5.6.6.2.3 September 2012 Sampling Event

The September 2012 sampling event included the collection of groundwater from well P9. Consultants installed well P9 at the toe of the UPA directly above the observed seep at the head of the central drainage pathway, as illustrated in **Figure 34**.

Figure 34: Location of P9 and Observed Intermittent Seep Area

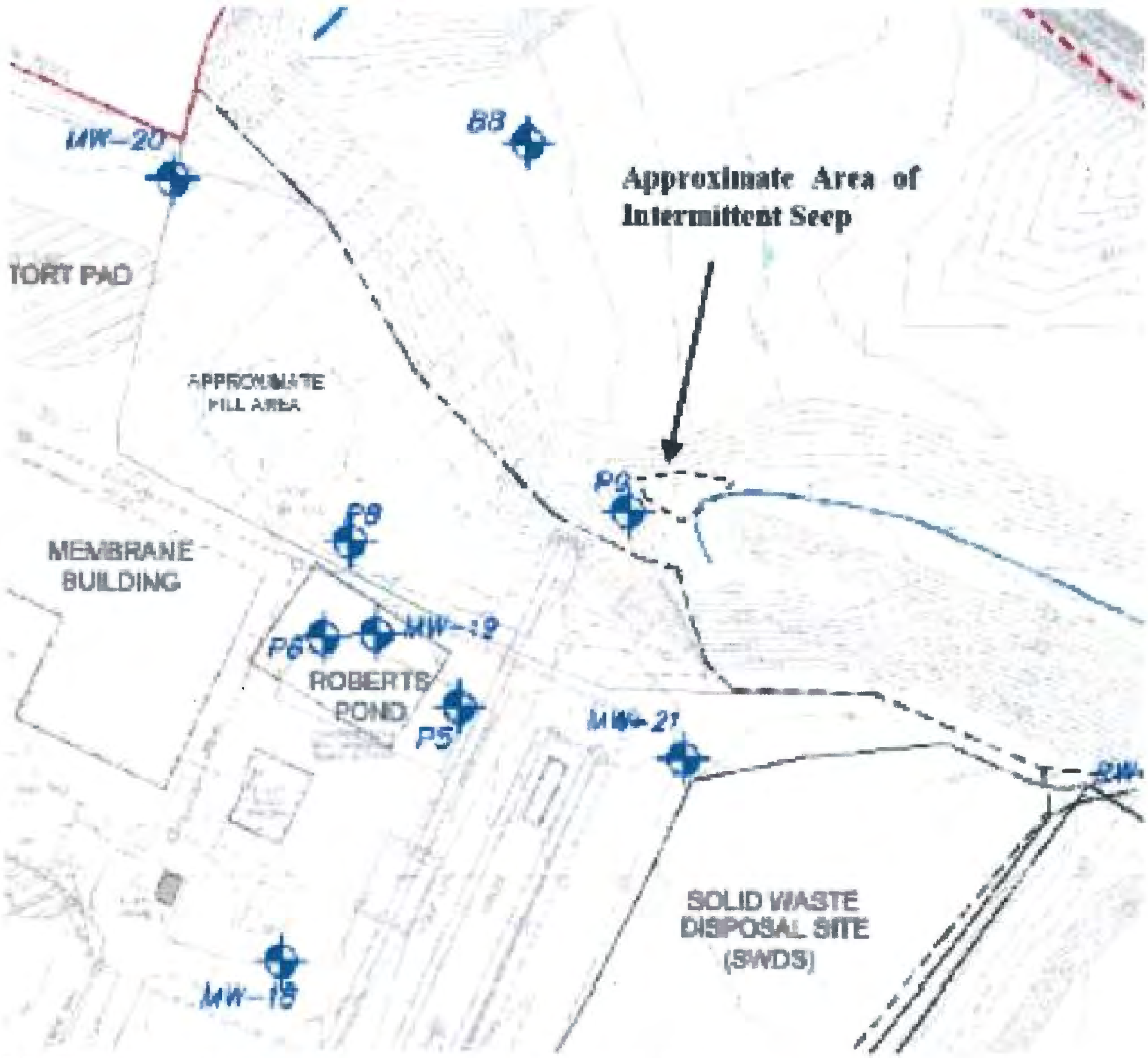


Illustration 5-3: Observed Intermittent Seep Area

Filtered and unfiltered groundwater samples were analyzed for mercury and Aroclor 1268. Mercury was not detected in either sample. Aroclor 1268 was detected at concentrations below the MCL in the unfiltered sample, but not detected in the filtered sample. The filtered results suggest particulates in the sample may have affected the detection of Aroclor 1268 in the unfiltered sample. **Table 82** summarizes the analytical results.

Table 82: Groundwater Data for Mercury and Aroclor 1268 in September 2012

Analyte	Standard		P-09 unfiltered	P-09 filtered
	2L	MCL	WBA	
mercury	1	2	< 0.15	< 0.15
Aroclor 1268	NE	0.5	0.131	< 0.0651

Notes:

Samples were only analyzed for mercury and Aroclor 1268

Concentrations units are milligrams per liter (mg/L)

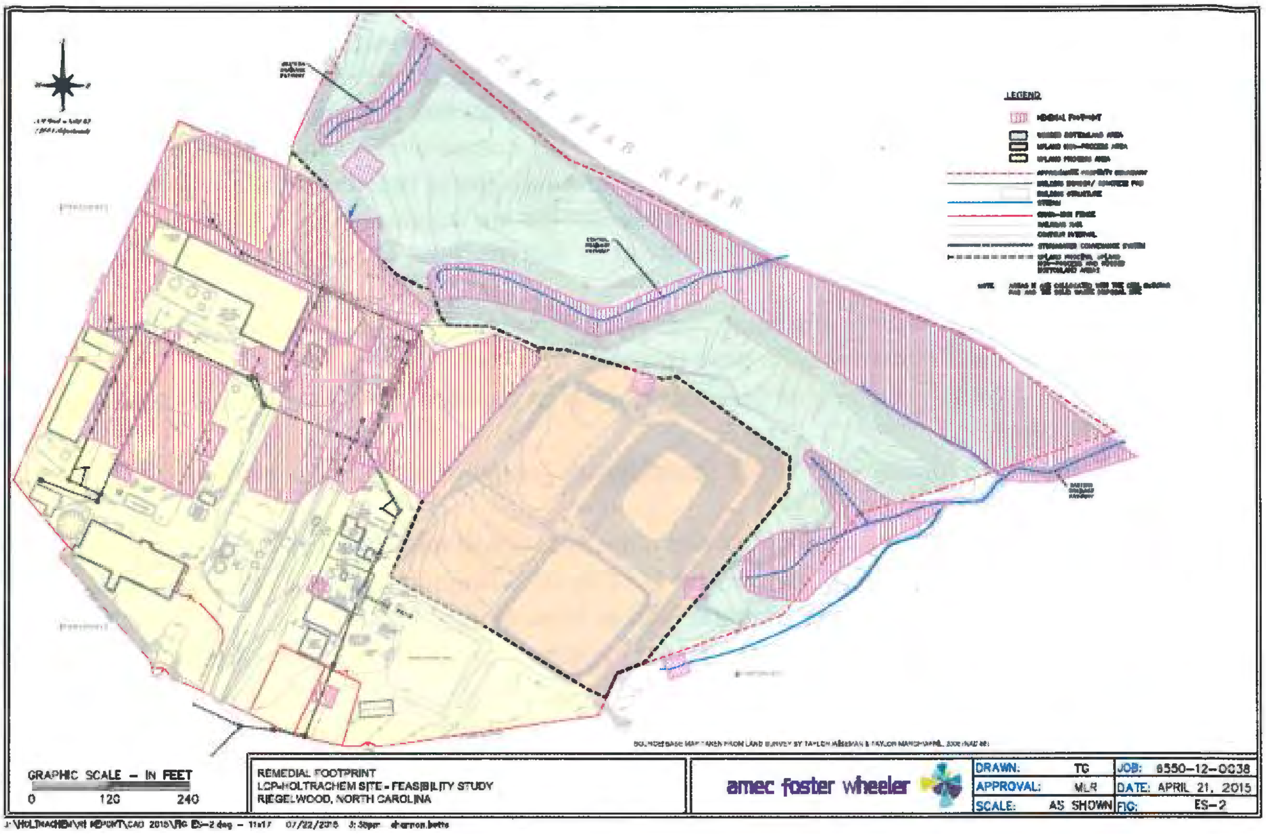
2L = Title 15A North Carolina Administrative Code Subchapter 2L Groundwater Standards (I5A NCAC 2L Standard)

MCL = Safe Drinking Water Act's Maximum Contaminant Level

5.7 Location of Contamination and Routes of Migration

5.7.1 Location of Contamination

Figure 35: Remedial Footprint



Soil, Sediment and Surface Water

The pink shading in **Figure 35** illustrates areas that have contaminated soil, sediment and surface water at concentrations that may pose unacceptable risks to human health and/or the environment. Contamination depths vary across the site from only at the surface to ten feet or greater below land surface. It is estimated that there are approximately 75,000 yd^3 of contaminated soil, sediment and WWTS. The surface water becomes contaminated in the drainage pathways that are ephemeral and flow directly to the river. A calculation of volume of surface water was not estimated due to the variability.

Air

Currently, occasional concentrations of mercury are detected at the site during air monitoring events. The concentrations do not pose an unacceptable risk to human health or the environment.

Groundwater

Contamination was detected in groundwater in the surficial deposits. The contamination does not pose an unacceptable risk to human health or the environment. The water table ranges from less than one foot bgs to 13 feet bgs. No appreciable vertical flow is expected due to low formation permeability in the Peedee confining unit.

Groundwater in the surficial deposits at the site cannot be used for potable purposes according to 15A NCAC 2C.0107, because potable wells should be cased to a minimum depth of 35 feet bgs. Groundwater in the Peedee formation at the site cannot be a portable water supply due to its low permeability and low flow conditions estimated at about 20 gallons per day. Formations beneath the Peedee are reportedly naturally saline and would not be used for potable water purposes.

Based on multiple criteria, the aquifer does not meet the requirements specified in the EPA "Guidelines for Ground-Water Classification Under the EPA Groundwater Protection Strategy" to be considered a drinking water aquifer and is characterized as a EPA Class III, Subclass IIIA, not suitable as a potential source of drinking water and of limited beneficial use, and the human health and ecological pathways for groundwater are incomplete. This determination on groundwater is based on multiple lines of evidence that indicate detected constituents in groundwater are not migrating and that there is no current or future detriment to human health or the environment by this medium. The evidence supporting this determination is summarized below:

- Former production processes and equipment related to manufacturing that could produce additional sources of contamination were removed from the site.
- The time and direction of travel of the contaminants in groundwater have been projected with reasonable certainty.
- The only adjacent property onto which groundwater contaminants could migrate is the IP property.
- The groundwater data does not indicate site constituents will migrate onto the IP property.
- An existing public water supply system for the City of Wilmington, IP, the site, and surrounding community is dependent on surface water intakes from the Cape Fear River upstream of the site.
- The detected groundwater constituents are not expected to reach the Cape Fear River, which is the nearest downgradient surface water body.
- The thickness, hydraulic conductivity, and recharge rates observed for the shallow, perched aquifer fail to meet the minimum productivity requirements for it to be a drinking water aquifer.

5.7.2 Potential Routes of Current and Future Migration

Figure 9 on page 20 illustrates the Conceptual Site Model showing migration pathways. Potential current and future migration of contaminants could occur via

- overland flow of rain water that may transport contaminated soil and/or sediment to the WBA and Cape Fear River,
- permitted discharges of water to the Cape Fear River,
- potential damage to the Engineered Stockpiles, retention basins, etc. from a hurricane or tropical storm,
- atmospheric deposition, and
- leaching of contaminants into groundwater.

<u>Rainwater Migration Pathway</u>
Contaminated sediment within the drainage pathways is likely to be mostly immobile during low flow conditions and mobile during high flow conditions. Examples of high flow conditions include heavy precipitation or flooding events. The drainage pathways discharge uncontrolled storm water and possibly soil and sediment run-off into the Cape Fear River.

In June and August 2006, surface water samples were collected from drainage pathways during two extreme rain events. These two rainfall events had more rain than 91% and 99.95% of other rainfall events recorded at the U.S. Geological Survey's gauge for that year. The results for the eastern and central ditches indicate the storm water samples fall within the same range of the surface water concentrations for these two ditches. The western ditch results indicate the largest change in concentrations, where each of the compounds detected were higher for the storm water samples than the surface water samples. The Total Suspended Solids (TSS) concentration for the western ditch for the storm water results was also higher, suggesting a more turbid sample compared to the surface water samples. The data provides some indication that contaminated sediment in the drainage ditches may become mobile during storm events or flooding.

Permitted Discharges

The facility treats collected storm water and then sends it to IP. IP has an NPDES permit to discharge its treated water to the Cape Fear River. Contamination may migrate via this permitted discharge.

Hurricane and/or Tropical Storm Damage

The site has been affected by numerous hurricanes and tropical storms. A plan is currently in place to prepare for such events to minimize damage. However, there currently remains a potential that a major storm could cause damage to the Engineered Stockpiles, retention basins, stored chemicals used in the waste water treatment process, etc.

Atmospheric Deposition

Air monitoring is conducted at the facility frequently for mercury. Since the Engineered Stockpile #1 was placed on top of the former Mercury Cell Building, the concentrations of mercury detected in the air have reduced drastically. This migration pathway is minimal.

