistical hypothesis tests). In addition, graphical comparisons to historical (2003 through 2005) values along with the target concentrations will be presented.

5 PROJECT ORGANIZATION AND SCHEDULE

5.1 Project Management

CBS will be responsible for overall project management for the sampling program and will be the primary interface between regulatory agency personnel and the contractors performing the work described in this field sampling program.

The Contractor that will perform the field sampling will be selected as the start of the sampling events approaches. The Field Sampling Manager will monitor the progress of sampling tasks, regularly review the project schedule, and will serve as the primary contact with CBS for sampling activities and health and safety issues. The Field Sampling Manager will have full responsibility for executing and administering the project health and safety programs and will have the required Occupational Safety and Health Administration (OSHA) 40-hour Hazardous Waste Operations (HAZWOPER) training (29 CFR 1910.120) and the additional 8-hour HAZWOPER supervisor training.

Anchor QEA will provide field sampling oversight and technical assistance to the field sampling team.

EPA will provide field oversight as well.

5.2 Project Schedule

Field mobilization and general preparations for field sampling will commence after approval to proceed is received from the government parties. Two sampling events are anticipated: in spring and fall of year 5 post-construction (i.e., 2017).

A draft report of the analysis will be provided 90 days following receipt of the validated laboratory data.

In the event that the data are inconclusive, then, as per CDA Section IX.E (Appendix A), CBS is required to continue enhanced monitoring in Year 10, and if necessary, in Year 15. Should additional sampling become necessary, a revised sampling plan will be submitted to EPA.

The revised sampling will use data collected during the first 5-year period to adjust, if necessary, the approach employed, including the locations and number of samples collected.

6 REFERENCES

Efron, B., 1981. Nonparametric standard errors and confidence intervals. *Canadian Journal of Statistics*, 9: 139–158.

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Normandeau Associates, Inc. 2006. Fish Tissue Sampling and Lipid Analysis at Conard's Branch and Richland Creek near Neal's Landfill: Fall 2005. Letter submitted to Russ Cepko, CBS on February 22, 2006.

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APPENDIX A
CONSENT DECREE AMENDMENT
SECTION IX

IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF INDIANA
INDIANAPOLIS DIVISION

UNITED STATES OF AMERICA, et al., Plaintiffs, v. CBS CORPORATION, f/k/a, VIACOM INC., f/k/a CBS CORPORATION, f/k/a WESTINGHOUSE ELECTRIC CORPORATION, et al., Defendant. THE CITY OF BLOOMINGTON, INDIANA, et al., Plaintiffs, v. CBS CORPORATION, f/k/a, VIACOM INC., f/k/a CBS CORPORATION, f/k/a WESTINGHOUSE ELECTRIC CORPORATION, et al., Defendant.	Cause No. 1:81-cv-0448-RLY-KPF JUDGE RICHARD L. YOUNG MAGISTRATE JUDGE KENNARD P. FOSTER

AGREED AMENDMENT TO THE CONSENT DECREE PROVIDING FOR REMEDIAL ACTIONS AT NEAL'S LANDFILL LEMON LANE LANDFILL, AND BENNETT'S DUMP AND ADDRESSING GENERAL MATTERS

law or under this Consent Decree against the Hazardous Substances Response Trust Fund (established pursuant to the Internal Revenue Code, 26 U.S.C. § 9507), for or arising from any activity performed or expenses accrued pursuant to this litigation or under this Consent Decree, provided, however, that U.S. EPA hereby approves the Work which CBS is required to take pursuant to this Consent Decree as consistent with the National Contingency Plan for the purpose of allowing CBS to assert against any other person (other than Parties to this Consent Decree) any claim with respect to hazardous waste generated by that person.

3. Except as set forth in Paragraph IV.B.2.d and IV.B.2.f, CBS agrees not to assert any claims or demands for compensation or payment under CERCLA Sections 107 or 113 or any other provision of law against the United States for or arising from any activity performed or expenses accrued pursuant to this litigation or under this Consent Decree.

4. Nothing in this Paragraph VIII.E shall impair the obligation of the United States to fully pay in the event that the Court determines that the United States is liable to CBS for breach of the warranty provided by the United States in Paragraph IV.B.2.d.

IX. REMEDY CONFIRMATION CLAUSE FOR NEAL'S LANDFILL

A. General

1. The remedy selected by U.S. EPA in the Neal's Landfill ROD Amendment for OU2/3 is intended to reduce PCB concentrations in fish in Conard's Branch to "target" concentrations, which U.S. EPA has determined to be protective of

human health and the environment. These target concentrations are set forth in Table 1 below.

Table 1

Target PCB Concentration to Protect Ecological Receptors	
Sampling Location (1)	**Target Mean PCB Concentration in Whole Fish (mg/kg Wet Basis)**
Location B – lower reach of Conard's Branch above Vernal Pike Bridge	2.3
Location D – Richland Creek at the Vernal Pike Bridge	0.9
Target PCB Concentration to Protect Human Receptors	
Sampling Location (1)	**Target Mean PCB Concentration in Fillets (mg/kg Wet Basis)**
Location F – Richland Creek at State Route 43 Bridge in Owen County	0.2

(1) "B","D", and "F" refer to fish sampling locations as previously designated and utilized in 2001 - 2005 sampling

2. The Parties believe that the remedial actions selected by U.S. EPA in the Neal's Landfill ROD Amendment for OU2/3 (hereinafter, for the purposes of this Section, "the remedy") are adequate to achieve the above target concentrations in a period of 10 years (or less) from the date of the completion of construction of the Remedial Action to address PCB contamination in groundwater, surface water and sediment at Neal's Landfill. The purpose of this Section IX Remedy Confirmation Clause ("RCC") is to provide a process (subject to conditions set forth in Paragraphs IX.F and IX.G below) for U.S. EPA to modify the remedy for groundwater, surface water, and sediment contamination if U.S. EPA concludes, based upon criteria set forth in Paragraph IX.D, that the remedy has not achieved and will not achieve the target concentrations in fish.

3. To measure progress toward achieving the target concentrations for PCBs in fish, CBS shall collect fish samples from the sampling locations in Table 1 above (*i.e.* locations B, D and F) in accordance with a Sampling Plan approved by U.S. EPA under Paragraph IX.H below. The Parties shall use these fish samples to determine the mean concentration of PCBs in fish at each sampling location, and then the Parties shall use this mean concentration to measure progress toward achieving the target concentrations for PCBs in fish. For the purpose of this RCC, the term "mean concentration of PCBs in fish" shall refer to a simple arithmetic mean of fish tissue PCB concentrations at each sample location based upon the sample mixes set forth in the chart below. CBS shall continue to perform fish monitoring in accordance with the approved Sampling Plan until (1) CBS demonstrates statistically, in accordance with the methodology set forth in Paragraphs IX.B and IX.C below, that the mean concentration of PCBs in fish at each sample location is equal to or less than the pertinent target concentration, or (2) U.S. EPA modifies the remedy in accordance with the procedures set forth under this RCC, in which case CBS's further monitoring obligations shall be determined consistent with the modified remedial action.

Population of Fish Sampled to Measure Progress Toward Achieving Target Concentrations in Fish Protective of Ecological Receptors	
Sampling Location	**Sample Mix**
Location B – lower reach of Conard's Branch above Vernal Pike Bridge	50% Creek Chub 50% Green Sunfish, or 100% Creek Chub (if insufficient sunfish available)
Location D – Richland Creek at the Vernal Pike Bridge	33% Top Predator (e.g., Sunfish or Rock Bass) 33% Omnivores (e.g., Creek Chub) 33% Bottom Feeders (e.g. White Suckers)
Population of Fish Sampled to Measure Progress Toward Achieving Target Concentrations in Fish Protective of Human Receptors	
Sampling Location	**Sample Mix**
Location F – Richland Creek at State Route 43 Bridge in Owen County	75% Top Predator (e.g., Sunfish or Rock Bass) 25% Bottom Feeders (e.g. White Suckers)

4. U.S. EPA will evaluate the remedy every five years after the completion of construction to determine whether the mean concentration for PCBs in fish is statistically greater than or less than the target concentrations. Subject to the limitations set forth in Paragraphs IX.F and IX.G below, U.S. EPA may modify the remedy for groundwater and sediment contamination if it can statistically demonstrate that the remedy "has not achieved and will not achieve the target concentrations in fish" in accordance with the methodology set forth in Paragraphs IX.B and IX.D below, or in accordance with an alternative methodology mutually agreed to by U.S. EPA and CBS. In the event that U.S. EPA makes such a demonstration, it shall provide notice to CBS of this fact and of U.S. EPA's intent to modify the remedy pursuant to the RCC. CBS will then have the opportunity under Paragraph IX.F below to challenge U.S. EPA's determination. If CBS cannot meet its burden under Paragraph IX.F, U.S. EPA may modify the remedy subject to the limitations set forth under Paragraph IX.G below. In modifying the remedy, U.S. EPA shall be guided by the ROD amendment process in the National Contingency Plan.

5. Upon selection of the modified remedy by U.S. EPA, CBS shall be

required to perform the modified remedy. CBS, however, may exercise its right under Section XXIV (Disputes Resolution) of the Original Consent Decree to challenge U.S. EPA's selection pursuant to Paragraph IX.G.5 below.

B. Statistical Hypothesis Testing

1. There is inherent uncertainty in determining whether mean PCB concentrations in fish are above or below the target concentrations because of variability in sampling data. U.S. EPA and CBS shall use statistical sampling and analysis procedures to control the risk of reaching false conclusions with respect to whether the mean concentrations of PCBs in fish have achieved or will achieve the target concentrations set forth in Paragraph IX.A.1 above. Unless U.S. EPA and CBS, in consultation with the other Governmental Parties, mutually agree upon an alternative statistical methodology (e.g. regression analysis or statistical modeling), they shall use the statistical methodology known as "classical statistical hypothesis testing," which is described in the guidance documents *U.S. EPA QA/G-4 Guidance on Systematic Planning Using the Data Quality Objectives Process (February 2006), and U.S. EPA QA/G-9S Data Quality Assessment: Statistical Methods for Practitioners (February 2006).* U.S. EPA and CBS, in consultation with the other Governmental Parties, may mutually agree to use a regression model to test trends in the mean concentration of PCBs in fish, or to compare mean concentrations to target concentrations or historical data, while accounting for cofactors such as the year when sampling was conducted, the season when sampling was conducted, the sample location, the species of fish sampled, and the lipid content of the sampled fish.

2. The following terms shall be given the same meaning in this RCC that they have in the two guidance documents cited above:

- baseline condition
- alternative condition
- gray region
- false rejection of the baseline condition
- false acceptance of the baseline condition
- false rejection decision error limit
- false acceptance decision error limit

C. Termination of CBS's Obligation to Modify Remedy under the RCC

1. At any time after the completion of construction of the remedy to address PCB contamination in groundwater, surface water, and sediment at Neal's Landfill, CBS may request a determination by U.S. EPA that the remedy has successfully achieved the target concentration for PCBs in fish set forth in Paragraph IX.A.1. CBS shall use statistical hypothesis testing to demonstrate to EPA that the remedy has achieved the target concentrations set forth in Paragraph IX.A.1 at each sampling location. Thus, CBS shall perform a total of three tests, one for each location.

2. In conducting the statistical hypothesis tests, CBS shall assume as its baseline condition that the mean PCB concentration in fish from any given sampling location is equal to or greater than the target concentration for that sampling location. If CBS can statistically prove with 95% confidence the alternative condition (*i.e.*, if CBS can demonstrate that the mean PCB concentration for fish is below the target value by a statistically significant margin) for all sample locations, CBS will have adequately demonstrated that the remedy has been successful. At that point, CBS's obligations under this RCC will terminate and CBS and the United States will so notify the Court. CBS will continue to have operation and maintenance obligations at the Site. These O&M obligations will include fish sampling (at the reduced level specified in the Long-term Monitoring Plan approved by U.S. EPA under the Neal's Landfill SOW for OU2/3) in

support of U.S. EPA's five-year review process. If U.S. EPA does not concur with CBS's statistical demonstration under the previous Paragraph IX.C.1 and this Paragraph IX.C.2, CBS may petition the Court under Section XXIV (Dispute Resolution) of the Original Consent Decree to demonstrate that U.S. EPA's non-concurrence is arbitrary and capricious or otherwise not in accordance with law.

