Human Health Risk Assessment
Onondaga Lake
Lake Bottom Subsite: Sediment Consolidation Area
Camillus, NY

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Executive Summary

Prior Onondaga Lake Assessment Indicated Need for Sediment Remediation to Protect Ecological Receptors Present In and Near the Lake and Humans who Consume Fish

A Record of Decision (ROD) selecting a remedy for the Onondaga Lake Bottom subsite was issued jointly by the New York State Department of Environmental Conservation (NYSDEC) and USEPA in July 2005 (NYSDEC and EPA, 2005). The selected remedy includes hydraulically dredging sediments from the lake, piping the water/sediment mixture up to a sediment consolidation area (SCA) at Wastebed 13 and into geotextile tubes, collecting and treating the water that drains from the geotextile tubes, and encapsulating the geotextile tubes containing sediments in a lined cell on the wastebed. The SCA will then be capped, maintained, and monitored to ensure that it is protective of human health and the environment.

The need to remediate lake sediments was based on a Baseline Human Health Risk Assessment (HHRA) (TAMS 2002a) and Baseline Ecological Risk Assessment (BERA) (TAMS 2002b) that was performed for the sediments and other media within the lake. The reports identified risks exceeding acceptable levels for people consuming fish from Onondaga Lake and for ecological receptors present in and near the lake. The human health risk assessment also evaluated risks associated with direct contact with sediments (inadvertently ingesting small amounts of sediment or having sediment contact the skin) and this did not result in unacceptable risks.

In response to a recent request from the community and elected officials, EPA has prepared this supplemental HHRA to identify any potential risks posed by sediment management and dewatering activities which will take place at the SCA. This assessment incorporated numerous conservative assumptions, and indicates all potential risks are within levels identified by EPA as acceptable.

This Supplemental Assessment is Focused on the Sediment Consolidation Area (SCA)

Consistent with EPA risk assessment guidance, a four-step process was utilized for assessing potential human health risks for the SCA:

1 **Hazard Identification –** Identifies the contaminants of potential concern associated with site-related contaminants based on several factors such as toxicity, frequency of occurrence and concentration.
2 **Exposure Assessment –** Estimates the magnitude of actual and/or potential human exposures, the frequency and duration of these exposures and the exposure pathways (e.g.., ingesting contaminated sediment) under future exposure scenarios and under the reasonable maximum exposure anticipated.
3 **Toxicity Assessment –** Determines the types of adverse health effects associated with chemical exposures, and the relationship between magnitude of exposure (dose) and severity of adverse effects (response).
4 **Risk Characterization –** Summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of site-related risks and hazards, and presents a discussion of the uncertainties of the process.

Each of these steps is discussed below.

Hazard Identification

Concentrations of chemicals in sediments were compared with health protective screening values to determine which chemicals should be considered in the risk assessment (termed contaminants of potential concern [COPCs]). All COPCs were then further considered in the HHRA.

Exposure Assessment

The exposure assessment evaluates pathways by which people are or can be exposed to the contaminants of concern in different media (e.g., sediment, soil, air). This exposure assessment considers only hypothetical future exposure scenarios. The quantification of exposure is based on factors including, but not limited to, the concentrations that people are or can be exposed to, the potential frequency of exposure (number of days per year), and the duration of exposure (number of years). The exposure assessment is based on the maximum site-specific parameters that can reasonably be expected at the site, which is termed the reasonable maximum exposure or RME.

All potential ways people could be exposed to chemicals in sediments (termed exposure scenarios) were evaluated. Two hypothetical future exposure scenarios were evaluated here:

1. **Offsite exposure to chemicals that might volatilize from sediments and water during sediment management and dewatering in the SCA and migrate beyond the SCA.** A five year time frame is evaluated consistent with the anticipated duration of activities at the SCA.

2. **Onsite exposure to chemicals in sediments in the SCA if somehow the sediment containment system was to fail and people were to come into contact with the sediments.** Although this scenario is unlikely due to the design and engineering of the SCA, this hypothetical exposure, which evaluates potential risks during the time between a hypothetical failure and when the materials are again secured, was included at the request of the community. This assessment was conducted using the assumptions typically used to estimate residential exposures and is a very health-protective approach because in the unlikely event of a failure of the SCA, any potential exposure that might occur to the sediments would require people coming onto Wastebed 13 and contacting sediments on or near the SCA. The exposure scenario requires that these individuals would need to contact the sediments daily for the 45 day period after the release. During this period, engineering controls such as additional fencing and/or cover material would be implemented to mitigate exposures and corrective actions would be initiated.

Both scenarios are hypothetical and apply conservative health-protective assumptions to evaluate people of all ages in residential settings.