Leaching to groundwater

In general, the potential soil to groundwater transport mechanism is chemical leaching of constituents from soils or waste disposal areas, and transport through the shallow vadose zone to the water table. The two primary contaminants, mercury and Aroclor 1268, strongly sorb to soils at the site limiting their ability to leach. The groundwater data does not indicate site constituents will migrate onto the IP property or into the Cape Fear River. The transport of contaminants in groundwater is also restricted by the Peedee Formation confining unit.

Mercury is strongly sorbed to humic materials and sesquioxides in soils and sediments at a pH higher than four and to the surface layer of peat. Mercury is also sorbed to sediments and soils with high iron and aluminum content, which has been readily observed at the site. Once sorbed to soil and particulate material, inorganic mercury is often not readily desorbed.

The ability of PCBs to be degraded or transformed in the environment depends on the degree of chlorination of the biphenyl molecule as well as on the isomeric substitution pattern. Aroclors 1254 and 1268 are some of the more chlorinated compounds in the PCB family, they strongly sorb to soil as a result of their low water solubility and high K_{ow}.[8] Subsequently, this condition greatly limits these Aroclors ability to leach in soils. Higher clay and organic content, such as is the case with much of the site soil, also substantially reduces leaching of these Aroclors into groundwater.

[8] K_{ow} is the octanol: water distribution coefficient.

6.0 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

The facility ceased operations in 2000. Currently, the site use is limited to security, maintenance and storm water management. The majority of Columbus County, including the site property, is zoned "General Use".[9] The site and immediately surrounding property to the south, east and west include industrial facilities. The Cape Fear River borders the north side of the site. Property north of the Cape Fear River is undeveloped low-lying land. The closest residential property is located about 0.9 mile southwest, just outside the IP property boundary.

IP and the City of Wilmington use the Cape Fear River as a source for drinking water. IP maintains a surface water intake about ¼-mile west (upstream) of the site, where they draw river water into the Riegelwood Mills water treatment facility for local distribution. The City of Wilmington maintains a surface water intake 8.3 miles upstream of the site. People also use the Cape Fear River near the site recreationally.

Reasonably anticipated future land use of the site is industrial/vacant. Heavily industrialized IP is a thriving business that surrounds the site on three sides. EPA anticipates that the current land use will remain in place. Based on multiple criteria, the aquifer is characterized as an EPA Class III, Subclass IIIA, not suitable as a potential source of drinking water and of limited beneficial use per "Guidelines for Ground-Water Classification Under the EPA Groundwater Protection Strategy", and the human health and ecological pathways for exposure to contaminated groundwater are incomplete. Data indicates that detected constituents in groundwater are not migrating and are not causing detriment to human health or the environment.

[9] http://mangomap.com/maps/20702/Columbus-County-Zoning#

Figure 36: Columbus County Zoning

7.0 SUMMARY OF SITE RISKS

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

7.1 Human Health Risk Assessment

The baseline risk assessment estimates what risks the site poses if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that the remedial action needs to address. This section of the ROD summarizes the results of the baseline risk assessment.

7.1.1 Identification of Chemicals of Concern

The following three tables present the chemicals of concern (COCs) and exposure point concentration (EPC) for each of the COCs detected in surface soil, subsurface soil and surface water, respectively. They also include the range of concentrations detected for each COC, the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), and how the EPC was derived. EPC is the concentration that is used to estimate the exposure and risk from each COC. Sediment, groundwater and air data did not indicate risks to human health; therefore, only surface soil, subsurface soil and surface water are included in the tables.

The data indicates that Aroclor 1268, mercury, and 2,3,7,8-TCDD TEQ are the most frequently detected COCs in soils and surface water at the site. Aroclor 1254 and benzo(a)pyrene are less frequently detected, but contribute towards risks posed to human health.

Table 83: Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Surface Soil

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil (0-1 foot)

Exposure Point	Chemical of Concern	Concentration Detected		Frequency of Detection		Exposure Point Concentration *	Statistical Measure
		Minimum*	Maximum*	Percent	Number of Samples		
Upland Area Surface Soil	Aroclor-1268	0.016 J	2,700	99%	82/83	2,600	95% UCL-t
	benzo(a)pyrene	0.036 J	26 D	28%	17/61	3.5	97.5% Cheb-m
	mercury	0.0184 J	1,300	99%	196/197	2,800	99% Cheb-m
Wooded Bottomland Area Surface Soil	Aroclor-1254	0.0045 J	67	46%	19/41	20	99% Cheb-m
	Aroclor-1268	0.098	3,800	100%	39/39	1,300	97.5% Cheb
	2,3,7,8-TCDD TEQ (dioxins/furans)	0.00000115	0.001384	100%	29/29	0.0013	97.5% Cheb
	2,3,7,8-TCDD TEQ (PCBs)	0.00000032	0.000282	100%	29/29	0.00014	95% Cheb

Notes:
* = Concentrations are expressed in parts per million (ppm). In this table ppm = milligrams per kilogram (mg/kg)
Cheb = Chebyshev Minimum Variance Unbiased Estimate (MVUE) of Upper Confidence Limit (UCL)
Cheb-m = Chebyshev (mean,std) Upper Confidence Limit (UCL)
D = result reported from dilution
J = compound was detected below the reporting limit in the sample
PCBs = polychlorinated biphenyls
TCDD TEQ =tetrachlorodibenzo-p-dioxin toxicity equivalent quotient
UCL-t = Upper Confidence Limit of Log-transformed Data, H-Statistic

Table 84: Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Subsurface Soil

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Subsurface Soil (1-10 feet)

Exposure Point	Chemical of Concern	Concentration Detected		Frequency of Detection		Exposure Point Concentration *	Statistical Measure
		Minimum*	Maximum*	Percent	# of Samples		
Upland Area Subsurface Soil	Aroclor-1254	0.0074 J	5.1	25%	25/101	3	97.5% Cheb-m
	Aroclor-1268	0.0036 J	2,700	96%	224/233	2,900	99% Cheb-m
	mercury	0.00822 J	11,000 X	99%	343/348	4,400	99% Cheb-m

Notes:
* = Concentrations are expressed in parts per million (ppm). In this table ppm = milligrams per kilogram (mg/kg)
Cheb-m = Chebyshev (mean,std) Upper Confidence Limit (UCL)
J = compound was detected below the reporting limit in the sample
X = sample contained beads of mercury

Table 85: Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Surface Water

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Wooded Bottomland Area Drainage Pathway Surface Water

Exposure Point	Chemical of Concern	Concentration Detected		Frequency of Detection		Exposure Point Concentration *	Statistical Measure
		Minimum*	Maximum*	Percent	# of Samples		
Surface Water	Aroclor-1268	0.062	17	80%	12/15	4.4	App. Gamma
	Total 2,3,7,8-TCDD TEQ (dioxin/furan)	3.34E-06	3.38E-04	100%	6/6	3.40E-04	Max
	Total 2,3,7,8-TCDD TEQ (PCB)	3.20E-06	1.19E-04	100%	4/4	1.20E-04	Max

Notes:
* = Concentrations are expressed in parts per billion (ppb). In this table ppb = micrograms per liter (µg/L)
App. Gamma = Approximate Gamma
J = compound was detected below the reporting limit in the sample
Max = Maximum Detected Value
TCDD TEQ =tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

7.1.2 Exposure Assessment

EPA risk assessment guidance documents and professional judgement were used to determine exposure intakes from soil, indoor air and surface water. These were based on the Conceptual Site Model (**Figure 9** on page 20). There is not an exposure pathway for groundwater. Potentially exposed populations include current and future trespassers, recreators, and anglers, as well as future industrial and construction workers.

The HHRA included both reasonable maximum exposure (RME) and central tendency exposure (CTE) intake calculations. RME intakes protect 95% or greater of the study population, while CTE intakes address moderate or median exposure scenarios. The HHRA discussed CTE intakes and related risk calculations in the Uncertainties section, used primarily as supplemental information and a risk management tool.

7.1.3 Toxicity Assessment

In the HHRA, the hierarchy of sources used for toxicity values was:

1) Integrated Risk Information System (IRIS),
2) Provisional Peer-Reviewed Threshold Values (PPRTVs) as presented in the Region 9 Preliminary Remediation Goal (PRG) Table, and
3) other sources such as the Human Effects Assessment Summary Tables (HEAST), National Center for Environmental Assessment (NCEA), and California EPA values as presented in the Region 9 PRG Table.

Oral reference doses (RfDs) and cancer slope factors (CSFs) were revised in accordance with Risk Assessment Guidance for Superfund (RAGS) Part E guidance. The HHRA provided a brief toxicity profile of mercury, PCBs, and dioxins furans.

7.1.4 Risk Characterization

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

Risk = CDI x SF

where: risk = a unitless probability (e.g., 2×10^{-5}) of an individual developing cancer
CDI = chronic daily intake averaged over 70 years (mg/kg-day)
SF = slope factor, expressed as $(\text{mg/kg-day})^{-1}$.

These risks are probabilities that usually are expressed in scientific notation (e.g., $1\text{x}10^{-6}$). An excess lifetime cancer risk of $1\text{x}10^{-6}$ indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in million chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual's developing cancer from all other causes has been estimated to be as high as one in three. EPA's generally accepted risk range for site-related exposures is 10^{-4} to 10^{-6}.

The potential for non-carcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., life-time) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). A HQ less than 1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic non-carcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all chemical(s) of concern that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. A HI less than 1 indicates that, based on the sum of all HQ's from different contaminants and exposure routes, toxic non-carcinogenic effects from all contaminants are unlikely. A HI greater than 1 indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

Non-cancer HQ = CDI/RfD

where: CDI = Chronic daily intake
RfD = reference dose.

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

The HHRA identified cancer risks and non-cancer hazards. The following paragraphs summarize the estimates for each receptor:

Industrial Worker - Upland Surface Soil Exposures: Arsenic, six carcinogenic PAHs, dioxins, furans, and PCBs were associated with estimated carcinogenic risk greater than 10^{-6}. Mercury and Aroclor 1268 had hazard indices greater than 0.1. The primary exposure pathways were dermal absorption and ingestion of soil.

Industrial Worker - Indoor Air Exposures: VOCs in indoor air were associated with risks ranging from 1 x 10^{-5} in the Air Compressor Building to 8 x 10^{-5} in the New Cell Building. COCs per locations include

- **Air Compressor Building**: benzene, chloroform and trimethylbenzene;
- **New Cell Building**: benzene, chloroform, tetrachloroethene, trichloroethene, and vinyl chloride;
- **Office Building**: benzene and chloroform;
- **Prep Building**: benzene and chloroform

Trimethylbenzene and bromomethane were also estimated to have inhalation hazard indices greater than 0.1.

Hazards associated with mercury in ambient air (which were assumed to be mercury salts and not elemental mercury based on the sampling locations) were addressed by considering inhalation exposures to soil particulates and volatiles for industrial workers, construction workers, and trespassers. Calculated hazard indices for mercury by the inhalation pathways were well below one.

Detected concentrations of mercury and VOCs were either less than current industrial air Regional Screening Levels or are within the national background range for residential properties. Thus, these data do not indicate a risk from the vapor intrusion pathway.

Trespasser - Upland Surface Soil Exposures: Risk greater than 10^{-6} was associated with benzo(a)pvrene, dibenzo(a.h)anthracene, dioxins, furans, and PCBs in surface soils. Mercury and Aroclor 1268 were associated with hazard indices greater than 0.1. The primary pathways were dermal absorption and ingestion.

<u>Construction Worker - Upland Surface and Subsurface Soil Exposures</u>: Risk greater than 10^{-6} was associated with benzo(a)pvrene, iron, mercury. Aroclor 1254 and Aroclor 1268 were associated with hazard indices greater than 0.1. The primary pathways were dermal absorption and ingestion.

<u>Trespasser Recreator - Bottomland Surface Soil Exposures</u>: Dioxins furans and PCBs were associated with risk greater than 10^{-6}. Aroclor 1254 and Aroclor 1268 were associated with hazard indices greater than 0.1.

<u>Surface Water Exposures</u>: By the dermal pathway, dioxins furans and PCBs were associated with risk greater than 10^{-6}. Aroclor 1254 and Aroclor 1268 had hazard indices greater than 0.1.

<u>Resident Angler - Fish ingestion from the Cape Fear River:</u> DDD, DDE, DDT, Aldrin, dieldrin, alphachlordane, gamma-chlordane, and bis-2-ethvlhexylphtlialate were associated with risk greater than 10^{-6}. Dioxins, furans and PCBs were associated with risks greater than 10^{-6}. DDD and Aroclor 1268 were associated with hazard indices greater than 0.1.

7.1.5 Uncertainty Analysis

The HHRA includes a discussion of uncertainty associated with the data evaluation, exposure assessment, toxicity assessment, and risk characterization. Below are the primary uncertainty factors in this HHRA.

Limited data were available to model congener dioxins furans and PCB concentrations from surface water to fish tissue, resulting in a high degree of uncertainty. In particular, although only octachlorodibenzo-p-dioxin (OCDD) was detected in surface water, the HHRA assumed that the other congeners of dioxins, furans, and PCBs were present at the sample-specific detection limits. As a result, less than 1% of the estimated risk is associated with detected OCDD in surface water. If the other congeners were not included in the risk characterization, the estimated risk would not have exceeded 10^{-6}. In addition, the HHRA discounted mercury data prior to the risk characterization because of data quality issues. This approach for mercury may have resulted in an underestimation of hazards for fish ingestion.