3. In the event that CBS cannot meet the test set forth in the preceding Paragraph IX.C.2 with respect to all sample locations but it can meet the test with respect to a sample location in Richland Creek (*i.e.*, sample location D or F), CBS shall be relieved of its obligation to implement the sampling plan for enhanced fish monitoring approved by U.S. EPA under Paragraph IX.H with respect to that sample location and shall implement instead at that location the fish sampling specified in the Long-term Monitoring Plan approved by U.S. EPA under the Neal's Landfill Statement of Work for Operable Units 2 and 3.

4. For the purpose of estimating sample sizes for conducting each statistical hypothesis test, CBS shall estimate sample requirements as follows:

a. The upper bound of the gray region shall be set at the target concentrations set forth in Paragraph IX.A.1;

b. The lower bound of the gray region shall be set at 20% less than the upper bound. Specifically, the lower bound will be set at 1.8 mg/kg for location B, 0.72 mg/kg for location D, and 0.16 mg/kg for location F;

c. The false rejection decision error limit at the upper bound of the gray region (*i.e.*, the boundary of the gray region at the target concentration) shall be set at 5%, and;

d. The false acceptance decision error limit at the lower bound of the gray region (*i.e.*, the boundary of the gray region opposite the boundary formed by the target concentration) shall be set at 20%.

5. In accordance with Paragraph IX.H.3, the parameters set forth in Paragraph IX.C.4 above may be modified in light of the number of fish that are reasonably available in the streams for sampling. In the event that the parameters set forth in Paragraph IX.C.4 are modified, CBS may petition U.S. EPA to modify the hypothesis test set forth in Paragraph IX.C.2. In response, U.S. EPA may determine that hypothesis test shall remain unchanged, or alternatively, U.S. EPA may modify the hypothesis test pursuant to the mutual agreement of U.S. EPA and CBS. In either event, the hypothesis test shall be performed in accordance with U.S. EPA's determination, except that CBS may exercise its right under Section XXIV (Disputes Resolution) of the Original Consent Decree to challenge U.S. EPA's determination that the hypothesis test shall remain unchanged on the grounds that U.S. EPA's determination is arbitrary and capricious or otherwise not in accordance with law.

D. Evaluation of Achievement of Target Concentrations in Fish

1. First Five-Year Review

a. To demonstrate at the first five-year review that the remedy has not achieved and will not achieve the target concentrations in fish, U.S. EPA must show that (1) the mean concentration of PCBs in fish at any sampling location is greater than the target concentration set forth in Paragraph IX.A.1 for that location, and (2) the mean concentration of PCBs in fish at the same location has shown no improvement in comparison to pre-remedy data collected from the same location in 2003 through 2005. To

make this showing, U.S. EPA shall satisfy each part of the following two-part test with respect to any one of the three sampling locations:

i. First Part: U.S. EPA shall use statistical hypothesis testing to demonstrate that the mean concentration of PCBs in fish at a sampling location has failed to achieve the target concentration for that location. In conducting this test, U.S. EPA shall assume as its baseline condition that the mean concentration of PCBs in fish at the sampling location is equal to or less than the target concentration for the sampling location. In the event that U.S. EPA can statistically prove the alternative condition with 95% confidence (*i.e.*, that the mean concentration of PCBs in fish is greater than the target concentration by a statistically significant margin) at any one of the three sampling locations, U.S. EPA may then proceed to the second part of the test.

ii. Second Part: For each sampling location where the mean concentration of PCBs in fish is greater than the target value by a statistically significant margin (*i.e.*, for any sampling location where U.S. EPA has rejected the baseline condition that the mean concentration of PCBs in fish at the location is equal to or less than the target concentration), U.S. EPA shall use statistical hypothesis testing to determine whether there has been an improvement in the mean concentration of PCBs in fish in comparison to pre-remedy data collected from the same location in 2003 through 2005, as shown in the documents identified under Paragraph IX.D.1.a.iii below. In conducting this test, U.S. EPA shall assume as its baseline condition that the mean concentration of PCBs in fish in year 5 is equal to or less than the mean concentration for PCBs in fish at the same sampling location in 2003 through 2005. In the event that U.S. EPA can statistically prove the alternative condition with 95% confidence (*i.e.*, that the mean concentration of PCBs in

fish at year 5 is greater than the mean concentration in 2003 through 2005 by a statistically significant margin) for at least one sample location, U.S. EPA will have adequately demonstrated that the remedy has not and will not achieve the target concentrations for fish set forth in Paragraph IX.A.1.

iii. For the purposes of the previous Paragraph IX.D.1.a.ii, the term "pre-remedy data" shall mean data included within the following documents:

(1) All documents listed below from the Administrative Record for the Neal's Landfill ROD Amendment for OU2/3:

- Document 179 - From U.S. EPA - Split Fish Sample Analytical Results for the Neal's Landfill Site (7/23/04)
- Document 205 - From CBS - Neal's Landfill Fish Samples May 2003 Validation with Attachments (8/6/04)
- Document 206 - From CBS - Neal's Landfill Fish Samples November 2003 Validation with Attachments (8/11/04)
- Document 207 - From Tetra Tech - Tetra Tech's Data Validation Review of Neal's Landfill Fish Samples May 2003 Validation (8/17/04)
- Document 208 - From Tetra Tech - Tetra Tech's Data Validation Review of Neal's Landfill Fish Samples November 2003 Validation (9/1/04)
- Document 210 - From Tetra Tech - Fish Tissue Sample Analytical Results at the Neal's Landfill Site with Attachments (9/7/04)
- Document 212 - From CBS - Viacom's Comments to Tetra Tech's Data Validation Review of Neal's Landfill Fish Samples May 2003 Validation (9/22/04)
- Document 213 - From U.S. EPA - Revised Fish Sample Analytical Results at the Neal's Landfill Site with Attachments (9/21/04)
- Document 215 - From Tetra Tech Responses to Viacom's Comments on Data Validation Review of Neal's Landfill Fish Samples May 2003 Validation (10/5/04)

- Document 259 - From U.S. EPA - Fish Tissue Split Sample Analytical Results at Neal's Landfill with Attachments (2/20/06)

- Document 260 - From CBS - Fall 2005 Fish Tissue Sampling for Aroclor and Lipid Analysis at Conard's Branch and Richland Creek Near Neal's Landfill (2/27/06)

- Document 262 - From CBS - Neal's Landfill November 2005 Fish Sample Congener PCB Validation (3/23/06)

- Document 265 - From Tetra Tech - Tetra Tech's Data Validation Review of Neal's Landfill Fish Sample November 2005 Cogener PCB Validation (4/27/06)

or (2) all other documents added as an update to the Administrative Record for the Neal's Landfill ROD Amendment for OU2/3, provided that any such document includes pre-remedy fish data collected in 2003, 2004, or 2005 from one or more of the fish sample locations set forth in Paragraph IX.A.1, and that such data qualifies as contract lab program ("CLP") data or has been subject to quality assurance and quality control ("QA/QC") safeguards equivalent to those required for CLP data. Any Party may propose to place additional fish data in the Administrative Record as an update to the Neal's Landfill ROD Amendment for OU2/3 for the purposes of this Paragraph, and U.S. EPA shall accept any such proposed data, provided that it satisfies the conditions set forth in the proceeding sentence (*i.e.*, the data were collected in 2003, 2004, or 2005 from one or more of the fish sample locations set forth in Paragraph IX.A.1, and such data qualifies as CLP data or has been subjected to QA/QC safeguards equivalent to those required for CLP data).

b. For the purpose of estimating sample sizes for conducting each statistical hypothesis test set forth in Paragraph IX.D.1.a.i above, U.S. EPA shall apply the following parameters:

i. The upper bound of the gray region shall be set at a

value equal to the target concentration set forth in Paragraph IX.A.1, plus 20% of the target concentration. Specifically, the upper bounds will be set at 2.8 mg/kg for location B, 1.1 mg/kg for location D, and 0.24 mg/kg for location F;

ii. The lower bound of the gray region shall be set at the target concentration set forth in Paragraph IX.A.1;

iii. The false rejection decision error limit shall be set at 5% at the lower bound of the gray region (*i.e.*, the boundary of the gray region formed by the target concentration); and

iv. The false acceptance decision error limit shall be set at 20% at the upper bound of the gray region (*i.e.*, the boundary of the gray region opposite the boundary formed by the target concentration).

c. For the purpose of setting sample sizes for conducting each statistical hypothesis test set forth in Paragraph IX.D.1.a.ii above, U.S. EPA shall apply the following constraints:

i. The upper bound of the gray region shall be set at a value equal to 20% of the mean of the historical data for each fish species at each sampling location;

ii. The lower bound of the gray region shall be set at zero, (corresponding to the case that there is no difference between the mean concentration of PCBs in post remediation fish and the mean concentration for PCBs in fish at the same sampling location in 2003 through 2005);

iii. The false rejection decision error limit shall be set at 5% at the lower bound of the gray region, and

iv. The false acceptance decision error limit shall be set at 20% at the upper bound of the gray region.

d. In accordance with Paragraph IX.H.3, the parameters set forth in Paragraph IX.D.1.b and IX.D.1.c above may be modified in light of the number of fish that are reasonably available in the streams for sampling. In the event that the parameters set forth in Paragraph IX.D.1.b and IX.D.1.c are modified, CBS may petition U.S. EPA to modify the hypothesis tests set forth in Paragraph IX.D.1.a. In response, U.S. EPA may determine that the hypothesis tests shall remain unchanged, or alternatively, U.S. EPA may modify the hypothesis tests pursuant to the mutual agreement of U.S. EPA and CBS. In either event, the hypothesis tests shall be performed in accordance with U.S. EPA's determination, except that CBS may exercise its right under Section XXIV (Disputes Resolution) of the Original Consent Decree on the grounds that U.S. EPA's determination is arbitrary and capricious or otherwise not in accordance with law.

2. Second Five-Year Review

a. To demonstrate at the second five-year review that the remedy has not and will not achieve the target concentrations in fish, U.S. EPA must show that (1) the mean concentration of PCBs in fish at one or more sample locations is greater than the target concentration listed in Paragraph IX.A.1 for that sample location, and (2) there is not a sufficient basis for U.S. EPA to conclude, based on trend data, that the mean concentration of PCBs in fish at that sample location will reach the target concentration in the future. To make this showing, U.S. EPA shall satisfy each part of the following two-part test with respect to any one of the three sample locations:

i. First Part: U.S. EPA shall repeat the same statistical

hypothesis testing that it used for the first part of the two-part test described above in Paragraph IX.D.1.a.i with respect to the first five-year review. Specifically, U.S. EPA shall use statistical hypothesis testing to demonstrate that the mean concentration of PCBs in fish at any sample location has not achieved the target concentration for that sample location. In conducting this test, U.S. EPA shall assume as the baseline condition that the mean PCB concentration in fish at a sample location is equal to or less than the target concentration set forth in Paragraph IX.A.1 with respect to that location. In the event that U.S. EPA can statistically prove the alternative condition (*i.e.*, that the mean concentration of PCBs in fish is greater than the target value with 95% confidence) for any sample location, U.S. EPA may then proceed to the second part of the test.

ii. Second Part: For each sampling location where the mean concentration of PCBs in fish is greater than the target concentration by a statistically significant margin (*i.e.*, for any sampling location where U.S. EPA has rejected the baseline condition that the mean concentration of PCBs in fish at the sample location is equal to or less than the target concentration), U.S. EPA shall use statistical hypothesis tests to determine if there is a deceasing trend at that location with respect to the mean concentration of PCBs in fish. In conducting this test, U.S. EPA shall assume as the baseline condition that there is no trend or the trend is increasing (trend is greater than or equal to zero) at the sample location. In the event that U.S. EPA cannot statistically prove the alternative condition (*i.e.* that PCB concentrations in fish are decreasing over time) with 95% confidence for at least one sample location, U.S. EPA will have adequately demonstrated that there is no significant decreasing trend and that failure to achieve the target concentrations in fish set forth in Paragraph IX.A.1 has occurred, and that the target

concentrations will not be met in the future.

b. For the purpose of estimating sample sizes for conducting statistical hypothesis testing set forth in Paragraph IX.D.2.a.i above, U.S. EPA shall apply the same parameters set forth in Paragraph IX.D.1.b above.

c. For the purpose of determining sample sizes for conducting each statistical hypothesis test set forth in Paragraph IX.D.2.a.ii above, U.S. EPA shall apply the following parameters:

i. The upper bound of the gray region shall be set at zero (corresponding to the case that there is no trend at that location with respect to the mean concentration of PCBs in fish);

ii. The lower bound of the gray region shall be set at a value corresponding to a 1% per year decrease in the mean concentration (*i.e.*, a slope for the trend line of –1%);

iii. The false rejection decision error limit shall be set at 5% at the upperbound of the gray region; and

iv. The false acceptance decision error limit shall be set at 20% at the lower bound of the gray region.

d. In accordance with Paragraph IX.H.3, the parameters set forth in Paragraph IX.D.2.b and IX.D.2c above may be modified in light of the number of fish that are reasonably available in the streams for sampling. In the event that the parameters set forth in Paragraph IX.D.2.b and IX.D.2c are modified, CBS may petition U.S. EPA to modify the hypothesis tests set forth in Paragraph IX.D.2.a. In response, U.S. EPA may determine that hypothesis tests shall remain unchanged, or alternatively, U.S.