For the sediment exposure scenario, a representative site concentration was calculated for all COPCs as a conservative estimate of the mean (i.e, the 95% upper confidence limit on the mean concentration). For the inhalation scenario, in order to conservatively estimate the air concentrations of chemicals at receptors, health-based air concentrations at the work zone perimeter were used as a starting point. Control measures will be implemented within the SCA to ensure that these criteria are met. An air dispersion model was then used to estimate the chemical concentrations in offsite air at community receptors assuming all chemicals were present at the boundary at the full extent of the allowable concentration. This approach likely overestimates risk because it assumes that site boundary concentrations are at the maximum level for all chemicals, when in reality the worst case is that one or a select few chemicals may be approaching this level while the majority of chemical concentrations would be significantly below the criteria.

All exposure assumptions were selected based on EPA guidance on deriving estimates that represent the reasonable maximum exposure (RME) and as such, these estimates are intended not to underestimate risks, and they likely overestimate risks for most individuals.

Toxicity Assessment

The toxicity assessment conservatively estimates the types of adverse health effects potentially associated with exposures to contaminants at the site and the relationship between the magnitude of exposure (dose) and severity of adverse effects (response). EPA has identified toxicity values for both carcinogenic effects (termed slope factors or unit risks) and non-carcinogenic effects associated with the COPCs. The toxicity values for effects other than cancer include oral reference dose (RfD), the absorbed RfD for dermal exposure, and the inhalation reference concentrations (RfC). The non-cancer health endpoints (e.g., the target organ) are also assembled and considered in the risk assessment. These toxicity values applied in the risk assessment are selected to represent effects on the most sensitive endpoints and life stages and as such provide a health protective means to evaluate risks.

Risk Characterization

In risk characterization, quantitative exposure estimates and toxicity factors are combined to calculate numerical estimates of potential health risk. In this section, potential cancer and noncancer health risks are estimated assuming long-term exposure to chemicals detected in site media. A 1×10^{-6} cancer risk represents a one-in-one-million additional probability that an individual may develop cancer over a 70-year lifetime as a result of exposure under the conditions and scenarios evaluated. The findings presented here are compared with the range of acceptable risk levels cited in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), of 1×10^{-6} to 1×10^{-4}. No cancer risk estimates were greater than the 1×10^{-4} risk level that is the upper end of the EPA target risk range. The following cancer risk estimates were derived:

- **Inhalation – Adults and Children:** The hypothetical future inhalation cancer risk estimates for offsite adults and children were 4×10^{-6} with primary contributors to risk being ethylbenzene and naphthalene.
- **Contact with Sediments – Adults:** The hypothetical future cancer risk estimates associated with exposure to sediments (oral and dermal exposure routes) was 1×10^{-6} for all carcinogenic chemicals combined.
- **Contact with Sediments – Children:** The hypothetical future cancer risk estimate associated with exposure to sediments (oral and dermal routes) was 3×10^{-5} for children ages zero to 2 and 1×10^{-5} for children ages 2-6, with the primary contributors to risk being hexavalent chromium and the carcinogenic PAHs.
- **Contact with Sediments – Adolescents:** The hypothetical future cancer risk estimate associated with exposure to sediments (oral and dermal routes) was 3×10^{-6} for adolescents

ages 6 to 16 (Appendix B Table 8.1) also associated primarily with hexavalent chromium and the carcinogenic PAHs.

The following noncancer risk estimates were derived:

All Scenarios: All noncancer risk estimates had hazard indices less than or equal to one indicating low potential for adverse effects and that non-cancer risks were within acceptable levels. Detailed risk estimates are provided in Appendix B Tables 7-1 through 7-3 and Appendix B, Table 8-2 (inhalation exposure) and Table 8-3 (sediment exposure) show the hazard indices (HI) for COPCs summed based on the primary target organs (or systems) that they effect. Tables 8-2 and 8-3 also show the primary chemicals contributing to the total hazard index for each pathway-endpoint combination. For adult exposure to sediments (see Table 7-2), none of the scenarios had hazard quotients or combined hazard indices (0.2) greater than 1.0. Although the total HI (approximately 2) for child exposure to sediments (ingestion and dermal contact) slightly exceeds 1 (as shown in Table 7-1), the HI values for each endpoint do not exceed 1 (as shown in Table 8-3). In addition, although the total HI (approximately 4) for the inhalation exposure exceeds 1 (as shown in Table 7-3), the HI values for all receptors for each endpoint do not exceed 1 (as shown in Table 8-2).

Hypothetical risk estimates were derived using conservative assumptions as a means to evaluate plans for the SCA and to ensure the SCA activities are safe and protective of human health. The findings from this assessment can be used by risk managers to ensure that the SCA is designed, constructed, monitored, and managed within acceptable risk levels. Many of the assumptions applied here tend to overestimate potential site risks. These include the following:

1. **Hexavalent Chromium.** Chromium can exist is several forms, and two forms are most commonly considered in an HHRA, the trivalent form and the hexavalent form. Results for samples collected from 4 locations near the Crucible Lake Pump Station site that were analyzed for both total and hexavalent chromium did not identify any hexavalent chromium; these results were therefore considered to be in the trivalent form, which is significantly less harmful, and were ultimately screened out and not considered further in this HHRA. All other chromium results were analyzed only for total chromium, and were conservatively considered to be in the hexavalent form, which is more toxic. Under this conservative assumption, hexavalent chromium risk estimates were responsible for approximately 90% of the cancer risk estimates for ingestion of sediments. This is likely an overestimate of the true risk, since hexavalent chromium is reasonably assumed only to be a small percentage of the total chromium in the sediments, and the limited data which are available indicate that the chromium is not present as hexavalent chromium.