There is uncertainty associated with mercury concentrations in Upland Area soils. The sampling team visually observed mercury beads at the Retort Pad area and former Cell Building area, but collected limited soil samples where they observed beaded mercury. Thus, the overall mercury concentrations in upland soils may be underestimated.

Risk characterization based on RME scenarios is conservative and may serve to overestimate risks associated with site media. However, use of the moderate CTE scenarios did not significantly reduce the hazards or risks noted with the RME scenarios.

7.2 Ecological Risk Assessment

The ecological risk assessment is a multi-step process. The assessment was completed in accordance with *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA 1997), NCDENR's *Guidelines for Performing Screening Level Ecological Risk Assessments within the North Carolina Division of Waste Management* (NCDENR 2003) and the *Baseline Ecological Risk Assessment Work Plan and Sampling and Analysis Plan* (CH2M HILL 2009).

The documents prepared that are part of the ecological risk assessment include:

- *Ecological Risk Assessment Step 1 through Step 3(a), LCP-Holtrachem Site, Riegelwood, NC* (March 2006),
- *Ecological Risk Assessment Revised Step 3a. LCP-Holtrachem Site, Riegelwood, NC* (January 2008),
- *Baseline Problem Formulation Step 3b. LCP-Holtrachem Site. Riegelwood, NC* (February 2009; revised September 2009), and
- *Baseline Ecological Risk Assessment for LCP-Holtrachem Site, Riegelwood, NC* (September 2010).

During the risk assessment process, constituents of potential concern, ecological habitats, and representative ecological receptors were identified. For each representative ecological receptor group, measurable assessment endpoints were formulated and potential risks were then estimated for each endpoint. EPA approved the Baseline Ecological Risk Assessment (BERA) in October 2010. A summary of the process results follows.

7.2.1 Assessment Endpoints

The following receptor groups were evaluated in the BERA:

- Soil invertebrates
- Insectivorous birds (terrestrial)
- Insectivorous mammals (terrestrial)
- Herbivorous birds (terrestrial)
- Herbivorous mammals (terrestrial)
- Amphibians and reptiles (aquatic terrestrial)
- Omnivorous birds (aquatic terrestrial)
- Omnivorous piscivorous birds (aquatic terrestrial)
- Insectivorous piscivorous mammals (aquatic and terrestrial)
- Benthic macroinvertebrates

7.2.2 Constituents of Potential Ecological Concern

During Step 3a, a refined screening for constituents of potential ecological concern (COPECs) was completed using supplemental toxicological benchmarks and a weight of evidence (WOE) approach. The WOE approach includes consideration of the magnitude of potential risk, background data, frequency of detection, frequency of exceedances over screening levels, and bioaccumulation potential. The list of COPECs identified in Step 3a is summarized in **Table 86.**

Table 86: Lower Trophic Level Final Direct Toxicity COPECs

Soil	Sediment		Surface water		Stormwater
Upland and Bottomland	Bottomland Drainage Ditches	Cape Fear River	Bottomland Drainage Ditches	Cape Fear River	Bottomland Drainage Ditches
Chromium	Mercury	Mercury	Aluminum	Aluminum	Aluminum
Manganese	Aroclor-1016*	Aroclor-1016*	Arsenic	Barium	Cadmium
Mercury	Aroclor-1221*	Aroclor-1221*	Barium	Iron	Copper
Vanadium	Aroclor-1232*	Aroclor-1232*	Cadmium	Lead	Iron
Aroclor-1016*	Aroclor-1242*	Aroclor-1242*	Chromium	Manganese	Manganese
Aroclor-1221*	Aroclor-1248*	Aroclor-1248*	Iron	Silver*	Mercury
Aroclor-1232*	Aroclor-1254	Aroclor-1254	Lead	Thallium	Silver
Aroclor-1242*	Aroclor-1260*	Aroclor-1260*	Manganese	Vanadium	Vanadium
Aroclor-1248*	Aroclor-1268	Aroclor-1268	Mercury	Zinc	Zinc
Aroclor 1254	4,4'-DDD	4,4'-DDD	Nickel	Aroclor 1268	Aroclor 1268
Aroclor 1260*	4,4'-DDE	4,4'-DDE	Selenium	4,4'-DDD	Methoxychlor*
Aroclor 1268	4,4'-DDT	4,4'-DDT	Silver*	4,4'-DDE	Toxaphene*
4,4'-DDD	Chlordane (technical)*	Dieldrin	Vanadium	4,4'-DDT	4-Chloro-3-methylphenol*
4,4'-DDE	Dieldrin	Endrin	Zinc	Aldrin	Anthracene*
4,4'-DDT	Endrin	gamma-BHC (Lindane)*	Dioxins/PCBs TEQs – mammals, birds, and fish	Dieldrin	Benzo(a)pyrene*
beta-BHC	gamma-BHC (Lindane)	Heptachlor epoxide*	Total Dioxin/ Furan/ PCB 2,3,7,8-TCDD TEQs – mammal, birds, and fish	Endosulfan I	Benzo(b) fluoranthene*
Dieldrin	Heptachlor epoxide	Toxaphene*	Aroclor-1016*	Endosulfan II	Benzo(ghi) perylene*
Endrin	Toxaphene*	Chlordane (technical)*	Aroclor-1221*	Endosulfan sulfate	Benzo(k) fluoranthene*
gamma-BHC (Lindane)	Acenaphthene	Dioxins TEQs - mammals	Aroclor-1232*	Endrin	Hexachloro-butadiene*

During Step 3b, the COPECs were refined for inclusion in the BERA. In the first step of the refinement, concentrations of soil COPECs were compared to background. Next, wildlife No Observed Adverse Effects Level (NOAEL) and Lowest Observed Adverse Effects Level (LOAEL) PRGs were calculated for the detected COPECs and concentrations of COPECs were compared to PRGs as a way of evaluating risk. Concentrations of total mercury exceeded PRGs for methylmercury and mercuric chloride at the majority of soil sampling locations. Zinc also exceeded PRGs in nearly every soil sample.

Only in isolated areas did other COPECs exceed PRGs. Other COPECs exceeding PRGs consistently coincided with locations where mercury and zinc exceed their PRGs. COPECs were also compared to soil and benthic benchmarks and sediment from the Cape Fear River were compared to both wildlife PRGs and invertebrate benchmarks.

After the results of this analysis in Step 3b, it was decided that the BERA would focus on mercury compounds with additional analysis of zinc. Although other COPECs did exceed wildlife PRGs across multiple stations, the focus of the BERA was on mercury and zinc. Most instances of elevated detections of mercury and zinc coincided with elevated levels of these additional COPECs. Future remediation of these areas for mercury and zinc would likely remove the majority of the elevated detections of other less frequently detected COPECs. The final list of COPECs carried into the BERA included methylmercury, mercuric chloride, mercuric sulfide, and zinc.

7.2.3 Site Investigations in Support of the BERA

7.2.3.1 Terrestrial

Site investigation activities were conducted in Bottomland Area soils within Terrace A, the Upland Non-Process Area, and Wetland B. Due to the drier characteristics of the majority of Wetland B, the substrate is considered soil from an ecological exposure perspective. Media collected included soil and invertebrate and plant tissue. Toxicity tests were conducted on site soils. Community surveys of invertebrates were also completed.

Five surface soil samples were collected from each study area (15 total samples). Samples were analyzed for metals, mercury analysis, TOC, and pH. Six of the 15 samples were also analyzed for grain size. Mercury analyses included total mercury, methyl mercury, and fractions 1, 2, and 5. In addition, inorganic divalent mercury (mercury 2+) was also analyzed since this oxidized form of elemental mercury is the dominant form in the environment.

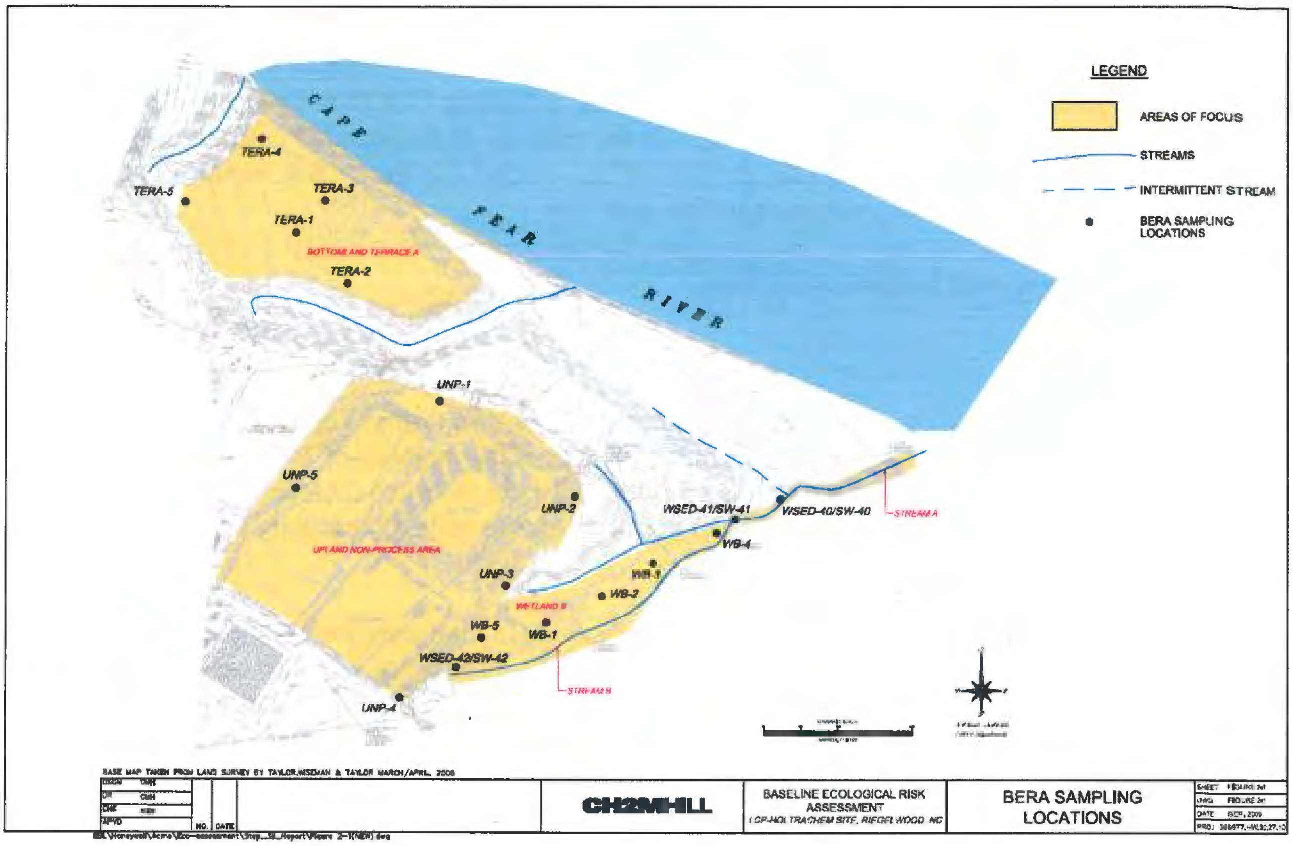
Plants and soil invertebrates were collected within 5 feet of the 15 soil samples, with the exception of UNP-5. Only plants could be collected at UNP-5. Plant and invertebrate species collected were those typically consumed by wildlife living at the site. Plant and invertebrate samples were analyzed for total mercury, methylmercury, mercury 2+, and zinc.

Laboratory toxicity testing (28-days) was completed for 9 soil samples (i.e. 3 from each study area). The test organism was the adult stage earthworm *Eisenia fetida*. Study endpoints were survival and growth. Similar toxicity testing was conducted in the reference area soil. At the conclusion of the toxicity tests, earthworms were depurated and the tissue was analyzed for total mercury, methylmercury, mercury 2+, and zinc.

A soil invertebrate survey was conducted at each soil sample location. An undisturbed area within 5 feet of the sample location was chosen for the survey. Invertebrates were first collected from leaf litter. Once leaf litter was cleared, a 1 square foot hole was dug six inches deep. Soil invertebrates in the hole were collected, counted, and identified.

A soil reference sample location SOREF-1 was collected in the same area as the Phase II sampling in November 2005. The reference sample was analyzed for metals, mercury fractions, VOCs, pesticides, PCBs, SVOCs, pH and TOC. Reference soil was used for toxicity testing of earthworms; however, earthworm tissue was not analyzed at the end of toxicity testing. A soil invertebrate survey was also conducted.

Figure 37: BERA Sampling Locations



7.2.3.2 Aquatic

Site investigation activities were conducted for Streams A and B[10] and the Cape Fear River. No fish or larval amphibians were observed within Streams A and B or the other streams on-site.[11] Media collected included surface water and sediment. Toxicity tests were conducted on collected sediments.

Three surface water samples were collected within Wetland B. An independent laboratory analyzed the samples for metals (filtered), total mercury, methylmercury, mercury 2+, pesticides, SVOCs, PCBs, pH, and hardness. Contractors collected temperature, pH, and dissolved oxygen data in the field. Three sediment samples (0-6 inches in depth) were collected within Wetland B. Samples were analyzed for metals, methylmercury, mercury fractions, pesticides, PCBs, and SVOCs.