EPA may modify the hypothesis tests pursuant to the mutual agreement of U.S. EPA and CBS. In either event, the hypothesis tests shall be performed in accordance with U.S. EPA's determination, except that CBS may exercise its right under Section XXIV (Disputes Resolution) of the Original Consent Decree to challenge U.S. EPA's determination that the hypothesis tests shall remain unchanged on the grounds that U.S. EPA's determination is arbitrary and capricious or otherwise not in accordance with law.

3. Third Five-Year Review (and Beyond)

a. Beginning with the third five-year review, U.S. EPA will no longer take into account the long-term trend of PCBs in fish to determine whether or not the remedy has achieved or will achieve the target concentrations set forth in Paragraph IX.A.1. Rather, U.S. EPA must show only that the mean concentration of PCBs in fish at any sampling location is statistically greater than the target concentration set forth in Paragraph IX.A.1 with respect to that location. To make this showing, U.S. EPA shall repeat the same statistical hypothesis testing that it used for the first part of the two-part tests described above in Paragraphs IX.D.1.a.i and IX.D.2.a.i with respect to the first and second five-year reviews with the baseline condition configured as described in those paragraphs.

b. For the purpose of estimating sample sizes for conducting statistical hypothesis testing set forth in Paragraph IX.D.3.a above, U.S. EPA shall apply the same parameters set forth in Paragraph IX.D.1.b.

c. In accordance with Paragraph IX.H.3, the parameters required under Paragraph IX.D.3.b above may be modified in light of the number of fish that are reasonably available in the streams for sampling. In the event that the parameters

required under Paragraph IX.D.3.b are modified, CBS may petition U.S. EPA to modify the hypothesis test set forth in Paragraph IX.D.3.a. In response, U.S. EPA may determine that hypothesis test shall remain unchanged, or alternatively, U.S. EPA may modify the hypothesis test pursuant to the mutual agreement of U.S. EPA and CBS. In either event, the hypothesis test shall be performed in accordance with U.S. EPA's determination, except that CBS may exercise its right under Section XXIV (Disputes Resolution) of the Original Consent Decree to challenge U.S. EPA's determination that the hypothesis test shall remain unchanged on the grounds that U.S. EPA's determination is arbitrary and capricious or otherwise not in accordance with law.

E. Standard for Continuing Enhanced Monitoring

If the statistical hypothesis tests described in Paragraphs IX.C and IX.D above are inconclusive (*i.e.*, they fail to prove either that the remedy has achieved the target concentrations or, alternatively, that the remedy has not achieved and will not achieve the target concentrations), CBS shall continue to perform the enhanced monitoring required by the Sampling Plan approved by U.S. EPA in accordance with Paragraph IX.H, below, except to the extent that CBS is relieved of this obligation in accordance with Paragraph IX.C.3 above.

F. CBS's Right to Challenge U.S. EPA's Determination to Modify the Remedy

1. In the event that U.S. EPA determines in accordance with Paragraph IX.D that the target concentration of PCBs in fish has not been achieved and will not be achieved at one or more sample locations, U.S. EPA will provide CBS with a notice of this determination and of U.S. EPA's intent to modify the remedy under the RCC. CBS then

will be given time to conduct an evaluation and submit a petition to U.S. EPA challenging this determination. To prevail on its challenge, CBS bears the burden of demonstrating at least one of the following:

a. U.S. EPA's determination under Paragraph IX.D was incorrect;

b. The failure to achieve the target concentration(s) in fish set forth in Paragraph IX.A.1 was caused by conditions at the Site changing after entry of this Amendment for reasons beyond the control of CBS; or

c. Sampling Location B was the only sampling location where the mean concentration of PCBs in fish exceeded the target concentration set forth in Paragraph IX.A.1, and that improvements in PCB concentrations in fish tissue at other sampling locations show that the remedy is protective of mink based upon the assumptions and conclusions set forth in U.S. EPA's ecological risk assessment. In such a case, CBS may petition U.S. EPA for approval to reduce enhanced monitoring of PCB concentrations in fish.

2. In the event that CBS persuades U.S. EPA of the merits of its challenge, U.S. EPA shall not modify the remedy under this RCC. However, nothing in this RCC in any way limits any rights of the United States under the re-opener clause at Paragraph VIII.B.4 of this Amendment to the Consent Decree.

3. In the event that U.S. EPA does not accept CBS's challenge, CBS may exercise its right under Section XXIV (Disputes Resolution) of the Original Consent Decree to challenge U.S. EPA's determination on the grounds that it is arbitrary and capricious or otherwise not in accordance with law. Assuming that CBS does not challenge

U.S. EPA's determination (or dispute resolution is resolved in U.S. EPA's favor), U.S. EPA may proceed to modify the remedy subject to the limitations set forth in Paragraph IX.G.

G. Modification of the Remedy under this RCC

1. Within 180 days of issuance of U.S. EPA's notice of its intent to modify the remedy under the RCC (or, in the event that CBS invokes dispute resolution, within 60 days of a final decision by U.S. EPA or the District Court, whichever is later, determining that U.S. EPA may modify the remedy under this RCC), CBS shall submit to U.S. EPA for review and approval a work plan for investigating and evaluating additional remedies that would accord the incremental reduction in risk necessary to achieve the target concentrations set forth in Paragraph IX.A.1. This work plan shall include:

a. A proposed list of additional remedies that CBS shall investigate and evaluate. The supplemental remedies proposed by CBS may include, but are not limited to, the removal of additional sediments within the streams if the sediments are shown to be recontaminated above 1 mg/kg on average and the sediments are believed to be a main contributor to the PCB levels in fish.

b. A proposed schedule for investigating and evaluating the proposed remedies.

2. Upon approval of the work plan, CBS shall proceed with the investigation and evaluation of the supplemental remedies in accordance with the approved schedule. At the completion of the investigation, CBS shall submit to U.S. EPA for review and approval a proposed plan for modifying the remedy to achieve the target concentrations set forth in Paragraph IX.A.1. The proposed plan shall include:

a. A description of the investigatory actions performed by CBS;

b. An evaluation of the additional remedies based upon the nine evaluation criteria set forth in the National Contingency Plan for evaluating remedial actions;

c. A recommendation as to the preferred supplemental remedial action; and

d. All documents, reports or other materials that were prepared or considered by CBS in preparing the proposed plan, together with an index of this record.

3. In addition to submitting the proposed plan required under Paragraph IX.G.2, CBS may propose an alternative plan for modifying the remedy. In support of this alternative plan, CBS shall demonstrate that (i) the target concentrations set forth in Paragraph IX.A.1 are technically impracticable, (ii) target concentrations proposed by CBS as an alternative to those set forth in Paragraph IX.A.1 are protective of human health and the environment, and (iii) remedial alternatives proposed by CBS, including potentially a "no further action" alternative, will achieve the alternative target concentrations proposed by CBS. In the event that U.S. EPA determines that CBS has adequately demonstrated all three conditions, U.S. EPA shall publish the proposed alternative plan for public comment in accordance with the procedures set forth below in Paragraph IX.G.4. Alternatively, in the event that U.S. EPA determines that CBS has not adequately demonstrated one (or more) of the conditions, U.S. EPA may reject the alternative plan, and CBS may challenge U.S. EPA's determination under Section XXIV (Dispute Resolution) of the Original Consent Decree on the grounds that U.S. EPA's determination is arbitrary and capricious or otherwise not in accordance with law.

4. Unless the alternative plan is approved by U.S. EPA pursuant to Paragraph IX.G.3, U.S. EPA may approve CBS's proposed plan or it may prepare its own proposed plan for additional remedial measures to achieve the target concentrations set forth in Paragraph IX.A.1. In either event, U.S. EPA shall publish the proposed plan for public comment in accordance with the requirements of the National Contingency Plan. After receiving and reviewing public comments, U.S. EPA may select an additional remedial action to achieve the target concentrations set forth in Paragraph IX.A.1. This RCC does not provide U.S. EPA with the authority to modify in any way the remedial actions that have been implemented by CBS for Operable Unit 1 for Neal's Landfill.

5. In the event that CBS disagrees with any additional remedial measures selected by U.S. EPA under this RCC, CBS retains the right, prior to implementation, to challenge U.S. EPA's decision before the Court pursuant to Section 113(j)(2) of CERCLA on the ground that all or part of the decision is arbitrary and capricious or otherwise not in accordance with law. To the extent that CBS prevails on its challenge, it is not required to implement the additional remedial measures selected by U.S. EPA.

6. Within 60 days of U.S. EPA's selection of the additional remedial action (or, in the event that CBS challenges U.S. EPA's selection, within 60 days of the Court's decision upholding the U.S. EPA's selection), CBS shall submit to U.S. EPA for review and approval a proposed plan and schedule for the design and construction of the additional remedial action. Upon approval of this proposed plan, CBS shall proceed with the design and construction of the additional remedial measures in accordance with the approved schedule.

7. All plans, reports and schedules submitted to U.S. EPA for review and approval under this Paragraph IX.G are subject to the pertinent provisions of the Statement of Work for Operable Units 2 and 3 at Neal's Landfill with respect to the approval of deliverables.

H. Sampling Plan

1. Within two years of execution of the Consent Decree, CBS shall submit to U.S. EPA for approval a sampling plan for enhanced fish monitoring, containing a plan for statistical evaluation of the fish tissue data. The plan shall comply with requirements set forth in the Consent Decree and shall be consistent with U.S. EPA's Data Objective ("DQO") Process as described in U.S. EPA's publication, *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4 (February 2006)*. The plan shall require fish sampling at the locations where target concentrations are set in Paragraph IX.A.1.

2. Further, the enhanced fish monitoring plan shall require CBS to collect sufficient fish samples to meet the parameters set forth in Paragraphs IX.C and IX.D for statistical hypothesis testing. This plan will require composite samples of at least 3 fish per composite sample to reduce the overall variance.

3. In the event that U.S. EPA or CBS believes that sample size estimates and composite sampling in the enhanced fish monitoring plan will result in sampling requirements that are not reasonable in light of the limited number of fish available for sampling at the agreed-upon locations in Conard's Branch and Richland Creek, U.S. EPA and CBS shall confer in an effort to reach agreement upon whether or not there should be adjustments to (i) composite sampling requirements and/or (ii) the

sampling parameters set forth in Paragraphs IX.C and IX.D. In the event that U.S. EPA and CBS cannot reach agreement, U.S. EPA may determine that no adjustments to sampling requirements are necessary, or alternatively, U.S. EPA may adjust the sampling requirements. In either event, CBS shall implement the enhanced fish monitoring plan in accordance with U.S. EPA's determination, except that CBS shall have the right to challenge U.S. EPA's determination under Section XXIV (Disputes Resolution) of the Original Consent Decree on the grounds that U.S. EPA's determination is arbitrary and capricious or otherwise not in accordance with law.

4. The enhanced fish monitoring plan shall require that the fish chosen from each location be representative of the sizes of fish found at that location, consistent with past sampling events and representative of the size of fish eaten by the human and ecological receptors assumed in the risk assessments prepared by U.S. EPA. Generally this requirement can be met by showing that the mean size of fish collected are within 1 standard deviation of the same species of fish collected by CBS or U.S. EPA at the appropriate location during prior sampling events after the completion of the source control operable unit.

5. The enhanced fish monitoring plan should ensure a balanced data set of composite samples to be included in the mean from both summer and fall time periods at each location. Specifically, "balanced" means that there are an equal number of fall and summer samples to be included in the mean. The mean can be calculated for samples collected over one year or two years.

6. The fish are to be analyzed using total congener and lipid methods equivalent to those analytical methods used in 2005.

APPENDIX B
ALGORITHMS FOR ESTIMATING POPULATION VARIANCE FROM PRE-REMEDIAL SAMPLES

ALGORITHM FOR ESTIMATING SAMPLE SIZE AT LOCATION B

Step 1. Calculate the number of pseudo-composites of creek chub that can be generated from historical data using the following equation:

No. of pseudo-composites = (no. of individual fish)/3 + no. of composites (A1)

For the number of samples listed in Table 5 of Section 2.4, this can be calculated as 10 samples.

Step 2. Resample with replacement from the pool of individuals and composites. Continue drawing until three fish have been obtained. Once three samples have been drawn, increment pseudo-composite counter by one and record the average concentration of the three individual fish. If either the first or the subsequent resamples is a composite, then discard previous individual samples (as appropriate to reach a composite equivalent to three or more individuals), and increase the pseudo-composite counter by one and record the concentration of the composite.

Step 3. Repeat Step 2 until the 10 pseudo-composites has been reached. Calculate variance of the pseudo-composite sample. This represents one estimate of the population variance.

Step 4. Repeat steps 2 and 3 5,000 times and use the average value of the population variance in Equation 1 in Section 2.4.2 to calculate the sample size.

ALGORITHM FOR ESTIMATING SAMPLE SIZE AT LOCATIONS D AND F

Step 1. Calculate the number of pseudo-composites that can be generated from historical data for each group identified in Table 3 of Section 2.3 using Equation A1. Based on the number of historical samples listed in Table 5 of Section 2.3, at Location D this can be calculated as 8 pseudo-composites (6 from individuals + 2 composites) for top predators, 9 pseudo-composites for omnivores (8 + 1), and 2 pseudo-composite for bottom feeders (1 + 1). At Location F, only one pseudo-composite can be generated for each group from the individual fish. Therefore, use the individual samples as pseudo-composites. Thus, the numbers of pseudo-composite for top predators and bottom feeders are 3 and 4, respectively.

Step 2. Identify the limiting group at each location and calculate the total sample size for each bootstrap realization over all groups. A group is limiting if it produces the least number of pseudo-composites when individual fish are combined. For example, at Location D, the bottom feeders are limiting because they produce the fewest number of pseudo-composites (i.e., 2). Thus, in order to comply with the proportions between the feeding groups listed in Table 3 (i.e., 33 1/3 percent:33 1/3 percent:33 1/3 percent for Location D), the bottom feeders limit the number of pseudo-composites for the other two groups to two. The total sample size at Location D therefore is 6 (i.e., 2 pseudo-composites from each group). At Location F, to honor the proportions in Table 3 of Section 2.3 (75 percent top predators: 25 percent bottom feeders), the top predators are limiting. Thus, the total sample size over both groups is 4 (3 top predators and 1 bottom feeder).

Step 3. At Location D, generate pseudo-composites of each group in the same manner as described in Step 2 of the algorithm for Location B until the required number of pseudo-composites has been obtained (i.e., 2 from each group). At Location F, sample with replacement from pool of available top predators and bottom feeders to produce 3 top predators and 1 bottom feeder respectively. At each location combine the groups together to produce one bootstrap realization of the target mix. Calculate the variance. This represents one estimate of the population variance of the target mix.

Step 4. Repeat steps 5 and 6 5,000 times. Calculate the mean of the variance for use in Equation 1 in Section 2.4.2 to calculate the sample size.

APPENDIX C
LISTING OF PRE-REMEDIATION DATA

Table C-1

Fish Tissue Concentrations Used in the Bootstrap Evaluations at Location B

Sample ID	Date	PCB Concentration (mg/kg Wet Whole Body)	No. of Fish	Sample Type	Species	Group	Sampling Agency
NL03-01-0004	5/28/2003	6.7	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0005	5/28/2003	10.8	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0006	5/28/2003	11	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0007	5/28/2003	12.7	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0008	5/28/2003	9.7	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0009	5/28/2003	8.5	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0010	5/28/2003	7.8	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0011	5/28/2003	10.5	2	comp	Creek Chubs	Omnivore	Viacom
NL03-01-0012	5/28/2003	11.4	2	comp	Creek Chubs	Omnivore	Viacom
NL03-02-0001	11/18/2003	3.321135	1	indv	Creek Chubs	Omnivore	Viacom
NL03-02-0002	11/18/2003	0.983109	1	indv	Creek Chubs	Omnivore	Viacom
NL03-02-0003	11/18/2003	11.55592	1	indv	Creek Chubs	Omnivore	Viacom
NL03-02-0004	11/18/2003	3.527382	1	indv	Creek Chubs	Omnivore	Viacom
NL03-02-0005	11/18/2003	1.558753	1	indv	Creek Chubs	Omnivore	Viacom
NL03-02-0006	11/18/2003	8.490196	1	indv	Creek Chubs	Omnivore	Viacom
NL-0022	11/10/2005	1.98	1	indv	Creek Chubs	Omnivore	Viacom
NL-0023	11/10/2005	1.92	1	indv	Creek Chubs	Omnivore	Viacom
NL-0024	11/10/2005	1.61	1	indv	Creek Chubs	Omnivore	Viacom
NL-0025	11/10/2005	1.13	1	indv	Creek Chubs	Omnivore	Viacom
NL-0026	11/10/2005	1.04	1	indv	Creek Chubs	Omnivore	Viacom
NL-0027	11/10/2005	1.62	1	indv	Creek Chubs	Omnivore	Viacom
NL-0028	11/10/2005	5.29	1	indv	Creek Chubs	Omnivore	Viacom
NL-0029	11/10/2005	2.92	1	indv	Creek Chubs	Omnivore	Viacom

Sample ID	Date	PCB Concentration (mg/kg Wet Whole Body)	No. of Fish	Sample Type	Species	Group	Sampling Agency
NL-0030	11/10/2005	1.70	1	indv	Creek Chubs	Omnivore	Viacom
NL-0031	11/10/2005	3.51	4	comp	Creek Chubs	Omnivore	Viacom

Notes:
mg/kg - milligram per kilogram
PCB - polychlorinated biphenyl

Table C-2

Fish Tissue Concentrations Used in the Bootstrap Evaluations at Location D

Sample ID	Date	PCB Concentration (mg/kg Wet Whole Body)	No. of Fish	Sample Type	Species	Group	Sampling Agency
NL03-01-0017	5/28/2003	1.7	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0018	5/28/2003	1.4	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0019	5/28/2003	0.47	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0020	5/28/2003	0.94	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0021	5/28/2003	1.3	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0022	5/28/2003	0.83	1	indv	Creek Chubs	Omnivore	Viacom
NL03-01-0042	5/28/2003	0.46	1	indv	Longear Sunfish	Top Predator	Viacom
NL03-01-0043	5/28/2003	1.1	1	indv	Longear Sunfish	Top Predator	Viacom
NL03-01-0044	5/28/2003	0.4	1	indv	Longear Sunfish	Top Predator	Viacom
NL03-01-0045	5/28/2003	0.15	1	indv	Longear Sunfish	Top Predator	Viacom
NL03-01-0046	5/28/2003	1.2	1	indv	Longear Sunfish	Top Predator	Viacom
NL03-01-0029	5/28/2003	1.6	1	indv	White Suckers	Bottom Feeder	Viacom
NL03-01-0030	5/28/2003	2.5	1	indv	White Suckers	Bottom Feeder	Viacom
NL03-01-0031	5/28/2003	1.2	1	indv	White Suckers	Bottom Feeder	Viacom
NL03-01-0032	5/28/2003	2.3	1	indv	White Suckers	Bottom Feeder	Viacom
NL03-01-0033	5/28/2003	2.7	1	indv	White Suckers	Bottom Feeder	Viacom
NL03-01-0034	5/28/2003	1.7	7	comp	White Suckers	Bottom Feeder	Viacom
NL03-01-0047	5/28/2003	1.9	2	comp	Longear Sunfish	Top Predator	Viacom
NL03-02-0013	11/18/2003	0.25	1	indv	Creek Chubs	Omnivore	Viacom
NL03-02-0014	11/18/2003	0.30	1	indv	Creek Chubs	Omnivore	Viacom
NL03-02-0015	11/18/2003	0.54	1	indv	Creek Chubs	Omnivore	Viacom
NL03-02-0016	11/18/2003	0.30	1	indv	Creek Chubs	Omnivore	Viacom

Sample ID	Date	PCB Concentration (mg/kg Wet Whole Body)	No. of Fish	Sample Type	Species	Group	Sampling Agency
NL03-02-0017	11/18/2003	0.53	1	indv	Creek Chubs	Omnivore	Viacom
NL03-02-0018	11/18/2003	0.66	1	indv	Creek Chubs	Omnivore	Viacom
NL03-02-0007	11/18/2003	1.35	1	indv	Longear Sunfish	Top Predator	Viacom
NL03-02-0008	11/18/2003	1.12	1	indv	Longear Sunfish	Top Predator	Viacom
NL03-02-0009	11/18/2003	0.27	1	indv	Longear Sunfish	Top Predator	Viacom
NL03-02-0010	11/18/2003	0.28	1	indv	Longear Sunfish	Top Predator	Viacom
NL03-02-0011	11/18/2003	0.78	1	indv	Longear Sunfish	Top Predator	Viacom
NL03-02-0012	11/18/2003	0.54	1	indv	Longear Sunfish	Top Predator	Viacom
NL04-02-001	9/23/2004	0.91	1	indv	Creek Chubs	Omnivore	USFWS
NL04-02-002	9/23/2004	1.12	1	indv	Creek Chubs	Omnivore	USFWS
NL04-02-003	9/23/2004	0.47	1	indv	Creek Chubs	Omnivore	USFWS
NL-0006	11/9/2005	0.08	1	indv	Creek Chubs	Omnivore	Viacom
NL-0007	11/9/2005	0.12	1	indv	Creek Chubs	Omnivore	Viacom
NL-0008	11/9/2005	0.09	1	indv	Creek Chubs	Omnivore	Viacom
NL-0009	11/9/2005	0.24	1	indv	Creek Chubs	Omnivore	Viacom
NL-0010	11/9/2005	0.67	1	indv	Creek Chubs	Omnivore	Viacom
NL-0011	11/9/2005	0.34	1	indv	Creek Chubs	Omnivore	Viacom
NL-0005	11/9/2005	0.24	4	comp	Creek Chubs	Omnivore	Viacom
NL-0001	11/9/2005	0.88	1	indv	Longear Sunfish	Top Predator	Viacom
NL-0002	11/9/2005	0.61	1	indv	Longear Sunfish	Top Predator	Viacom
NL-0003	11/9/2005	0.25	1	indv	Longear Sunfish	Top Predator	Viacom
NL-0004	11/9/2005	1.43	1	indv	Longear Sunfish	Top Predator	Viacom
NL-0013	11/10/2005	0.22	1	indv	Creek Chubs	Omnivore	Viacom
NL-0014	11/10/2005	0.32	1	indv	Creek Chubs	Omnivore	Viacom

Sample ID	Date	PCB Concentration (mg/kg Wet Whole Body)	No. of Fish	Sample Type	Species	Group	Sampling Agency
NL-0015	11/10/2005	0.21	1	indv	Creek Chubs	Omnivore	Viacom
NL-0016	11/10/2005	0.62	1	indv	Longear Sunfish	Top Predator	Viacom
NL-0017	11/10/2005	0.59	1	indv	Longear Sunfish	Top Predator	Viacom
NL-0018	11/10/2005	0.21	1	indv	Longear Sunfish	Top Predator	Viacom
NL-0019	11/10/2005	0.24	1	indv	Longear Sunfish	Top Predator	Viacom
NL-0020	11/10/2005	0.09	1	indv	Longear Sunfish	Top Predator	Viacom
NL-0021	11/10/2005	0.66	4	comp	Longear Sunfish	Top Predator	Viacom

Notes:
mg/kg - milligram per kilogram
PCB - polychlorinated biphenyl

Table C-3

Fish Tissue Concentrations Used in the Bootstrap Evaluations at Location F

Sample ID	Date	PCB Concentration (mg/kg Wet Fillet)	PCB Sample Remark	No. of Fish	Sample Type	Species	Group	Sampling Agency
NL04-01-001	6/18/2004	0.3	Aroclors	1	indv	White Suckers	Bottom Feeder	EPA
NL04-01-002	6/18/2004	0.069	Aroclors	1	indv	Creek Chubs	Omnivore	EPA
NL04-01-003	6/18/2004	0.17	Aroclors	1	indv	Creek Chubs	Omnivore	EPA
NL04-01-004	6/18/2004	0.096	Congener	1	indv	Creek Chubs	Omnivore	EPA
NL04-01-005	6/18/2004	0.12	Aroclors	1	indv	Rock Bass	Top Predator	EPA
NL04-01-006	6/18/2004	0.0544	Congener	1	indv	Rock Bass	Top Predator	EPA
NL04-01-007	6/18/2004	0.17	Aroclors	1	indv	Smallmouth Bass	Top Predator	EPA
NL04-01-008	6/18/2004	0.17	Aroclors	1	indv	Northern Hogsucker	Bottom Feeder	EPA
NL04-01-009	6/18/2004	0.155	Aroclors	1	indv	Golden Redhorse	Bottom Feeder	EPA
NL04-01-010	6/18/2004	0.106	Congener	1	indv	Northern Hogsucker	Bottom Feeder	EPA