[10] Streams A and B are also collectively referred to as the western drainage pathway in other portions of the ROD.
[11] "Streams on-Site" refer to the ephemeral drainage pathways in the wooded bottomland areas.

Two types of toxicity testing were conducted for site surface water and sediment. In the first toxicity test, the larval green frog (*Rana clamitans*) was exposed to bulk sediment and surface water for 30-days. The endpoints were mortality, percent malformation and growth. At the termination of the toxicity test, tadpole tissues were analyzed for total mercury, methylmercury, and mercury 2+ for bioaccumulation analysis. In the second test, neonate amphipods (*Hyalella azteca*) were exposed to bulk sediments for 28-days. Endpoints were mortality and growth.

A benthic invertebrate survey was conducted at each sediment sample location using the kick-net method. Invertebrates in the sediment were collected, counted, and identified.

An off-site upgradient stream was sampled to provide background information on aquatic media. Surface water from the reference stream was analyzed for metals (dissolved), total mercury, methylmercury, mercury 2+, VOCs, SVOCs, pesticides, PCBs, pH, and hardness. Reference sediment was analyzed for mercury, methylmercury, mercury fractions, VOCs, SVOCs, pesticides, and PCBs. Reference water and sediment samples were used for toxicity testing, and a benthic invertebrate survey was also completed as described above.

7.2.4 Exposure Analysis

The exposure analysis considered direct exposure by lower trophic-level organisms (e.g. benthic macroinvertebrates) to constituents in soil, surface water, and sediment. Likewise, the risk associated through the food web was considered for receptor of concern representing the assessment endpoints. Food web exposure includes the exposure of upper trophic-level receptors to COPECs in soil, surface water, and sediment through direct ingestion (intentional or inadvertent) and consumption of prey items with COPEC body burdens.

The following species were selected to represent receptors of concern in the food web modeling:

- Carolina wren - insectivorous bird (terrestrial)
- Short-tailed Shrew - insectivorous mammal (terrestrial)
- Purple Finch - herbivorous bird (terrestrial)
- Meadow Vole - herbivorous mammal (terrestrial)
- Bullfrog and Northern Water Snake - Amphibians and Reptiles (aquatic terrestrial)
- Wood Duck - omnivorous bird (aquatic)
- Green Heron - omnivorous piscivorous bird (aquatic)
- Mink - piscivorous mammal (aquatic)
- Little Brown Bat - insectivorous mammal (aquatic)

7.2.5 Exposure Point Concentrations

The upper confidence limit (UCL) on the mean (recommended 95 or 99 UCL) was used as an EPC where possible for each medium. Samples were pooled across the three areas. ProUCL 4 was used to calculate UCLs (if two recommended values were given, the higher value was used). If a UCL could not be calculated because of an insufficient sample size, as for sediment, surface water, and tadpole tissue, the maximum concentration was used. Sample concentrations from the reference location were not used to determine EPCs. For terrestrial invertebrates, only field collected invertebrates were used because these organisms are the most representative of site conditions.

To assess the potential for adverse effects from mercury exposure, toxicity values were available for three species of mercury (methyl mercury, mercuric chloride, mercuric sulfide). For the risk assessment, mercury 2+, Fraction 1, and Fraction 2 were treated as mercuric chloride. Fraction 5 was treated as mercuric sulfide. In most cases, the sum of the individual mercury species was less than the total mercury measured in the same sample. This mercury not accounted for (MNAF) was added to the mercuric chloride measurement when developing EPCs for food web modeling as a conservative measure. The MNAF was not treated as methylmercury since this constituent was measured directly in all media. The exception to the treatment of MNAF involved drinking water. For this media, total mercury detected was assumed to be mercuric sulfide for the purposes of modeling.

Mercury and zinc in aquatic plants, aquatic invertebrates, and small mammals were not measured directly and had to be estimated for food web exposure. For aquatic plants, sediment concentrations and the relationships among chemicals measured in soil and terrestrial plant tissue were used to develop site-specific bioaccumulation factors (BAFs), which were used to estimate aquatic plant EPCs. The BAF approach was also used for aquatic invertebrates. For small mammals, the BAF from Step 3b was applied to the total mercury concentration in soil. Methyl mercury and mercuric chloride were assumed to each represent 50% of the estimated total mercury tissue concentration.

7.2.6 Exposure Assumptions

Literature values for body weight and ingestion rates were available for most of the proposed receptors. Regression models were used to estimate receptor-specific ingestion rates and tissue concentrations. Parameters identified for each feeding guild included food and water ingestion rates, components of diet, incidental soil and sediment ingestion rates, and home ranges. Reference toxicity values were identified for both NOAELs and LOAELs. Assumptions and toxicity parameters have been reviewed and approved by FPA Region 4 risk assessors.

7.2.7 Risk Characterization – Direct Exposure

7.2.7.1 Soil Invertebrate Community

The potential for adverse effects to the soil invertebrate community was evaluated through a multi-parameter weight-of-evidence approach. The parameters considered using this approach were the result of a comparison of COPEC concentrations in soil to literature-based ecological screening values (ESVs), the 28-day bioassay results using *E. fetida* and the results of a qualitative survey of the soil invertebrate community at each sample location.

Only inorganic mercury exceeded the ESV with high exceedances (HQs greater than 10) in each of three areas. Methyl mercury did not exceed ESVs.

Toxicity tests using *E. fetida* were performed with nine soil samples from areas of elevated mercury concentrations in comparison to other areas of the site (TERA-1, TERA-3, TERA-5, UNP-1, LNP-3, UNP-5, WB-2, WB-4 and WB-5). A reference sample (SOREF-1) was also collected and a laboratory control also included in the toxicity testing. Although inorganic mercury concentrations in site toxicity test using *E. fetida* exceeded the ESV, negative effects were not observed in site samples when compared to the reference area. Since consistent performance was observed across site samples, the differences from the laboratory control were attributed to a less variable physical characteristic of the soils such as TOC.

The results of the community survey indicated that lower numbers of organisms or classes of organisms were not associated with high levels of mercury, except at UNP-3. Sample location UNP-3 had the highest concentration of inorganic mercury of the sites surveyed and one of the lowest number of total organisms compared to other survey locations. Sample location UNP-3 also tended to be drier and contained fill material, resulting in poor soil quality which may have contributed to the low number of organisms observed.

Risks to the survival, growth, and reproduction of soil invertebrate community were considered to be within protective levels because differences from the reference area were not observed and there was no trend in toxicity test response, survey results, or concentrations of constituents in soil.

7.2.7.2 Aquatic Community (Fish and Reptiles)

The potential for adverse effects to the fish and reptile community was evaluated using a similar weight-of-evidence approach with two parameters: a comparison of mercury concentrations in surface water to literature-based ESVs and 30-day bioassay results using *R. clamitans.*

Comparison of surface water data to mercury ESVs indicate mercury concentrations were above the Region 4 ESV but below the National Recommended Water Quality Criteria (NRWQC) and the total mercury criterion continuous concentration (CCC) of 0.77 μg/L for amphibians.

Toxicity tests using *R. clamitans* were performed with site surface water and sediment from three locations with sediment mercury concentrations that were elevated in comparison to other areas of the site (WSED-40, WSED-41, and WSED-42). A reference sample (SEDREF-1) was also collected and a laboratory control also included in the toxicity testing. Of the three site samples, only WSED-42 had significantly greater frequency of mortality compared to the laboratory control and reference. No significant differences were observed in the mean malformation and wet weight of site samples and the control and reference samples. However, the three site samples had significantly less mean length compared to the control, and WSED-40 and WSED-42 showed significantly lower mean length measurements than the reference.

The results of the toxicity testing indicated that WSED-42 had the highest mortality (51 percent) and lowest growth (1.6 cm organism and 47 mg organism) and was associated with the highest concentration of total mercury in sediment. Based on significant differences from the reference location, sediment mortality lowest observed effect concentration (LOEC) of 0.75 mg/kg and growth LOEC (based on length) of 0.63 mg kg were identified for mercury. Sediment mercury concentrations at WSED-41 were below the identified LOECs for mortality and growth. Mercury concentrations of 0.75 mg/kg (Method 7471) and 0.635 mg/kg (Method E1631) were observed at WSED-42 which meet the LOEC for mortality but are below the LOEC for growth. Surface water toxicity values could not be determined from results because total mercury was not detected in WSED-42.

To identify other potential causes of toxicity, a sample-by-sample comparison of concentrations in the toxicity test samples for constituents other than mercury was performed for surface water and sediment. Other possible surface water contributors to observed effects on tadpoles in the toxicity tests were identified as barium and Aroclor 1268 in surface water. However, further evaluation of these two compounds concluded that barium and Aroclor 1268 were unlikely contributors to observed effects in the bioassays. Barium compounds were considered to have a low toxicity to aquatic organisms because the form (barium sulfate) likely present is essentially non-toxic. In a literature review, ENSR (2004) reported 7- or 10-day lethal Aroclor concentrations with 50 percent mortality (LC50s) for amphibian early life stages ranging from 1,030 µg/L to 28,000 µg/L. Sample concentrations in the site toxicity tests were much lower, ranging from 0.14 to 2.3 µg/L. Considering that the highest concentrations of PCBs in surface water were also observed at SW-40, which had the lowest effects among the site samples, surface water toxicity was determined to be an unlikely contributor to observed effects in the bioassays.

In sediment, mercury concentrations from all three sample locations exceeded the lower effects level (LEL), but not the upper effects level (UEL). Other possible sediment contributors to observed effects in the amphibian toxicity tests were identified as manganese, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene in sediment. Further evaluation of these constituents showed that sediment concentrations of manganese, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene at WSED-40 and WSED-41 were either not detected or detected below ESVs, though significant negative effects were also observed at these locations. As a result, the contribution to toxicity by these constituents has been determined to be limited.

Amphibian growth was reduced compared to the reference, but the reduction was only approximately 15% of the reference condition. This difference is unlikely to have community-level effects, which is the endpoint being evaluated. Risks to the survival, growth, and reproduction of fish and reptile community are considered to be within protective levels because mortality differences from the reference area were observed at only one location, only marginal differences in growth were observed, the actual level of exposure is expected to be low because of the poor quality habitat for fish and reptiles in the drainage pathways, and attribution to total mercury is unclear.

7.2.7.3 Benthic Invertebrates

The potential for adverse effects to the benthic invertebrate community was evaluated using a multi-parameter weight-of-evidence approach. The parameters considered in this approach were the results of a comparison of COPEC concentrations in sediment to literature-based ESVs, 28-day bioassay results using *H. Azteca*, and the results of a qualitative survey of the aquatic invertebrate community. Mercury exceeded the LEL, but not the UEL, in all site samples when compared to literature-based ESVs.

The results of the *H. azteca* toxicity testing showed mortality and weight were not significantly different between site and control or reference samples. Other possible contributors to observed effects include manganese, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene in sediment. While these constituents may contribute to toxicity at WSED-42, where the highest effects were observed concentrations were either not detected or were detected below ESVs at the other two locations where significant negative effects were also observed. As a result, the contribution to toxicity was determined to be limited, abundance and diversity information gathered from the aquatic invertebrate community survey appeared to be unrelated to levels of mercury. There is some uncertainty that the survey size and area sampled at each location were limited.

Since growth differences from the reference area were observed at only one location and the difference was marginal, risks to the survival, growth, and reproduction of the benthic invertebrates were considered to be within protective levels.

7.2.8 Food Web Exposure – Terrestrial

7.2.8.1 Insectivorous Terrestrial Birds – Carolina Wren

Potential risks to the survival, growth, and reproduction of insectivorous bird populations were evaluated with the Carolina wren as the representative receptor. Exposure doses exceeded Toxicity Reference Values (TRVs) for methyl mercury (NOAEL-based HQ of 1.6 and LOAEL-based HQ of 0.9), mercuric chloride (NOAEL-based HQ of 2.1 and LOAEL-based HQ of 1.0), mercuric sulfide (NOAEL-based HQ of 3.0 and LOAEL-based HQ of 1.5), and zinc (NOAEL-based HQ of 16 and LOAEL-based HQ of 1.8) because of concentrations in terrestrial invertebrates and incidental soil ingestion. NOAEL-based and LOAEL-based HQs for the wren were also greater than 1.0 indicating the potential for adverse effects to this receptor. Invertebrates comprised the majority of the exposure doses for methyl mercury, mercuric chloride, and zinc, and incidental soil ingestion comprised the majority of the exposure dose for mercuric sulfide.

7.2.8.2 Insectivorous Mammal – Short-tailed Shrew

Potential risks to the survival, growth, and reproduction of insectivorous mammal populations were evaluated with the short-tailed shrew as the representative receptor. Exposure doses exceeded TRVs for mercuric chloride (LOAEL-based HQ of 1.4) and zinc (NOAEL-based HQ of 3.7 and LOAEL-based HQ of 1.3). NOAEL-based and LOAEL-based HQs for the shrew were also greater than 1.0 indicating the potential for adverse effects for this receptor group. Terrestrial invertebrates comprised nearly 100% of the exposure doses for mercuric chloride and zinc. Incidental soil ingestion was included in the exposure calculation.