Notes:
mg/kg - milligram per kilogram
PCB – polychlorinated biphenyl

APPENDIX D
ESTIMATED STANDARD-DEVIATIONS AT EACH LOCATION FROM BOOTSTRAP ANALYSIS

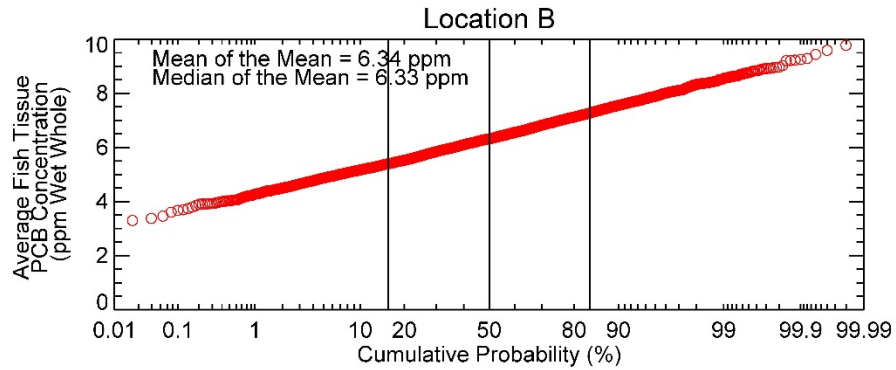
The number of fish samples estimated in Section 2 was derived from the estimate of the pre-remedy population mean and standard deviation of sample mix of fish at each location derived from the bootstrap analysis (Figure D-1). The mean standard deviation estimated from the bootstrap analysis, along with the steps illustrating the sample size calculation is shown in Table D-1 below.

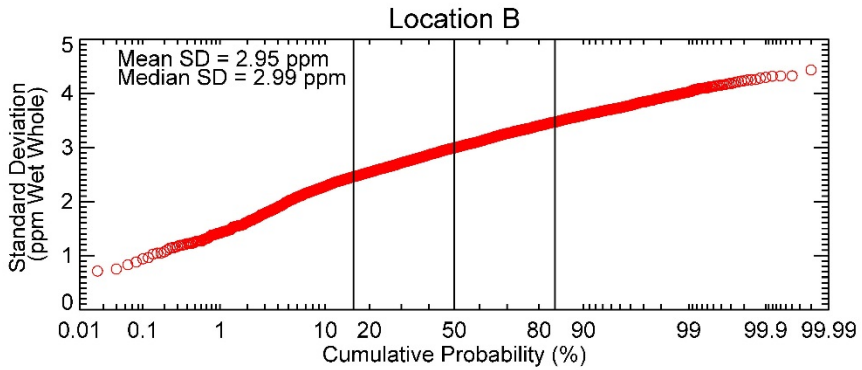
Table D-1
Illustration of Fish Sample Size Calculation

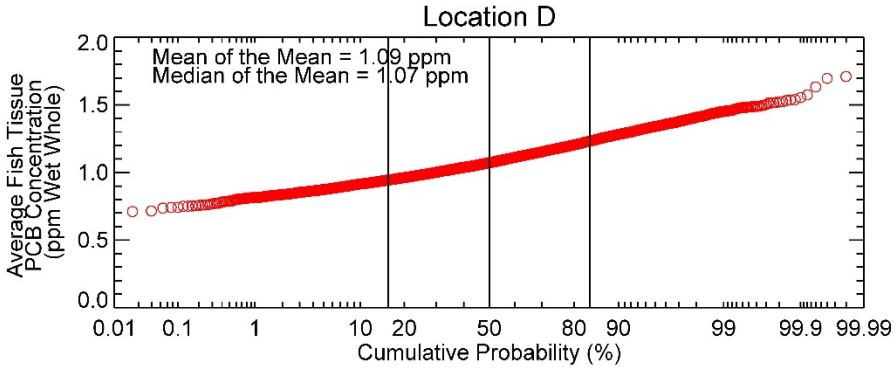
	Location B	Location D	Location F
AL: Target concentration level [in ppm]	2.3	0.9	0.2
$Z_{1-\alpha}$: In normal distribution using Type-I error tolerance α = 5%	-1.64		
$Z_{1-\beta}$: In normal distribution using Type-II error tolerance β = 20%	-0.84		
$d = AL \cdot \beta$: Width of gray region [in ppm]	0.46	0.18	0.04
σ : Standard deviation calculated from Bootstrap analysis [in ppm] – see Figure D-1, and Equation (2) in Section 2.4.2	0.74	0.28	0.06
n: Total sample size calculated using Equation (1) in Section 2.4.2	18	18[4]	16[4]

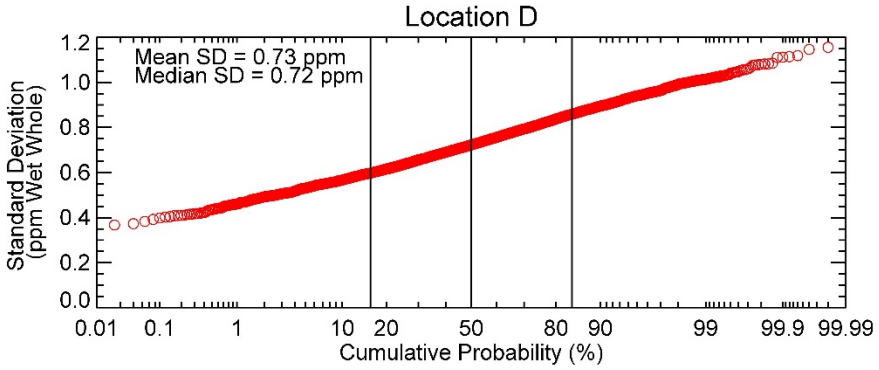
Notes:
1. The average standard deviation estimated from the bootstrap analysis was used.
2. The number of top predators, omnivores, and bottom feeders at each location will be collected as per the proportions listed in Table 3 in Section 2.
3. The sample sizes shown above represent the number of fish composites. The CDA requires 3 fish per composite.
4. The number of samples was adjusted up to nearest integer that would provide the target mix of top predators, omnivores and bottom feeders as per the requirements in the CDA.

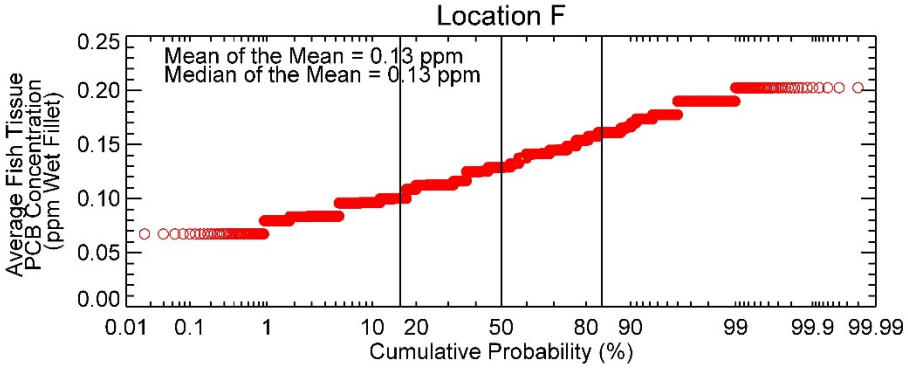
ppm - parts per million

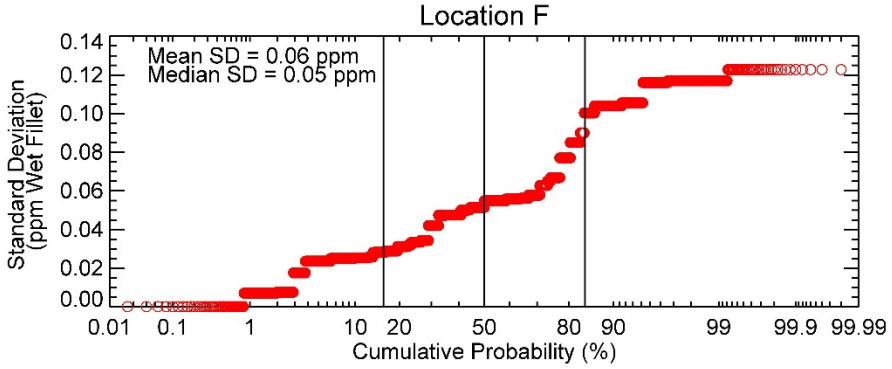












Note: Pre-remedy mean and standard deviation estimated using data collected from 2003-2005

Figure D-1

Cumulative Probability Plots of Population Means and Standard Deviations Estimated from a Bootstrap Evaluation at Each Location
Neal's Landfill Post-Remediation Fish Sampling Plan
Neal's Landfill Monitoring Program

ANCHOR QEA

Appendix B
Listing of Post-Remediation Data

Table 1
Final Validated Neal's Landfill
Fish Sample Data
MAY 2017
Composites (3 fish)

CBS SAMPLE ID	LAB SAMPLE ID	LOCATION	SAMPLE DATE	FISH SPECIES	FISH GUILD	Total PCB Congeners, pg/g	Validation Flags	LIPIDS, %	LENGTH, (cm)	WEIGHT (gm)	TYPE	COMMENTS
1		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore	**archive**		nm	18	66	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				18	64	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				15	40	Whole Body	
2		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore	**1,312,896**		0.80	13	27	Whole Body	3 gram extraction
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				13	27	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				12	23	Whole Body	
3		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore	**1,410,525**		1.30	13	25	Whole Body	3 gram extraction
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				12	21	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				12	20	Whole Body	
4		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore	**2,677,277**	J	2.85	11	20	Whole Body	3 gram extraction
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				11	17	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				12	18	Whole Body	
5		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore	**2,116,809**		1.98	11	17	Whole Body	3 gram extraction
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				12	19	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				11	16	Whole Body	
6		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore	**1,530,748**		1.40	12	20	Whole Body	3 gram extraction
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				13	28	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				14	35	Whole Body	
6D		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore	**1,207,522**		1.40	12	20	Whole Body	3 gram extraction
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				13	28	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				14	35	Whole Body	
7		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore	**2,122,080**	J	1.95	12	20	Whole Body	3 gram extraction
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				12	23	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				11	15	Whole Body	
8		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore	**1,940,244**		2.15	11	16	Whole Body	3 gram extraction
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				11	14	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				10	14	Whole Body	
9		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore	**1,369,442**		1.91	11	15	Whole Body	3 gram extraction
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				11	15	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				10	12	Whole Body	
10		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore	**2,054,283**		2.13	11	15	Whole Body	3 gram extraction
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				11	15	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				11	15	Whole Body	
11		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore	**archive**		nm	10	13	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				10	13	Whole Body	
		Location B - Conard's Branch @ VP	05/17/17	creek chubs	omnivore				10	13	Whole Body	

CBS SAMPLE ID	LAB SAMPLE ID	LOCATION	SAMPLE DATE	FISH SPECIES	FISH GUILD	Total PCB Congeners, pg/g	Validation Flags	LIPIDS, %	LENGTH, (cm)	WEIGHT (gm)	TYPE	COMMENTS
12		Location D - Richland Cr @ VP	05/18/17	creek chubs	omnivore	**232,609**	J	1.76	15	45	Whole Body	10 gram extraction
		Location D - Richland Cr @ VP	05/18/17	creek chubs	omnivore				15	60	Whole Body	
		Location D - Richland Cr @ VP	05/18/17	creek chubs	omnivore				17	69	Whole Body	
12D		Location D - Richland Cr @ VP	05/18/17	creek chubs	omnivore	**187,372**	J	1.76	15	45	Whole Body	10 gram extraction
		Location D - Richland Cr @ VP	05/18/17	creek chubs	omnivore				15	60	Whole Body	
		Location D - Richland Cr @ VP	05/18/17	creek chubs	omnivore				17	69	Whole Body	
13		Location D - Richland Cr @ VP	05/18/17	creek chubs	omnivore	**144,096**	J	1.78	13	25	Whole Body	10 gram extraction
		Location D - Richland Cr @ VP	05/18/17	creek chubs	omnivore				16	48	Whole Body	
		Location D - Richland Cr @ VP	05/18/17	creek chubs	omnivore				14	34	Whole Body	
14		Location D - Richland Cr @ VP	05/18/17	creek chubs	omnivore	**125,815**	J	1.00	12	15	Whole Body	10 gram extraction
		Location D - Richland Cr @ VP	05/18/17	creek chubs	omnivore				13	15	Whole Body	
		Location D - Richland Cr @ VP	05/18/17	creek chubs	omnivore				13	17	Whole Body	
15		Location D - Richland Cr @ VP	05/18/17	rock bass	top predators	**320,673**	J	2.33	18	131	Whole Body	10 gram extraction
		Location D - Richland Cr @ VP	05/18/17	rock bass	top predators				17	114	Whole Body	
		Location D - Richland Cr @ VP	05/18/17	rock bass	top predators				19	155	Whole Body	
16		Location D - Richland Cr @ VP	05/18/17	rock bass	top predators	**285,498**	J	2.33	16	101	Whole Body	10 gram extraction
		Location D - Richland Cr @ VP	05/18/17	rock bass	top predators				14	65	Whole Body	
		Location D - Richland Cr @ VP	05/18/17	rock bass	top predators				14	60	Whole Body	
17		Location D - Richland Cr @ VP	05/18/17	longear sunfish	top predators	**archive**		nm	13	50	Whole Body	
		Location D - Richland Cr @ VP	05/18/17	longear sunfish	top predators				13	61	Whole Body	
		Location D - Richland Cr @ VP	05/18/17	longear sunfish	top predators				13	57	Whole Body	
18		Location D - Richland Cr @ VP	05/18/17	longear sunfish	top predators	**224,133**		2.64	12	40	Whole Body	3 gram extraction
		Location D - Richland Cr @ VP	05/18/17	longear sunfish	top predators				11	36	Whole Body	
		Location D - Richland Cr @ VP	05/18/17	longear sunfish	top predators				11	31	Whole Body	
19		Location D - Richland Cr @ VP	05/18/17	hogsucker	bottom feeders	**606,499**		1.91	22	142	Whole Body	3 gram extraction
		Location D - Richland Cr @ VP	05/18/17	hogsucker	bottom feeders				21	124	Whole Body	
		Location D - Richland Cr @ VP	05/18/17	hogsucker	bottom feeders				21	127	Whole Body	
20		Location D - Richland Cr @ VP	05/18/17	white sucker	bottom feeders	**564,972**		2.68	23	140	Whole Body	3 gram extraction
		Location D - Richland Cr @ VP	05/18/17	white sucker	bottom feeders				24	152	Whole Body	
		Location D - Richland Cr @ VP	05/18/17	white sucker	bottom feeders				22	121	Whole Body	
21		Location D - Richland Cr @ VP	05/18/17	white sucker	bottom feeders	**297,479**		2.61	21	112	Whole Body	3 gram extraction
		Location D - Richland Cr @ VP	05/18/17	white sucker	bottom feeders				21	98	Whole Body	
		Location D - Richland Cr @ VP	05/18/17	white sucker	bottom feeders				21	105	Whole Body	
22		Location F - Richland Cr @Hwy 43	05/18/17	rock bass	top predators	**51,506**		0.185	18	131	fillet	10 gram extraction
		Location F - Richland Cr @Hwy 43	05/18/17	rock bass	top predators				19	188	fillet	
		Location F - Richland Cr @Hwy 43	05/18/17	rock bass	top predators				19	157	fillet	
23		Location F - Richland Cr @Hwy 43	05/18/17	rock bass	top predators	**6,358**		0.192	16	85	fillet	10 gram extraction
		Location F - Richland Cr @Hwy 43	05/18/17	rock bass	top predators				18	124	fillet	
		Location F - Richland Cr @Hwy 43	05/18/17	rock bass	top predators				19	162	fillet	
23D		Location F - Richland Cr @Hwy 43	05/18/17	rock bass	top predators	**7,974**		0.192	16	85	fillet	10 gram extraction
		Location F - Richland Cr @Hwy 43	05/18/17	rock bass	top predators				18	124	fillet	
		Location F - Richland Cr @Hwy 43	05/18/17	rock bass	top predators				19	162	fillet	

CBS SAMPLE ID	LAB SAMPLE ID	LOCATION	SAMPLE DATE	FISH SPECIES	FISH GUILD	Total PCB Congeners, pg/g	Validation Flags	LIPIDS, %	LENGTH, (cm)	WEIGHT (gm)	TYPE	COMMENTS
24-right		Location F - Richland Cr @Hwy 43	05/18/17	rock bass	top predators	**15,809**		0.180	20	198	fillet	10 gram extraction
		Location F - Richland Cr @Hwy 43	05/18/17	rock bass	top predators				20	181	fillet	
		Location F - Richland Cr @Hwy 43	05/18/17	rock bass	top predators				20	192	fillet	
25		Location F - Richland Cr @Hwy 43	05/18/17	longear sunfish	top predators	**11,888**		0.545	12	42	fillet	10 gram extraction
		Location F - Richland Cr @Hwy 43	05/18/17	longear sunfish	top predators				12	39	fillet	
		Location F - Richland Cr @Hwy 43	05/18/17	longear sunfish	top predators				11	31	fillet	
26		Location F - Richland Cr @Hwy 43	05/18/17	longear sunfish	top predators	**14,010**		0.714	12	42	fillet	10 gram extraction
		Location F - Richland Cr @Hwy 43	05/18/17	longear sunfish	top predators				11	33	fillet	
		Location F - Richland Cr @Hwy 43	05/18/17	longear sunfish	top predators				11	30	fillet	
27		Location F - Richland Cr @Hwy 43	05/18/17	longear sunfish	top predators	**21,066**		0.742	11	25	fillet	10 gram extraction
		Location F - Richland Cr @Hwy 43	05/18/17	longear sunfish	top predators				11	26	fillet	
		Location F - Richland Cr @Hwy 43	05/18/17	longear sunfish	top predators				11	28	fillet	
28-right		Location F - Richland Cr @Hwy 43	05/18/17	golden redhorse	bottom feeders	**65,163**		1.310	31	342	fillet	10 gram extraction
		Location F - Richland Cr @Hwy 43	05/18/17	golden redhorse	bottom feeders				32	411	fillet	
		Location F - Richland Cr @Hwy 43	05/18/17	golden redhorse	bottom feeders				34	488	fillet	
29-right		Location F - Richland Cr @Hwy 43	05/18/17	white sucker	bottom feeders	**archive**		nm	28	256	fillet	
		Location F - Richland Cr @Hwy 43	05/18/17	white sucker	bottom feeders				26	243	fillet	
		Location F - Richland Cr @Hwy 43	05/18/17	white sucker	bottom feeders				24	173	fillet	
30		Location F - Richland Cr @Hwy 43	05/18/17	golden redhorse	bottom feeders	**12,178**		0.775	31	334	fillet	10 gram extraction
		Location F - Richland Cr @Hwy 43	05/18/17	golden redhorse	bottom feeders				31	364	fillet	
		Location F - Richland Cr @Hwy 43	05/18/17	golden redhorse	bottom feeders				32	389	fillet	

Notes:
VP = Vernal Pike
PCBs in pg/g wet weight
Lipids in % wet weight
nm = not measured
J=estimate due to QC issues
9-21-18 final data

Table 1
Neal's Landfill
Fish Sample Final Validated Data
November 2017
Composites

CBS SAMPLE ID	LAB SAMPLE ID	LOCATION	SAMPLE DATE	FISH SPECIES	FISH GUILD	Total PCB Congeners, pg/g	Validation Flags	LIPIDS, %	LENGTH, (cm)	WEIGHT (gm)	TYPE	COMMENTS
1		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore	**archive**		nm	18	58	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				17	53	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				17	49	Whole Body	
2		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore	**2,566,505**		0.93	16	41	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				16	43	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				16	39	Whole Body	
3		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore	**1,691,504**		0.47	16	36	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				16	35	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				15	28	Whole Body	
4		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore	**1,614,936**		0.21	15	28	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				14	28	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				14	25	Whole Body	
5		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore	**2,796,427**		0.56	13	22	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				14	23	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				13	22	Whole Body	
5D		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore	**3,467,193**		0.56	13	22	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				14	23	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				13	22	Whole Body	
6		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore	**1,370,316**		0.38	13	19	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				13	18	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				13	19	Whole Body	
7		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore	**2,416,320**		0.42	13	18	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				13	20	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				13	19	Whole Body	
8		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore	**1,215,077**		0.41	16	13	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				16	12	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				20	12	Whole Body	
9		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore	**1,081,326**		0.35	12	16	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				12	16	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				12	15	Whole Body	
10		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore	**1,921,554**		0.42	12	14	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				11	16	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				11	14	Whole Body	
11		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore	**archive**		nm	11	13	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				11	12	Whole Body	
		Location B - Conard's Branch @ VP	11/08/17	creek chubs	omnivore				11	12	Whole Body	
12		Location D - Richland Cr @ VP	11/02/17	longear sunfish	top predators	**205,936**		0.90	13	42	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	longear sunfish	top predators				12	26	Whole Body	

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CBS SAMPLE ID	LAB SAMPLE ID	LOCATION	SAMPLE DATE	FISH SPECIES	FISH GUILD	Total PCB Congeners, pg/g	Validation Flags	LIPIDS, %	LENGTH, (cm)	WEIGHT (gm)	TYPE	COMMENTS
		Location D - Richland Cr @ VP	11/02/17	longear sunfish	top predators				13	40	Whole Body	
13		Location D - Richland Cr @ VP	11/02/17	rock bass	top predators	**431,794**		1.02	13	75	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	rock bass	top predators				20	169	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	rock bass	top predators				15	66	Whole Body	
14		Location D - Richland Cr @ VP	11/02/17	rock bass	top predators	**271,558**		1.57	14	38	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	rock bass	top predators				14	45	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	rock bass	top predators				11	27	Whole Body	
15		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore	**89,189**		0.60	14	28	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore				15	34	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore				17	44	Whole Body	
16		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore	**186,615**		0.24	18	65	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore				17	55	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore				17	55	Whole Body	
17		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore	**81,797**		0.22	14	35	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore				15	30	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore				16	49	Whole Body	
18		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore	**archive**			12	17	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore				12	17	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore				13	21	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	creek chub	omnivore				12	16	Whole Body	
19		Location D - Richland Cr @ VP	11/02/17	white sucker	bottom feeders				19	65	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	white sucker	bottom feeders	**423,253**		0.37	28	157	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	white sucker	bottom feeders				19	68	Whole Body	
20		Location D - Richland Cr @ VP	11/02/17	white sucker	bottom feeders		J		19	65	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	white sucker	bottom feeders	**36,429**		1.87	19	52	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	white sucker	bottom feeders				17	50	Whole Body	
20D		Location D - Richland Cr @ VP	11/02/17	white sucker	bottom feeders		J		19	65	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	white sucker	bottom feeders	**47,538**		1.87	19	52	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	white sucker	bottom feeders				17	50	Whole Body	
21		Location D - Richland Cr @ VP	11/02/17	white sucker	bottom feeders				20	84	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	white sucker	bottom feeders	**70,036**		0.10	17	49	Whole Body	
		Location D - Richland Cr @ VP	11/02/17	white sucker	bottom feeders				12	25	Whole Body	
22		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators	**71,064**	J	1.44	12	36	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				11	24	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				11	21	fillet	
23		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators	**55,419**	J	1.00	11	21	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				10	15	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				10	21	fillet	
24		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators	**41,671**	J	2.33	14	48	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				14	48	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				14	57	fillet	
25		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators	**40,899**	J	0.50	15	66	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				14	58	fillet	