7.2.8.3 Herbivorous Birds – Purple Finch

Potential risks to the survival, growth, and reproduction of herbivorous bird populations were evaluated with the purple finch as the representative receptor. Exposure doses exceeded TRVs for mercuric chloride (NOAEL-based HQ of 1.7: the LOAEL was not exceeded) and zinc (NOAEL-based HQ of 31 and LOAEL-based HQ of 3.5). NOAEL-based and LOAEL-based HQs for the finch were also greater than 1.0. Terrestrial plants comprised nearly 100% of the exposure doses for mercuric chloride and zinc.

7.2.8.4 Herbivorous Mammals – Meadow Vole

Potential risks to the survival growth, and reproduction of herbivorous mammal populations were evaluated with the meadow vole as the representative receptor. Exposure doses exceeded TRVs for mercuric chloride (LOAEL-based HQ of 1.2) and zinc (NOAEL-based HQ of 6.8 and LOAEL-based HQ of 2.4. The LOAEL-based HI for mercury was also greater than 1.0. Terrestrial plants comprised nearly 100% of the exposure doses for mercuric chloride and zinc.

Even though HIs for terrestrial receptors were generally greater than 1, the identified risks to terrestrial receptors were concluded as being unlikely to have population level effects, the endpoint being evaluated. Factors for this conclusion were that the magnitudes of TRV exceedances are low, the sample locations with elevated concentrations are few and represent only a small percent of the total area, and the analysis included three conservative features: the inclusion of a full soil ingestion factor for species consuming soil invertebrates, the exclusion of Area Use Factor (AUFs), and the use of the UCL as an EPC. Furthermore, the elevated concentrations of zinc in plants were described as possibly due to a natural occurrence. Risks to the survival, growth, and reproduction of terrestrial avian and mammalian species populations were considered low.

7.2.9 Food Web Exposure – Aquatic

7.2.9.1 Amphibians and Reptiles – Bullfrog and Northern Water Snake

Potential risks to the survival, growth, and reproduction of amphibian and reptile populations were evaluated with the bullfrog and northern water snake as the representative receptors. Except for the exposure of northern water snake to methyl mercury, exposure doses did not exceed TRVs. However, methyl mercury was estimated as 50% of the total mercury concentration in vertebrate prey. In general, methyl mercury content varies greatly among vertebrate species and within specific tissues (hair and brain tissue typically have the highest content, while liver and kidney content are lower as a result of demethylation). Risks to the survival, growth, and reproduction of northern water snake populations were listed as low because the approach used to estimate 50% methyl mercury content was determined to likely overestimate the actual methyl mercury content, and. because the magnitude of the TRV exceedance is small.

Based on these results, risks to the survival, growth, and reproduction of amphibians and reptile populations was considered low.

7.2.9.2 Omnivorous Birds – Wood Duck

Potential risks to the survival, growth, and reproduction of omnivorous bird populations were evaluated with the wood duck as the representative receptor. Since mercury and zinc exposure doses did not exceed TRVs risks to the survival, growth, and reproduction of omnivorous bird populations were considered low.

7.2.9.3 Omnivorous/Piscivorous Birds – Green Heron

Potential risks to the survival, growth, and reproduction of omnivorous piscivorous bird populations were evaluated with the green heron as the representative receptor. Since mercury and zinc exposure doses did not exceed TRVs. and only the NOAEL-based HI was greater than 1.0, risks to the survival, growth, and reproduction of omnivorous piscivorous bird populations were considered low.

7.2.9.4 Insectivorous & Piscivorous Mammals – Little Brown Bat and Mink

Potential risks to the survival, growth, and reproduction of insectivorous piscivorous mammal populations were evaluated with the little brown bat and mink as the representative receptors. Since mercury and zinc exposure doses did not exceed TRVs, risks to the survival, growth, and reproduction of insectivorous piscivorous mammal populations were considered low.

Except for mercuric sulfide and the northern water snake, no risks were identified for the survival, growth, and reproduction of aquatic avian and mammalian species populations. For water snakes exposed to methyl mercury, the identified risks were described as unlikely to have population level effects (the endpoint being evaluated) since the magnitude of the TRV exceedance was low, the sample locations with elevated concentrations are few and represent only a small percent of the total area, and the analysis included conservative factors. Risks to the survival, growth, and reproduction of northern water snake populations were also low.

7.2.10 Other Food Web Exposure Constituents of Interest

Food web exposure COPECs identified in Step 3a were compared to PRGs developed using assumptions presented in the Step 3b problem formulation. These comparisons were made to identify: (1) whether other COPECs (e.g. non risk-drivers) exceed PRGs in areas where the risk drivers do not: and (2) data gaps warranting further investigation. A few of these constituents exceeded NOAEL-based PRGs in one or more locations but were below the LOAEL-based PRGs. These constituents were not addressed further. Constituents exceeding LOAEL-based PRGs included mercury, TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin) Toxicity Equivalents (TEQs), aldrin, hexachlorobenzene, and chromium. Step 3b led to the conclusion that collection of additional data for mercury was sufficient to complete the BERA.

7.2.10.1 Chromium, Aldrin, and Hexachlorobenzene

Risks to the survival, growth, and reproduction of terrestrial avian and mammalian species populations from chromium, aldrin, and hexachlorobenzene, were considered to be within protective levels due to the low frequency of exceedance (3%).

7.2.10.2 TCDD TEQs

Calculated NOAEL-based and LOAEL-based HQs did not exceed 1.0 for piscivorous or omnivorous avian and reptile wildlife represented by the wood duck, green heron, adult bullfrog, and northern water snake. Risks to the survival, growth, and reproduction of avian piscivorous or omnivorous species populations from TCDD TEQs were considered to be within protective levels.

For the Carolina wren, NOAEL-based and LOAEL-based HQs exceeded 1.0 when all data was used. When elevated data from either TERA-5 or both TERA-5 and UNP-1 data were excluded, NOAEL-based HQs were reduced by an order of magnitude to levels between 1 and 3. LOAEL-based HQs were below 1.0.

Since the magnitude of exceedances of TRVs was low and there are few sample locations with elevated concentrations, which represent only a small percentage of the total area, risks to the survival, growth, and reproduction of reptile species populations were considered to be within protective levels. Risks from TCDD TEQs could not be ruled out due to an elevated LOAEL -based HQ when all data were used. Therefore, a soil PRG based on TCDD TEQ risk to the Carolina wren was calculated as part of the RI. The soil PRG was determined by back calculating the risk equations to a TCDD TEQ concentration in surface soil (0 to 0.5 foot bgs) that corresponds to an HQ of 1. The NOAEL-based soil PRG for the Carolina wren is 0.008 µg/kg, and the LOAEL-based soil PRG is 0.08 µg/kg. It should also be noted that TERA-5 is also the area of highest total mercury concentrations in soil, and future remediation for total mercury will likely remove elevated levels of TCDD.

Risk estimates for mammalian wildlife were calculated for the entire data set and with elevated data from TERA-5 or both TERA-5 and UNP-1 excluded. Since NOAEL-based or LOAEL-based HQs did not exceed 1.0 for mammalian herbivorous or omnivorous wildlife represented by the meadow vole or mink, risks to the survival, growth, and reproduction of mammalian herbivorous or omnivorous species populations from TCDD TEQs were considered to be within protective levels.

For flying insectivorous mammalian wildlife represented by the little brown bat, risk estimates using all data resulted in a NOAEL-based HQ for total TEQs of 6.6 and a LOAEL-based HQ of 0.6. These HQs suggest that population level effects, the endpoint being evaluated, are unlikely. Risks to the survival, growth and reproduction of flying insectivorous mammalian wildlife species populations from TCDD TEQs were considered to be within protective levels.

For insectivorous mammalian wildlife represented by the shrew, risk estimates using all data resulted in a NOAEL-based HQ for total TEQs of 66 and a LOAEL-based HQ of 6. An additional TRV was then used based on a mink study; the original TRV study was conducted on a rat.

With this additional TRV a range of HQs was established for the shrew using all data and with elevated data from TERA-5 or both TERA-5 and UNP-1 excluded. Under these scenarios, HQs based on the rat study ranged from 63 to 14 based on the NOAEL and between 6.6 and 1.4 based on the LOAEL. Under the same scenarios using the mink TRV NOAEL-based HQs were all below 1.

The identified risks from TCDD TEQs to insectivorous mammalian wildlife represented by the shrew are unlikely to have population level effects, the endpoint being evaluated. Factors contributed to this conclusion include the magnitude of exceedances of TRVs was low. TRVs are not exceeded when additional TRVs are considered, the sample locations with elevated concentrations are few and represent only a small percent of the total area, and off-site sources of TEQs are present. TERA-5 is also the area of highest total mercury concentrations in soil and future remediation for total mercury will likely remove elevated levels of TCDD. Risks to the survival, growth, and reproduction of insectivorous mammalian wildlife populations were considered to be within protective levels.

7.2.11 Uncertainties

Uncertainties included in the BERA include:

- The use of the MNAF in developing EPCs and for assessing toxicity may overestimate or underestimate risk.
- Incidental soil ingestion was included in the total chemical exposure calculations for terrestrial wildlife that ingest invertebrates, even though invertebrates were not depurated prior to chemical analyses. Incidental soil ingestion was included in the total chemical exposure calculations as a conservative assumption, even though some of the soil ingestion would come from invertebrates collected in the field. As a result of this approach, risks to terrestrial wildlife may be overestimated.
- Tissue concentrations were measured in tadpoles exposed to site sediment and surface water because in situ organisms were not available. Tissue concentrations based on laboratory exposure of tadpoles to site sediment and surface water were then used as surrogates for fish tissue concentrations for piscivorous wildlife. Differences in fish and tadpole bioaccumulation are not well studied, but are assumed to be minor. Risks to piscivorous wildlife may be under- or overestimated.

- Mercury and zinc concentrations in aquatic plants, aquatic invertebrates, and small mammals were not measured directly and had to be estimated using BAFs. Although the strongest available relationships were used, the use of modeled tissue concentrations and literature-based BAFs may under- or overestimate risk.
- Except for vertebrate prey, the values used in the BERA were based on measured tissue values (measured directly or by relationships derived from the measured tissue levels) and are considered more applicable for determining risks in the BERA. In general, methyl mercury content varies greatly among vertebrate species and within specific tissues. For vertebrate prey, the BERA used the EPA requested value of 50% based on the total mercury soil UCL (16.7 mg/kg) multiplied by the BAF and 0.5. Therefore, risk from exposure to methyl mercury may be overestimated.
- The recommended UCL from ProUCL 4.0 was used as the EPC, or if a UCL could not be calculated, the maximum concentration was used as the EPC. For some constituents, the actual EPC may be closer to the arithmetic average than the UCL. Risks based on UCL and maximum EPCs may be overestimated if the actual EPC is closer to the arithmetic average.
- An adequate avian TRV for mercuric sulfide was not identified and the TRV for mercuric chloride was used as a surrogate instead. Since mercuric sulfide is considered to be less toxic than mercuric chloride, risk estimates for birds and mercuric sulfide may be overestimated.
- A soil reference sample, location SOREF-1 was collected in the same area that was previously identified as the reference location for the site during the Phase II sampling in November 2005. This area showed poor earthworm survival, poor soil quality, and limited numbers or classes of organisms during the soil community survey. If earthworm survival had been higher in the reference area, survival in site soils may have been statistically lower.

Uncertainties identified by an EPA ecological risk assessor in reviewing the draft ROD include:

1. Site-specific data was collected for bioaccumulation of mercury into terrestrial invertebrates. Site-specific data was unavailable for bioaccumulation of Aroclor 1268 into insects. There is some uncertainty in the cleanup levels in the draft ROD on account of having used literature assumptions for bioaccumulation in the food-chain models that were used to develop the cleanup levels for Aroclor 1268. The uncertainty does not affect the selected remedy for the Wooded Bottomland Area Drainage Pathways. Most of the concentrations of Aroclor 1268 above preliminary remedial goals (PRGs) derived from conservative assumptions are encompassed in the footprint selected for excavation.

2. The changes to the toxicity reference value (TRV) and the bioaccumulation factors (BAFs) since the point at which the risk assessment was prepared may indicate uncertainty in the cleanup goal for protection of ecological receptors from Aroclor 1268 in Wooded Bottomland Area soils. The concentrations of Aroclor 1268 in Wooded Bottomland Area soils outside of the remedial footprint are mostly below 3 mg/kg. Soils with concentrations of Aroclor 1268 substantially above 3 mg/kg are typically located adjacent to the areas that are planned to be excavated under the selected remedy. It is recommended that any adjustments to toxicity values or other assumptions in the risk assessments be evaluated during the remedial design phase. Slight adjustments might be possible to the remedial footprint, but the overall remedy will remain the same.

3. The food-chain models that were used to derive the CULs in the ROD were checked as part of this review. The life history parameters were found in Table 3-15 of the baseline

ecological risk assessment (BERA) CH2MHILL (2010). The TRVs were found in Table 4-13 of the BERA. The ecological CULs from the BERA food-chain models used in the ROD were:

- 3 mg/kg for total mercury in Wooded Bottomland Area Soils (HI = 1) for the short-tailed shrew.
- 0.0854 µg/kg for 2,3,7,8-TCDD toxicity equivalents in Wooded Bottomland Area Soils (HQ = 0.9) for the Carolina wren
- 47 mg/kg for Aroclor 1268 in Wooded Bottomland Area Drainage Pathway Sediments (HQ = 1) for the green heron.