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CBS SAMPLE ID	LAB SAMPLE ID	LOCATION	SAMPLE DATE	FISH SPECIES	FISH GUILD	Total PCB Congeners, pg/g	Validation Flags	LIPIDS, %	LENGTH, (cm)	WEIGHT (gm)	TYPE	COMMENTS
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				14	52	fillet	
26		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators	**25,807**	J	3.42	13	42	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				13	46	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				12	28	fillet	
27		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators	**archive**		nm	11	25	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				11	21	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				10	20	fillet	
28		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators	**archive**		nm	10	17	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				9	14	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	longear sunfish	top predators				9	12	fillet	
29		Location F - Richland Cr @Hwy 43	11/08/17	rock bass	top predator	**21,337**	J	0.51	19	111	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	rock bass	top predator				16	78	fillet	
		Location F - Richland Cr @Hwy 43	11/08/17	rock bass	top predator				11	20	fillet	
30		Location F - Richland Cr @Hwy 43	11/02/17	white sucker	bottom feeder	**188,945**	J	0.55	29	220	fillet	
		Location F - Richland Cr @Hwy 43	11/02/17	white sucker	bottom feeder				29	237	fillet	
		Location F - Richland Cr @Hwy 43	11/02/17	white sucker	bottom feeder				30	275	fillet	
31		Location F - Richland Cr @Hwy 43	11/02/17	white sucker	bottom feeder	**123,114**	J	0.06	27	205	fillet	
		Location F - Richland Cr @Hwy 43	11/02/17	white sucker	bottom feeder				22	120	fillet	
		Location F - Richland Cr @Hwy 43	11/02/17	white sucker	bottom feeder				20	110	fillet	
31D		Location F - Richland Cr @Hwy 43	11/02/17	white sucker	bottom feeder	**65,931**	J	0.06	27	205	fillet	
		Location F - Richland Cr @Hwy 43	11/02/17	white sucker	bottom feeder				22	120	fillet	
		Location F - Richland Cr @Hwy 43	11/02/17	white sucker	bottom feeder				20	110	fillet	
32		Location F - Richland Cr @Hwy 43	11/02/17	hogsucker	bottome feeder	**archive**		nm	23	147	fillet	
		Location F - Richland Cr @Hwy 43	11/02/17	hogsucker	bottome feeder				24	183	fillet	
		Location F - Richland Cr @Hwy 43	11/02/17	hogsucker	bottome feeder				25	156	fillet	

Notes:

VP = Vernal Pike

PCBs in pg/g wet weight

Lipids in % wet weight

nm = not measured

J=estimate due to QC issues

Note that data for sample locations 2 thru 10 are externally diluted and not adjusted for original extraction efficiency.

All samples are composites from three fish

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Appendix C
Statistical Analysis

Post-Remediation Data Analysis Process

Before statistical hypothesis testing for Consent Decree Amendment (CDA) Section IX.C.2 was performed (as described in Section 3.2), data were reviewed and summarized statistically by location (see Table C-1) and by location and sampling event (see Table C-2). Data were then checked for parametric assumptions of normality (by location) and equal variance (by location and by sampling event). This checking was done qualitatively by examining quantile and box plots (see Figures C-1 through C-4). A straight line in the quantile plots indicates that the data are normally distributed or, if log-transformed, lognormally distributed. Boxplots give a visual indication of sample variance. Findings were confirmed quantitatively using a Shapiro-Wilk test and equal variance test. Raw data from Locations B and F met the normality and equal variance assumptions in May and November, whereas raw data from Location F did not (see Tables C-3 and C-4). Examination of quantile plots indicated that the Location F data were likely lognormally distributed (see Figure C-3); therefore, the Location F data were natural log transformed and retested (see Figure C-4). After transformation, Location F data met assumptions of normality and equal variance across the two sampling events (see Table C-3 and C-4).

Table C-1
Statistical Summary of Post-Remediation Data by Location

Location	Sample Size		Target Concentration (µg/g)	Total PCB Concentration (µg/g)				
	n_{May}	n_{Nov}		Mean	Median	Pooled Sample Variance[1], s_p^2	Pooled Sample Standard Deviation, s_p	Standard Error of the Sample Mean, $s_{\bar{Z}}$
B	10	10	2.3	1.894	1.807	0.41	0.64	0.14
D	10	10	0.9	0.242	0.215	0.025	0.16	0.035
F	9	9	0.2	0.047	0.033	0.002	0.04	0.010

Notes:
1. Equations for s_p^2 and $s_{\bar{Z}}$ are given in Section 3.2 of the *Post-Remediation Fish Sampling Data Analysis Report*.
See Appendix B for full post-remediation data set.
µg/g: microgram per gram
PCB: polychlorinated biphenyl

Table C-2
Statistical Summary of Post-Remediate Data by Location and Sampling Event

Location	Sampling Event	Sample Size, n	Total PCB Concentration (µg/g)		
			Mean	Median	Sample Variance, *s*
B	May	10	1.774	1.735	0.228
B	November	10	2.014	1.807	0.598
D	May	10	0.299	0.259	0.027
D	November	10	0.184	0.138	0.022
F	May	9	0.023	0.014	4.337E-04
F	November	9	0.070	0.055	2.896E-03

Note:
See Appendix B for full post-remediation data set.

Table C-3
Results of Shapiro-Wilk Test for Normality

Location	Sample Event	Data Transformation	Sample Size, n	W	p-value
B	All	None	20	0.929	0.148
B	May	None	10	0.909	0.276
B	November	None	10	0.943	0.582
D	All	None	20	0.923	0.114
D	May	None	10	0.850	0.058
D	November	None	10	0.854	0.064
F	All	None	18	0.779	**0.001**
F	May	None	9	0.747	**0.005**
F	November	None	9	0.828	**0.042**
F	All	Natural Log	18	0.973	0.845
F	May	Natural Log	9	0.911	0.322
F	November	Natural Log	9	0.969	0.883

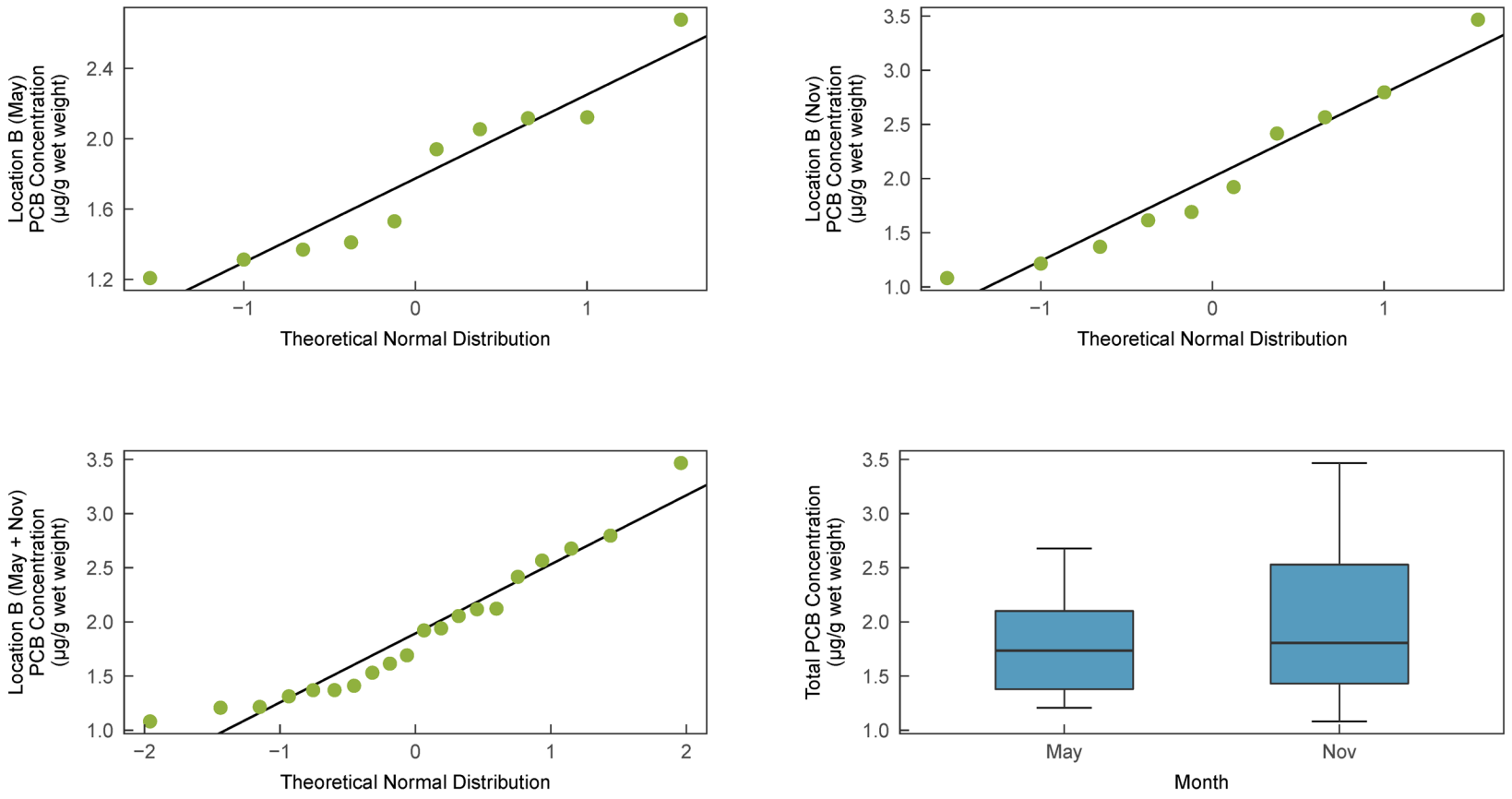
Notes:
See Appendix B for the full post-remediation dataset.
Bold: tests where H_0 is rejected ($p<0.05$)
H_0: data are normally distributed
W: test statistic

Table C-4
Results of Equal Variance Test of May and November Sample Events

Location	Data Transformation	May Sample Size, n_1	November Sample Size, n_2	F	p-value
B	None	10	10	0.381	0.166
D	None	10	10	1.214	0.777
F	None	9	9	0.150	**0.015**
F	Natural Log	9	9	1.257	0.754

Notes:
See Appendix B for the full post-remediation dataset.
Bold: tests where H_0 is rejected ($p<0.05$)
F: test statistic
H_0: ratio of variance is 1

Figures



Notes: Quantile-quantile plots compare sample data on the y-axis to a standard normal population on the x-axis with corresponding quantiles plotted against each other. The line with slope equal to the sample standard deviation and intercept equal to the sample mean is shown in black. A straight line indicates the sample data represent a population with a normal distribution. Data from the May and November 2017 sampling events are shown in the top panels. The bottom left panel show shows all 2017 sample data for Location B. In the lower right panel, blue boxes correspond to the 25% and 75% quantiles, and the middle line corresponds to the 50% quantile (median). The vertical lines extending up and down from the blue boxes indicate the range of data lying within 1.5 times the interquartile range. Any data outside this range are represented as black dots.