The transfer factors between abiotic media and concentrations in tissues needed to derive the PRGs were uptake of mercury from soil into terrestrial invertebrates to support the diet of the short-tailed shrew. Overall, the CULs were okay. It was difficult to review them because the information was in the BERA but also in the Step 3b document (CH2MHILL 2009). It would be advantageous to have a summary of the derivation of CULs in an appendix to the ROD for ease of reference.

4. A site-specific uptake factor from measurements of mercury in terrestrial invertebrates was used in the BERA (Figure 1). The calculation of the PRG for mercury in soils for the short-tailed shrew is shown in Appendix B of the BERA.

5. The PRG for 2,3,7,8-TCDD Toxicity Equivalents for the Carolina wren required an uptake factor for 2,3,7,8-TCDD from soil to terrestrial plants and an uptake factor for 2,3,7,8-TCDD from soil to terrestrial invertebrates. The uptake factor for 2,3,7,8-TCDD for plants came from EPA (2007). The document presented a formula for estimating a BAF for uptake from soils to plants for organic compounds as a function of the octanol-water partition coefficient in Figure 5 of the guidance document.

> Uptake of 2,3,7,8-TCDD toxicity equivalents in to terrestrial plants:
> $\log BAF_{plant} = -0.229 \times \log K_{OW} + 1.0237$
>
> BAF = Bioaccumulation Factor (concentration in plant in mg/kg dry weight to concentration in soil in mg/kg dry weight)
>
> K_{OW} = Octanol-water partition coefficient, L/kg
>
> $\log K_{OW}$ (2,3,7,8-TCDD) = 6.8 L/kg.
>
> BAF_{TCDD} = 0.29 in dry weight units.

> Uptake of 2,3,7,8-TCDD into Terrestrial Invertebrates (Sample *et al.* 1998)
>
> $\ln(earthworm)=B0+B1(\ln[soil])$
> earthworm = concentration in earthworm, mg/kg dry weight
>
> soil = concentration in soil, mg/kg dry weight
>
> B0 = 1.182
> B1=3.533.

6. The uptake of 2,3,7,8-TCDD toxicity equivalents in to terrestrial invertebrates was an equation obtained from Sample *et al.* 1998. The equation is presented in Table 7-2 of CH2MHILL (2009).

7. The calculation of the PRG for 2,3,7,8-TCDD toxicity equivalents is shown in Appendix C-2 to CH2MHILL (2009). The contribution to exposure to the Carolina wren from ingestion of plants is the concentration of TCDD in plants (0.0854 µg/kg x 0.29) multiplied by the dietary fraction of plants (0.06). The outcome (0.0854 µg/kg x 0.29 x 0.06) will be summed with the calculated exposure through ingestion of terrestrial invertebrates and incidental ingestion of soil. The predicted concentration in terrestrial invertebrates for 8.54E-5 mg/kg in soil was 5.3E-04 mg/kg in terrestrial invertebrates. The predicted TCDD concentration in terrestrial invertebrates is multiplied by the dietary fraction (0.94). The outcome (5.3E-04 x 0.94) will be summed with the calculated exposure through incidental ingestion of soil. The fraction of the food ingestion rate that was assumed to be incidental ingestion of soil was 10%. The rate is multiplied by the concentration of TCDD in soil. Total intake is:

   (8.54E-5 mg/kg x 0.29 X 0.06 +
   5.3E-04 mg/kg x 0.94 +
   8.54E-05 mg/kg * 0.1) x 0.248 / 1.4E-04,

   Where 0.248 is the body-weight normalized food ingestion rate of the Carolina wren, and 1.4E-4 mg/kg-day is the Lowest Observable Adverse Effect Level (LOAEL) TRV for 2,3,7,8-TCDD toxicity equivalents. The hazard quotient should be 0.9, which it is.

The green heron (*Butorides virescens*) was considered to be the most sensitive ecological receptor for Aroclor 1268 in Wooded Bottomland Area sediments with a CUL of 47 mg/kg. The calculation of the PRG for Aroclor 1268 in sediments for the green heron was found in CH2MHILL (2009). The green heron's diet consisted of aquatic invertebrates and forage fish in proportion of 55% aquatic invertebrates and 45% forage fish. The PRG for Aroclor 1268 in sediments for the green heron required an uptake factor for uptake of Aroclor 1268 from sediments to aquatic invertebrates and an uptake factor for Aroclor 1268 from sediments into forage fish. The uptake factors used came from the EPA comment memo that was attached to CH2MHILL (2009). The uptake factor from sediments to aquatic invertebrates used in CH2MHILL (2009) was 0.95, which was an average biota-to-sediment transfer (BSAF) in units of concentration in tissue normalized to lipid concentration to concentration in sediment normalized to organic carbon concentration. The comment indicated that the lipid content in benthic invertebrate tissue can be assumed to be 5%. The organic carbon content in sediments was indicated to be assumed to be 1%. The BSAF would ideally have been adjusted by the lipid content in the organism before using it in the food-chain model to calculate the PRG for the green heron. Since this multiplication was not performed, the previous model in Table 7-2, which came from Bechtel-Jacobs, 1998, was used for checking.

> Uptake of Aroclor 1268 into Aquatic Invertebrates (Bechtel Jacobs, 1998)
>
> ln(aq. invertebrate)=B0+B1(ln[sediment])
>
> B0 = 1.6
> B1 = 0.939.

7.2.12 Conclusions

The BERA was finalized in 2010 and addressed Steps 1 through 3B of the ERA process. Ecological resources at the site were identified and evaluated for potential risk from site-related COPECs. Ecological risk calculations included in the BERA were developed for areas containing viable wildlife habitat and did not include areas that were intended to be removed as part of the site redesign or planned remedial activities. Areas with available habitats include the terrestrial areas of the Upland Non-Process and Wooded Bottomland Areas. Soil, sediment, and surface water samples collected throughout the Wooded Bottomland Area, Upland Non-Process Area, Streams A and B, and Wetland B were used to evaluate potential risk in the BERA.

The BERA identified wildlife hazards associated with exposure to mercury and PCBs for the Wooded Bottomland Area, the Upland Non-Process Area, and Wetland B. The BERA focused on indicator COCs rather than all detected constituents in site media.

Hazards from mercury in sediment and soil are considered low. The hazards were spatially isolated, inputs to the risk analysis were conservative, and field observations indicated significant wildlife use. A PRG of 3 mg/kg for mercury in Wooded Bottomland Area soil was calculated by EPA based on the data collected for the BERA, and 3 mg/kg was selected as the Wooded Bottomland Area soil PRG for mercury. Although the BERA did not define a PRG for mercury in sediments, potential sediment toxicity to amphibians and benthic macroinvertebrates was indicated at a concentration greater than 0.75 mg/kg mercury. The value of 0.75 mg/kg was selected as the PRG for on-site sediments based on the lowest observed effects concentration in *R. clamitans* and *H. azteca* toxicity tests in the BERA.

Sediment PRGs for the COPEC driving most of the unacceptable risk in Bottomland surface sediment (i.e., Aroclor 1268) was determined by reverse calculation of LOAEL-based ecological risk equations to an HI equal to 1.0 for each receptor and COPEC evaluated in Step 3B. For Aroclor 1268, the most sensitive aquatic receptor (i.e., the receptor corresponding to the calculated lowest PRG) was the green heron. The LOAEL-based sediment PRG for Aroclor 1268 is 47 mg/kg. Aroclor 1268 was not an ecological COC for surface soil.

Although 2,3,7,8-TCDD TEQ was not listed as a COC in the BERA, a PRG was calculated as part of the Final FS Report for 2,3,7,8-TCDD TEQ (dioxins/furans) and 2,3,7,8-TCDD (dioxin-like PCBs) in Wooded Bottomland Area surface soil based on risk to the Carolina wren. The 2,3,7,8-TCDD TEQ (dioxins/furans) PRG for Bottomland surface soils (0-0.5 feet) is 85.4 ng/kg. The 2,3,7,8-TCDD TEQ (dioxin-like PCBs) PRG for Bottomland surface soils (0-0.5 feet) is 196 ng/kg.

In the FS, Bottomland sediments were also evaluated in the calculation of potential PRGs protective of wildlife receptors exposed to 2,3,7,8-TCDD TEQ (dioxins/furans) and 2,3,7,8-TCDD TEQ (dioxin-like PCBs). Potential risk was identified to the green heron from exposure to Bottomland sediments. The 2,3,7,8-TCDD TEQ (dioxin-like PCBs) PRG for Bottomland Area surface sediment (0-0.5 feet) is 210 ng/kg. The 2,3,7,8-TCDD TEQ (dioxins/furans) PRG for Bottomland Area surface sediment (0-0.5 feet) is 280 ng/kg.

Overall, available information suggests that the upgradient portion of Stream B may be an isolated area of concern. Stream A, upgradient of its confluence with Stream B, was previously identified for remedial action. Constituent concentrations downgradient of these two areas are expected to decrease with remediation in either stream.

8.0 REMEDIAL ACTION OBJECTIVES

The Remedial Action Objectives (RAOs) for the site are:

Upland Process and Non-Process Areas

- Reduce risk to construction/industrial workers from exposure through dermal adsorption and incidental ingestion from surface and subsurface soils containing mercury and Aroclor 1268 by reducing concentrations to levels that are protective for commercial and industrial uses.
- Prevent migration of mercury and Aroclor 1268 from upland surface soils and the solids in the storm water conveyance system to the Wooded Bottomland Area by reducing concentrations to levels that are protective of human and ecological receptors.
- Reduce risks to construction/industrial workers from and prevent migration of principal threat wastes by treating/solidifying the mercury waste and contaminated soils beneath the former Mercury Cell Building and Retort pads.

Wooded Bottomland Areas

- Reduce risk to adolescent trespassers from exposure through dermal adsorption of surface water containing Aroclor 1268 by reducing concentrations to protective levels.
- Reduce risk to adolescent trespassers from exposure through dermal absorption and incidental ingestion of surface soil containing Aroclor 1268 by reducing concentrations to protective levels.
- Reduce risk to ecological receptors from sediment contaminated with mercury and Aroclor 1268 by reducing concentrations to protective levels.
- Reduce risk to ecological receptors from surface soil contaminated with mercury by reducing concentrations to protective levels.

The completed remedy will reduce risks to human and ecological receptors to levels provided for in the NCP (i.e. excess cancer risk equal to or less than 10^{-5}, and excess non-cancer risk equal to or less than HI of 1). The selected remedy will lower the risks by reducing the concentrations of the soil, sediment and surface water contaminants to the cleanup levels in **Section 12.4** (**Table 104** and **Table 105**).

9.0 DESCRIPTION OF ALTERNATIVES

The site remedial alternatives are grouped into two categories within the site, Overall Site (Alternatives A-1 through A-6) and mercury waste and soil contamination considered PTW which is located in the Retort Area and Mercury Cell Building Pads (Alternatives S-1 through S-4). This grouping simplified the alternative development and evaluation due to the different conditions within each category. The evaluation and selection of the remedial alternative for mercury waste and contaminated soils associated with the Retort Area and Cell Building pads (S-1 through S-4) is independent of the remedial alternative selection for the remainder of the site. Implementation of the remedies under each category may be conducted concurrently where this would result in potential cost savings and efficiencies through reuse of common remedial components such as labor, equipment, access roads, and staging areas. Sequencing of remedial alternatives will be considered during remedial design. The final remedy selected for the site will include one alternative from the A-group and one alternative from the S-group. **Table 87** lists the ten alternatives designation and title.

Table 87: List of Remedial Alternatives

Area	FS Designation	Title
Overall Site	A-1	No Action
	A-2	Capping with Limited Excavation, Off-site Disposal or On-site Treatment, and Institutional Controls (ICs)/Engineering Controls (ECs)
	A-3	Combination of Capping and Excavation, On-site Disposal, and ICs/ECs
	A-4	Combination of Capping and Excavation, Off-site Disposal, and ICs/ECs
	A-5	Excavation, On-site Disposal, and ICs/ECs
	A-6	Excavation, Off-site Disposal, and ICs/ECs
Retort and Cell Building Pad Areas	S-1	No Action
	S-2	Capping with Vertical Impermeable Barrier Installation and ICs
	S-3	Treatment with In-Situ Stabilization/Solidification, Capping and ICs
	S-4	Excavation and Off-site Treatment and Disposal

9.1 Description of Remedy Components

Descriptions of each of the ten alternatives follow in Sections 9.1.1 through 9.1.10. **Table 88** lists each remedial area. The former RCRA surface impoundments that are closed are part of the site and will be included in the selected remedy although no separate remedial alternatives were developed and evaluated.

Table 88: Remedial Area Description

9.1.1 Alternative A-1: No Action

Estimated Costs:	
Capital Cost	$0
Annual O&M Cost	$0
Total Cost	$0
Total Present Worth Cost	$0
Estimated Timeframes:	
Construction Timeframe	0 months
Time to Achieve RAOs	beyond our lifetime

No Action includes no new remedial measures or ICs. According to the NCP (40 CFR § 300.430(e)(6)), No Action is retained for detailed analysis and used as a baseline in comparing alternatives. The No Action alternative assumes that current security monitoring and restrictions on trespassing would not be enforced, no additional monitoring would be conducted, and operation of the existing stormwater treatment system would be discontinued.

9.1.2 Alternative A-2: Capping with Limited Excavation, Off-site Disposal, and ICs/ECs

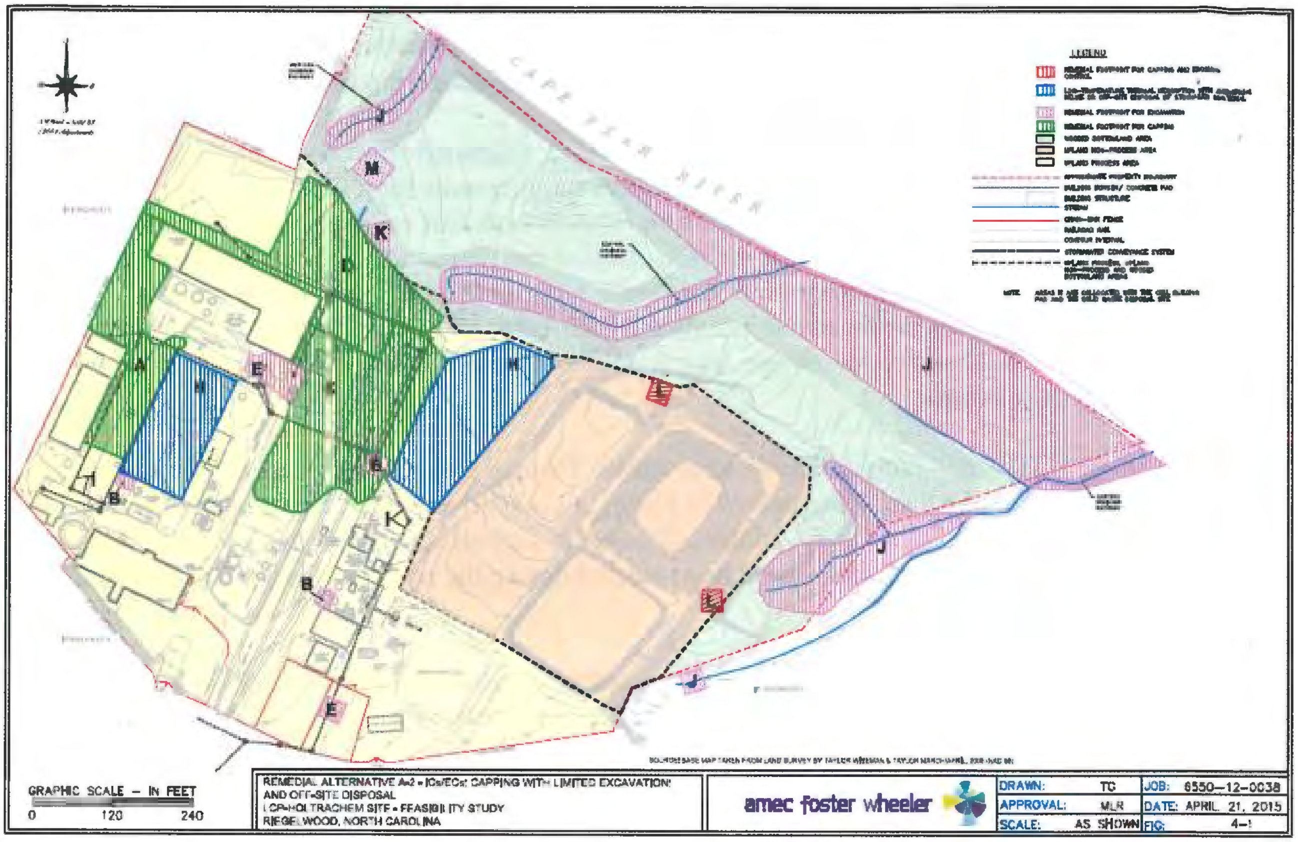
Estimated Costs	A-2a (off-site disposal of WWTS)	A-2b (on-site treatment of WWTS)
Capital Cost	$ 18,647,700	$ 20,180,300
Annual O&M Cost	$ 31,500	$ 31,500
Total Cost	$ 19,700,000	$ 21,300,000
Total Present Worth Cost	$ 19,000,000	$ 20,600,000
Estimated Timeframes		
Construction Timeframe	12 months	12 months
Time to Achieve RAOs	12 months	12 months

This alternative includes:

- Capping of most of the UPA
- Excavation of the Wooded Bottomland Area drainage ditches, low-lying portions of the Wooded Bottomland Area, and other isolated areas to approximately 2 feet with disposal of excavated material in an off-site EPA-approved TSCA chemical waste landfill
- Closure of the stormwater conveyance system
- Decommissioning of the stormwater treatment system and restoration of the site to natural drainage following completion of remedial action
- ICs/ECs
- Either transporting and disposing the WWTS off-site or treating the solids by low temperature thermal destruction (LTTD) so that the treated residuals can be beneficially reused as fill on the site
- Capping/erosion control would be implemented in the L Areas along the berm of the Upland Non-Process Area

Figure 38 illustrates remedial actions for Areas A through M (minus F and G).

Figure 38: Alternative A-2 Conceptual Remedial Plan



The rationale for selecting areas to be capped or removed is based on the size/local extent of detected contamination, the magnitude of PCB and mercury concentrations, and the location/exposure risk. Remedial activities in the UPA include mostly capping with excavation of isolated areas with mercury or PCB concentrations that exceed cleanup levels protective of the industrial or construction worker in accordance with the RAOs.

Capping and excavation in the UPA would also serve to protect the Wooded Bottomland Area by preventing contact of UPA soil with surface runoff and the potential migration of soil into the Wooded Bottomland Area. Areas in the UPA to be capped under Alternative A-2 include Areas A, C, and D. Several isolated areas (B, E, K, and M) with concentrations greater than the cleanup levels would be excavated because long-term maintenance of a small cap in each of these areas would not be practical. Similarly, the remedial areas in the Wooded Bottomlands Area (J Areas) would also be excavated to limit long-term maintenance. Excavated areas would be backfilled to approximately original grade and revegetated under this alternative. Capping and erosion control would occur in the L Areas, which are located along the steep portion of the Upland Non-Process Area berm. Removal of L Areas is not recommended due to the potential for destabilizing the berm during remedial action.

Capping

In Alternative A-2, a cap would be applied over the larger contiguous UPA that exceed the Aroclor 1254 and Aroclor 1268 surface and subsurface soil cleanup level of 11 mg/kg (Areas A, C, and D) and the L Areas along the berm of the Upland Non-Process Area impoundments. The anticipated extent of capping for this scenario is shown on **Figure 38**. The total cap area for this alternative is estimated to be approximately 2.4 acres. The final cap footprint would be confirmed during remedial design sampling.

Capping includes placing a membrane-soil cap system with a vegetated cover over the remediation area. The cap design must meet the North Carolina substantive requirements for a final cover on a RCRA Subtitle D solid waste landfill as well as post-closure requirements that are determined by EPA to be "relevant and appropriate" and identified as ARARs. Before cap placement, the area would be prepared by clearing vegetation and leveling in-ground structures. A protective soil layer and geotextile membrane would be placed over the area to isolate the PCB-containing soil. Another layer of protective soil would be placed on top of the membrane, plus a layer of topsoil that would be vegetated for final restoration and erosion control.

Material specifications would require fill soil to be clean. The cap composition assumed for costing is a protective underlayment of fill soil (compacted in place), a geosynthetic liner, a protective layer of fill soil on top of the liner soil, plus up to six inches of topsoil to support revegetation. The actual cap composition and soil layer thicknesses would be evaluated during the remedial design and will comply with capping ARARs.

Cap placement activities would be conducted using standard construction equipment (e.g., backhoes, bulldozers, graders, etc.). Topographic survey and GPS instrumentation would be used to confirm extents and final grades of cap emplacement.

Excavation

Alternative A-2 consists of excavating isolated Upland Process Areas B and E and Wooded Bottomland Areas J, K, and M. Areas B and E exceed the UPA Aroclor 1254+Aroclor 1268 surface and subsurface soil cleanup level (11 mg/kg). Areas J exceed the Wooded Bottomland Area Aroclor 1268 sediment cleanup level (47 mg/kg) and the mercury sediment cleanup level (0.75 mg/kg). Areas K and M exceed the Wooded Bottomland Area Aroclor 1254+Aroclor 1268 surface soil cleanup level (21 mg/kg). The anticipated extent of excavation for this scenario is shown on **Figure 38**. The total in-place excavation volume is estimated to be 10,900 yd^3. The actual excavation footprints of the isolated areas would be confirmed during remedial design sampling. Following excavation, clean backfill/topsoil would be placed in the areas to restore the ground surface to approximately pre-excavation grades and the areas seeded/revegetated to control erosion.

Removal activities would be conducted using standard construction equipment (e.g., backhoes, bulldozers) equipped with GPS instrumentation to monitor removal progress and confirm that excavations meet the established horizontal and vertical goals. Backfill would be placed to predetermined elevations using conventional earthmoving equipment. Seeding and erosion controls would be implemented upon verification that backfill design elevations have been met.

Where required, excavated soil would be stockpiled within a materials staging area for dewatering to meet appropriate disposal requirements before transportation. Drying would be accomplished through a combination of gravity dewatering and/or the addition of amendments (e.g., bed ash, fly ash, or portland cement). Drainage from dewatering operations and potentially impacted stormwater would be managed through the existing stormwater conveyance and treatment system. Excavated and dewatered materials would be transported for disposal to an appropriate EPA-approved off-site permitted RCRA solid waste or hazardous waste landfill or TSCA chemical waste landfill.

Stormwater Conveyance

The stormwater conveyance system (I Areas) would be closed by cleaning and/or sealing off and solidifying the pipes/inlets in place using flowable grout. Solids, if removed during closure of the system, would be dewatered and disposed in an appropriate off-site EPA-approved landfill.

Following completion of site-wide remedial activities active stormwater collection and management would no longer be necessary. Therefore, the existing stormwater treatment system would be decommissioned and the site returned to natural drainage. Long-term maintenance would include inspection and repair of erosion controls designed to mitigate sedimentation during stormwater flow events.

WWTS

WWTS (Areas H) containing PCB concentration greater than 50 mg/kg are temporarily stockpiled at the Mercury Cell Building pad and the SWDS. Alternative A-2 consists of either off-site disposal of the WWTS at an EPA-approved TSCA chemical waste landfill or treatment of PCBs through LTTD so that the residue can be beneficially reused as fill on-site where possible. The total volume of the stockpiled soil on both the Mercury Cell Building pad and the SWDS is approximately 23,700 yd^3.

LLTD ex-situ treatment would employ the application of heat and reduced pressure to volatilize and desorb PCBs from soil. The stockpiled soil would be dried, screened, and then placed in a thermal desorber, such as a rotary kiln or auger system, and heated to volatilize and transfer PCBs to a gas stream. The off-gas stream would be passed through wet scrubbers or fabric filters to remove particulate matter. PCBs would typically be removed through condensation followed by carbon adsorption, or destroyed in a secondary combustion chamber or a catalytic oxidizer.

Ancillary Activities

Site preparation would include the construction of access roads, support zones, and staging areas for personnel, equipment, and material. Clearing and installation of erosion controls would be required for support and staging areas.

Ancillary activities to support construction activities would include: cap/excavation area access and preparation, erosion control, backfill material delivery and staging, excavated material staging and handling, cover soil delivery and staging, construction waste disposal, cap placement verification, waste soil transport and disposal, stormwater management, dust monitoring/control, seeding/planting, and restoration, as needed.

Ambient air would be monitored for dust during construction. Dust control measures would be implemented, and would include wetting roads, stockpiles, and staging areas. Real-time air monitoring would be performed during construction activities to verify compliance with ARARs.[12]

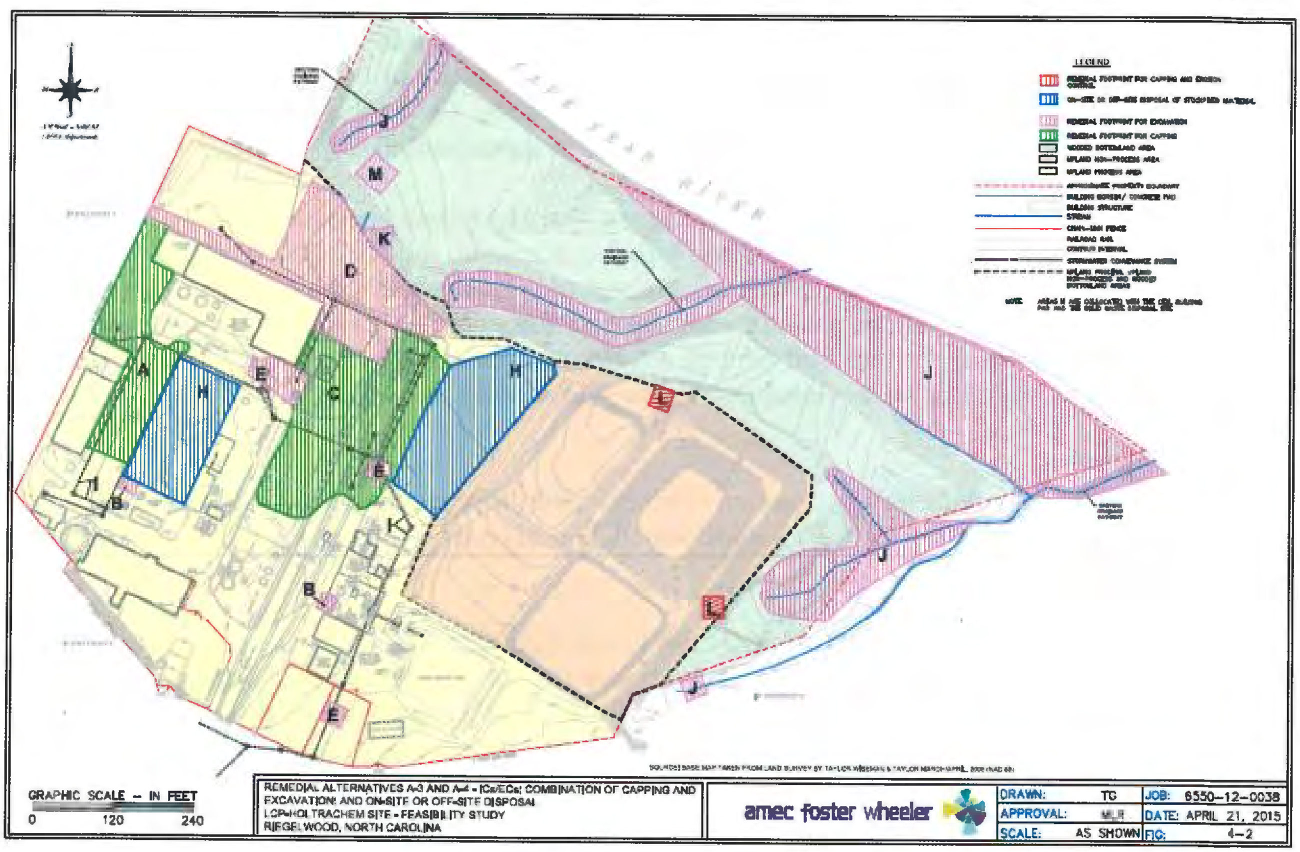
[12] The list of ARARs for the remedy alternatives is in Section 9.2, beginning on page 212.