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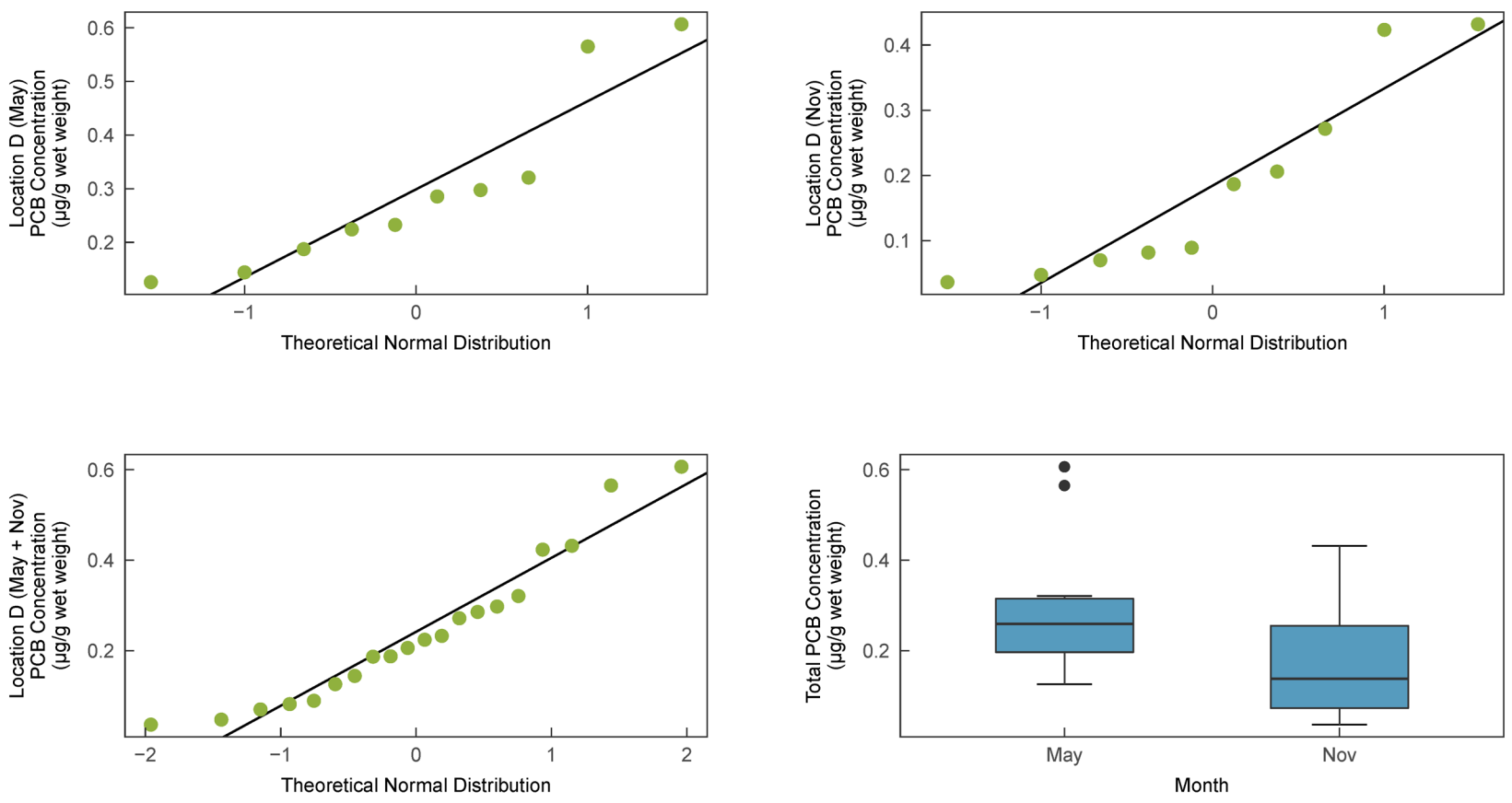
Figure C-1
Post-Remediation Location B PCB Concentration Quantile-Quantile Plots and Box Plots
Post-Remediation Fish Sampling Data Analysis Report
Neal's Landfill Site



Notes: Quantile-quantile plots compare sample data on the y-axis to a standard normal population on the x-axis with corresponding quantiles plotted against each other. The line with slope equal to the sample standard deviation and intercept equal to the sample mean is shown in black. A straight line indicates the sample data represent a population with a normal distribution. Data from the May and November 2017 sampling events are shown in the top panels. The bottom left panel show shows all 2017 sample data for Location D. In the lower right panel, blue boxes correspond to the 25% and 75% quantiles, and the middle line corresponds to the 50% quantile (median). The vertical lines extending up and down from the blue boxes indicate the range of data lying within 1.5 times the interquartile range. Any data outside this range are represented as black dots.

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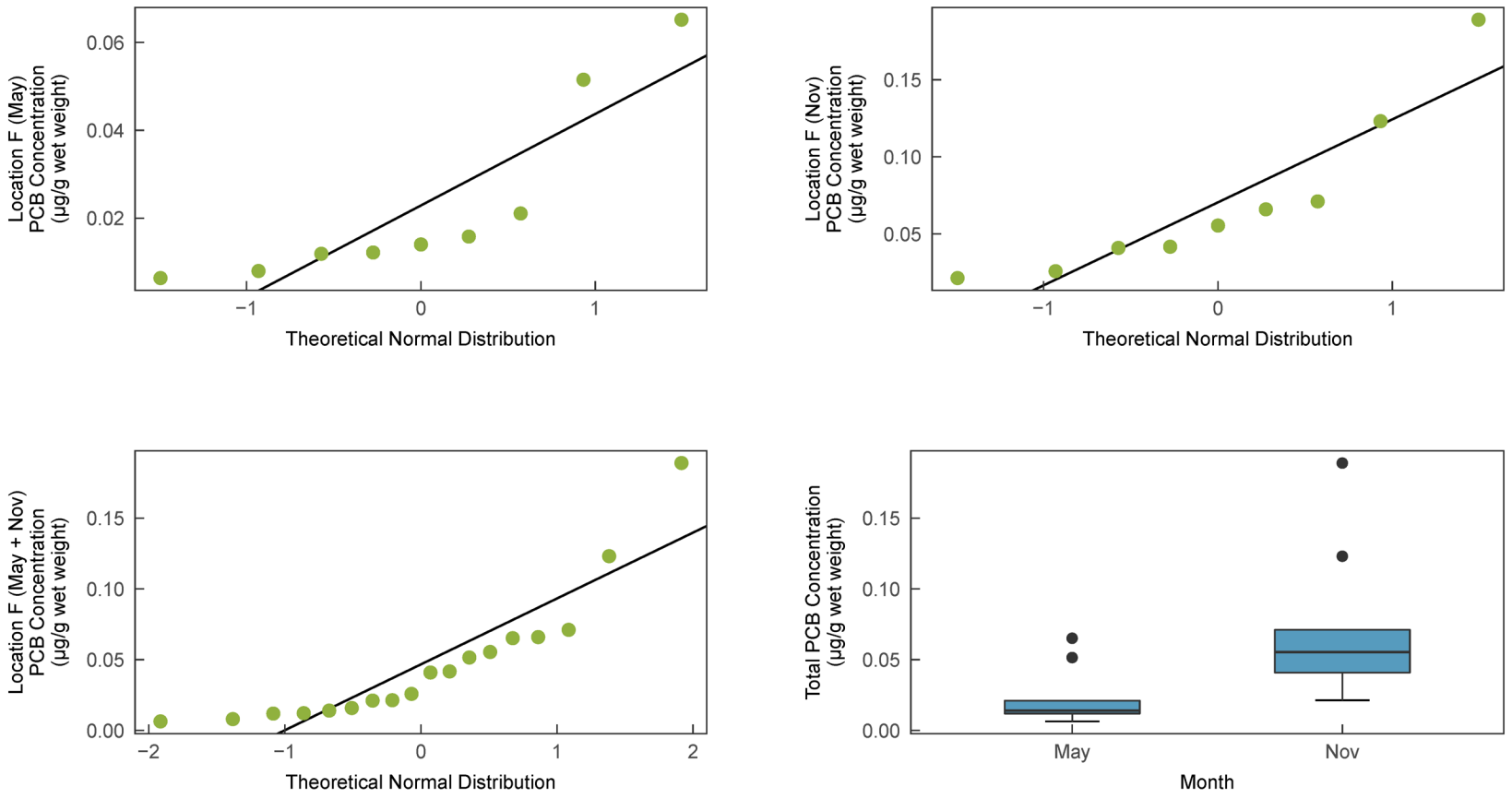
Figure C-2
Post-Remediation Location D PCB Concentration Quantile-Quantile Plots and Box Plots
Post-Remediation Fish Sampling Data Analysis Report
Neal's Landfill Site



Notes: Quantile-quantile plots compare sample data on the y-axis to a standard normal population on the x-axis with corresponding quantiles plotted against each other. The line with slope equal to the sample standard deviation and intercept equal to the sample mean is shown in black. A straight line indicates the sample data represent a population with a normal distribution. Data from the May and November 2017 sampling events are shown in the top panels. The bottom left panel show shows all 2017 sample data for Location F. In the lower right panel, blue boxes correspond to the 25% and 75% quantiles, and the middle line corresponds to the 50% quantile (median). The vertical lines extending up and down from the blue boxes indicate the range of data lying within 1.5 times the interquartile range. Any data outside this range are represented as black dots.

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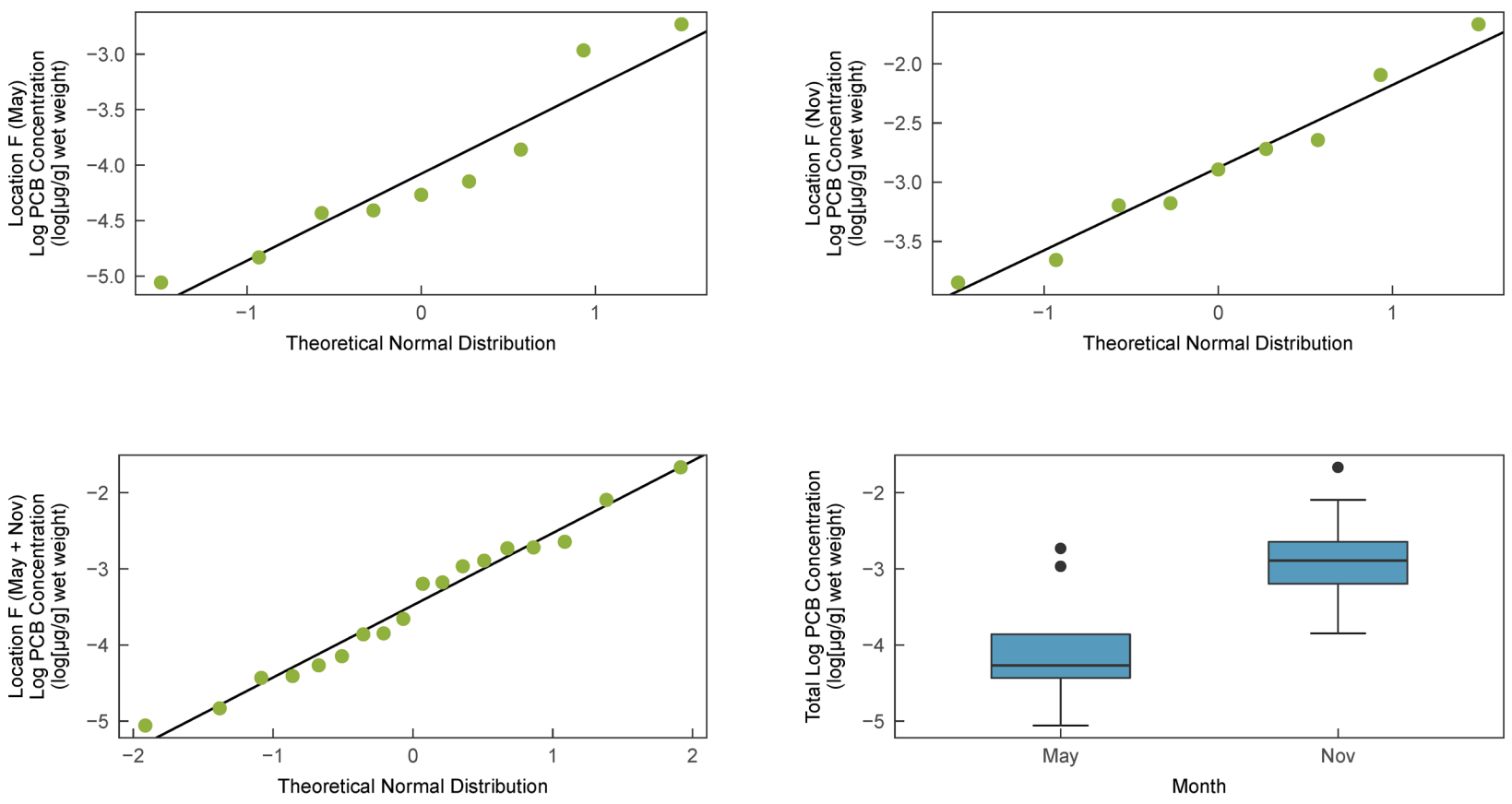
Figure C-3
Post-Remediation Location F PCB Concentration Quantile-Quantile Plots and Box Plots
Post-Remediation Fish Sampling Data Analysis Report
Neal's Landfill Site



Notes: Quantile-quantile plots compare log-transformed sample data on the y-axis to a standard normal population on the x-axis with corresponding quantiles plotted against each other. A line with slope equal to the sample log-transformed standard deviation and intercept equal to the sample log-transformed mean is shown in black. Because the data have been log-transformed, a straight line indicates the sample data represent a population with a log-normal distribution. Data from the May and November 2017 sampling events are shown in the top panels. The bottom left panel show shows all 2017 sample data for Location F. In the lower right panel, blue boxes correspond to the 25% and 75% quantiles, and the middle line corresponds to the 50% quantile (median). The vertical lines extending up and down from the blue boxes indicate the range of data lying within 1.5 times the interquartile range. Any data outside this range are represented as black dots.

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Figure C-4

Post-Remediation Location F Log Transformed PCB Concentration Quantile-Quantile Plots and Box Plots

Post-Remediation Fish Sampling Data Analysis Report
Neal's Landfill Site