Site-wide long-term maintenance and inspection would be required to evaluate backfill erosion and to verify cap and previously-closed RCRA unit performance over time. Long-term monitoring of groundwater would also be required to confirm closed unit integrity and compliance with ARARs. Periodic maintenance would be carried out as needed to preserve or restore the integrity of these systems. ICs and ECs would be employed to prevent unacceptable exposure to humans. ICs would consist of land use restrictions included in a deed notice and/or environmental restrictive covenant that is drafted in accordance with North Carolina statutory requirements and recorded in the County. ECs would consist of warning signs and fencing. The site is currently fenced along the west, south, and east property boundaries.

9.1.3 Alternative A-3: Combination of Capping and Excavation, On-site Disposal and ICs/ECs

Figure 39 illustrates remedial actions for areas A through M (minus F and G). The rationale for selecting areas to be capped or excavated is based on the size/local extent of detected contamination, the magnitude of PCB and mercury concentrations, and the location/exposure risk.

Figure 39: Alternatives A-3 and A-4 Conceptual Remedial Plan



Estimated Costs:	
Capital Cost	$12,122,700
Annual O&M Cost	$36,500
Total Cost	$13,300,000
Total Present Worth Cost	$12,600,000
Estimated Timeframes:	
Construction Timeframe	18-24 months
Time to Achieve RAOs	18-24 months

This alternative includes:

- Excavation of approximately 15,400 yd^3 of contaminated soil and sediment
- Capping approximately 1.7 acres of contaminated soil with a geosynthetic liner and vegetative cover
- Construction, operation, closure, maintenance and monitoring of an on-site disposal unit that meets TSCA chemical waste landfill ARARs in 40 CFR § 761.75
- Closure of the underground storm water conveyance system by cleaning and/or sealing off and solidifying the pipes/inlets in place using flowable grout
- Disposal of stockpiled WWTS, solids removed from the storm water conveyance system, and excavated contaminated soil and sediment that are not RCRA hazardous wastes in the constructed on-site TSCA disposal unit
- Treatment and/or disposal of RCRA hazardous wastes including soil that is considered RCRA characteristic waste or contains RCRA listed waste, if generated, at an off-site permitted RCRA treatment/disposal facility
- Decommissioning of the storm water treatment system and restoration of the site to natural drainage following completion of remedial action
- Disposal or recycling of demolition debris from the stormwater treatment system and other potentially dismantled structures. Disposition will be determined based on testing of the debris to determine if it is RCRA hazardous wastes.
- Monitoring and maintenance of the closed RCRA units (former surface impoundments) in accordance with RCRA ARARs for post-closure care of a hazardous waste surface impoundment
- Groundwater monitoring in accordance with ARARs to confirm TSCA disposal unit and closed RCRA units' integrity
- ECs in the form of fencing, warning signs and erosion control measures to control sedimentation from stormwater runoff
- ICs in the form of a restrictive covenant and/or Notice of Contaminated Site in accordance with North Carolina statute
- FYRs

Remedial activities in the UPA include capping and excavation of soil areas with mercury or PCB concentrations that exceed cleanup levels protective of the industrial or construction worker in accordance with the RAOs. Capping and excavation in the UPA would also serve to protect the Wooded Bottomland Area by preventing contact of UPA soil with surface runoff and the potential migration of soil into the Wooded Bottomland Area.

Table 88 on page 161 describes each remedial area. Areas in the UPA to be capped include Areas A and C. Areas A and C have detected concentrations of PCBs greater than 25 mg/kg but less than 50 mg/kg. Area D contains concentrations of PCBs greater than 50 mg/kg, and would be excavated under this alternative. Several isolated areas (B, E, K, and M) with concentrations greater than the cleanup levels would be excavated because long-term maintenance of a small cap in each of these areas would not be practical.

Similarly, the remedial areas in the Wooded Bottomlands Area (J Areas) would be excavated to limit long-term maintenance. Excavated areas would be backfilled to approximately original grade and revegetated under this alternative. Capping and erosion control would occur in the L Areas, which are located along the steep portion of the Upland Non-Process Area berm. Removal of L Areas is not recommended due to the potential for destabilizing the berm during remedial action.

<u>Capping</u>

In Alternative A-3, a cap would be applied over the larger contiguous Upland Process Areas that exceed the Aroclor 1254+Aroclor 1268 surface and subsurface soil cleanup level of 11 mg/kg in Areas A and C and the L Areas along the berm of the Upland Non-Process Area impoundments. The anticipated extent of capping for this scenario is shown on **Figure 39**. The total cap area for this alternative is estimated to be approximately 1.7 acres. The final cap area footprint in some areas would be confirmed during remedial design sampling.

Capping would be achieved by the same methods described for Alternative A-2. The cap composition assumed for costing is a protective underlayment of fill soil (compacted in place), a geosynthetic liner, a protective layer of fill soil on top of the liner soil, plus up to six inches of topsoil to support revegetation. The actual cap composition and soil layer thicknesses would be evaluated during the remedial design. Cap placement activities would be conducted using standard construction equipment (e.g., backhoes, bulldozers, graders, etc.). Topographic survey and GPS instrumentation would be used to confirm extents and final grades of cap emplacement.

The caps will be designed to meet site-specific ARARs which include the North Carolina RCRA Subtitle D landfill final cover as well as post-closure requirements that are relevant and appropriate.

<u>Excavation</u>

Alternative A-3 consists of excavating soil contamination in the Upland Process Areas B, D, and E and Wooded Bottomland Areas J, K, and M. Areas B, D, and E exceed the Upland Process Area Aroclor 1254+Aroclor 1268 surface and subsurface soil cleanup level (11 mg/kg) protective of human health. Areas J exceed the Wooded Bottomland Area Aroclor 1268 sediment cleanup level (47 mg/kg) and the mercury sediment cleanup level (0.75 mg/kg) protective of ecological receptors. Areas K and M exceed the Wooded Bottomland Area Aroclor 1254+Aroclor 1268 surface soil cleanup level (21 mg/kg) protective of an adolescent trespasser/recreators.

The anticipated extent of excavation for this scenario is shown on **Figure 39**. The total in-place excavation volume is estimated to be 15,400 yd^3. The actual excavation footprints of the isolated areas would be confirmed during remedial design sampling. Following excavation, clean backfill/topsoil would be placed in the areas to restore the ground surface to approximately pre-excavation grades and the areas would be seeded/re-vegetated to control erosion.

Removal activities would be conducted as described for Alternative A-2.

Stormwater Conveyance System

The stormwater conveyance system (I Areas) would be closed by cleaning and/or sealing off and solidifying the pipes/inlets in place using flowable grout. Solids, if removed during closure of the system, would be dewatered and disposed either (1) in the on-site TSCA disposal unit, or (2) at an EPA-approved off-site landfill if determined to be a RCRA hazardous waste.

Following completion of site-wide remedial activities active stormwater collection and management would no longer be necessary. Therefore, the existing stormwater treatment system would be decommissioned and the site returned to natural drainage. Long-term maintenance would include inspection and repair of erosion controls designed to mitigate sedimentation during stormwater flow events.

WWTS

WWTS (Areas H) containing PCB concentration greater than 50 mg/kg are temporarily stockpiled at the Mercury Cell Building pad and the SWDS. Alternative A-3 includes disposal of the WWTS in an on-site disposal unit that meets TSCA chemical waste landfill requirements which are identified as ARARs. The total volume of the stockpiled soil on both the Mercury Cell Building pad and the SWDS is approximately 23,700 yd^3.

On-site TSCA Disposal Unit

Approximately 39,100 yd^3 of contaminated soil, sediment, and solids would be disposed of in an on-site newly constructed TSCA disposal unit. Because some of the contaminated media include PCBs at concentrations greater than 50 mg/kg, the disposal unit will be designed and constructed to meet the requirements of a TSCA chemical waste landfill as listed in 40 CFR §761.75 that are identified as ARARs. RCRA hazardous wastes, if generated during the remedial action, will not be placed in the on-site TSCA disposal unit. They will be disposed of at an off-site EPA-approved RCRA Subtitle C landfill.

Waiver and Design

40 CFR § 761.75(b)(3) requires that the bottom of a chemical waste landfill be at least 50 feet above the historical high groundwater table. This distance is not naturally available at the site because there is shallow groundwater. The 50 feet depth requirement is the only item in paragraph (b) which cannot be met at the site. TSCA regulations at 40 CFR 761.75(c)(4) allows the Regional Administrator[13] to waive one or more of the requirements of paragraph (b) if evidence is submitted that indicates that operation of the landfill will not present an unreasonable risk of injury to health or the environment from PCBs when one or more of the requirements of paragraph (b) of this section are not met. This "no unreasonable risk of injury to health or environment" standard is less stringent than the CERCLA Section 121(b) threshold requirement that the selected remedy be protective of human health and the environment. The CERCLA protectiveness requirement is addressed as part of the Comparative Analysis of Alternatives in **Section 10.1**.

[13] Approval authority for CERCLA remedies selected in RODs (which includes ARAR determinations and use of a waiver where justified) has been delegated from the Regional Administrator to the Superfund Division Director.

To support the approval of a waiver under 40 CFR 761.75(c)(4) and meet the CERCLA threshold protectiveness requirement, the TSCA disposal unit will be constructed using a dual-liner system. A summary of the design specifications for a dual liner system includes the following:

- The dual liner system would consist of a primary and secondary liners, each constructed with synthetic membranes embedded between protective soil layers
- Each membrane would have a permeability equal to or less than 1×10^{-7} cm/sec, be made of a material that is chemically compatible with PCBs, and be at least 30 mils thick
- Both membranes would be placed upon an adequate soil underlining and with a soil cover to prevent excessive stress or rupture
- Between the liner systems would be a porous leachate collection layer (e.g., coarse gravel) that can be monitored (i.e., interstitial monitoring) for leak detection from the upper liner.

Installation of a dual liner system meeting the specifications will contain and confine the TSCA disposal unit contents from direct contact with groundwater, equivalent to a 50-foot natural buffer. A 200-foot thick dense clay confining unit (the Peedee formation) lies beneath the planned TSCA disposal unit location and shallow surficial aquifer and further limits the potential for migration of PCBs. Implementation of a dual-liner design along with the presence of the natural clay formation would prevent releases of PCBs and thus the on-site TSCA disposal unit would not present an unreasonable risk of injury to health and the environment from PCBs under TSCA and also meet the CERCLA protectiveness requirement.

A conceptual cross-section for the TSCA disposal unit is shown on **Figure 40**. The primary components include the following:

- TSCA disposal unit subgrade preparation including grading, compaction, and protection against desiccation and cracking
- A clay or equivalent underlayer to serve as a base for the sealing layer
- A geosynthetic, clay, or equivalent sealing liner at the base of the TSCA disposal unit to provide additional containment of the material inside the unit
- A base geomembrane on top of the sealing liner to contain and prevent exfiltration of leachate from the TSCA disposal unit
- A second gravel drainage layer to collect leachate and to divert it to drains at the edge of the TSCA disposal unit for discharge to the surface
- An underdrain system between the bottom of the TSCA disposal unit liner system and groundwater
- Disposed waste surrounded by fill material (daily soil cover)
- A clay cap or equivalent layer to contain the disposed material
- A geomembrane sealing layer covering the TSCA disposal unit to stop infiltration of precipitation into the disposed material
- A permeable geocomposite drainage layer on top of the geomembrane to divert infiltration to drains at the sides of the TSCA disposal unit
- A drainage system at the edge of the cover to move stormwater runoff away from the TSCA disposal unit
- A layer of topsoil, seeded with vegetation for cover stabilization and to encourage evapotranspiration of moisture that infiltrates the topsoil cover