2. **Methyl mercury.** Mercury is another chemical that can exist in several forms. However, these forms were not analyzed in most sediment samples, and mercury was reported as total mercury. For the hypothetical sediment exposure pathway in this HHRA, all mercury risk estimates were calculated assuming mercury was present as methyl mercury in sediments, which is the most conservative approach when assessing oral and dermal exposures. However, existing sediment data indicate the maximum percentage of methyl mercury is 1.4%. Nevertheless, all hazard indices for

mercury for both the sediment and the inhalation exposure pathways were within acceptable levels.

3. **Cobalt.** One exposure scenario estimates potential risk from direct contact from sediments in the hypothetical event of a failure of the SCA and individuals come into contact with the sediments. Under this scenario, cobalt contributes approximately 19% to the overall hazard index to the child from exposure to sediments (the total noncancer hazard index to the adult are less than 1, so no further evaluation is necessary). The sediment data set for cobalt consists of 133 samples collected from 37 locations within the area to be dredged. A length weighted average (LWA) was calculated for each location and these 37 LWAs were used to calculate the exposure point concentration for cobalt that was used in the risk assessment. Of these 37 locations, two locations near the Crucible Lake Pump Station site have significantly higher LWA cobalt concentrations than all other locations in the area to be dredged and strongly influence the overall exposure point concentration. These two locations represent less than 2% of the overall volume of sediment to be dredged and are not representative of the cobalt concentrations in the material that will be dredged. Therefore, the noncancer hazard index for cobalt is likely overestimated.

4. **Toxicity Values.** Significant uncertainty may be associated with the derivation of RfDs, CSFs, and all toxicity values. Toxicity values based on human epidemiological studies are not available for most chemicals, and those human studies that are available generally lack exposure data and are confounded by exposure to multiple chemicals, recall bias, and lifestyle issues. Laboratory animal studies are used to derive most toxicity values and the practice of extrapolating from effects in animals to predict human toxic response is a major source of uncertainty in risk assessment.

5. **Potential for Overestimation within Exposure Scenarios.** The SCA is planned to be closely managed and maintained. Consequently, the assumed potential for exposure to sediments is hypothetical and may overestimate risks, particularly for young children who would be unlikely to come into contact with this material.

6. **Exposure Assumptions.** There is considerable uncertainty regarding the likelihood of exposure to a given medium of concern. It is unknown whether all of the exposure pathways modeled will ever be actually complete or whether the individuals evaluated will actually be exposed to COPCs. Exposure estimates used to calculate risks and hazards may also be relatively uncertain. Many of the exposure parameter values applied are default values determined by USEPA rather than site-specific values. As such, risk estimates based on these exposure parameters generally represent conservative estimates.

7. **Inhalation of Volatilized Chemicals.** The air concentrations used as a starting point in deriving offsite air estimates are all assumed to be the lower of either the NYSDEC's DAR-1 guidance value ("Guidelines for Control of Toxic Ambient Air Contaminants') (NYSDEC, 2007), and EPA's Regional Screening levels (RSL) (US EPA, 2010a) for industrial settings after adjustment for a 5-year exposure duration for all chemicals identified in the sediments as volatile. Both bench scale testing of

sediments and testing of volatilization from sediments suggest that instead approximately half of the chemicals would actually be volatilized from sediments. This assumption contributes to a cumulative air exposure risk estimate that is higher than what would likely occur.

8. **Application of the Highest Receptor Location in Air Estimates.** Work zone perimeter concentrations were used to estimate offsite air concentrations. The resulting estimates were evaluated, and the highest yearly average concentration was applied. The selection of this maximum value means that all other yearly average concentrations would be lower and thus exposure estimates for most people would be lower than this value.

9. **Tentatively Identified Compounds (TICs).** Standard analytical protocols for Superfund sites require that an extensive list of chemicals be analyzed and reported. This list is known as the Target Compound List (TCL)/Target Analyte List (TAL) for organic chemicals and metals, respectively. The list was developed with consideration of the chemicals most commonly found at sites. Other chemicals that are not routinely analyzed for or reported might be present at sites. These chemicals are known as tentatively identified compounds (TICs), since neither the identity nor the concentration can be reported with certainty. The TICs could present a contribution to risk that has not been quantified, however, they typically do not contribute significantly to the overall risk or hazard at a site. The extensive database of more than 33,000 samples collected at the site provides a robust data set that supports the basis for the risks identified in this assessment.

Conclusions

This supplemental risk assessment applied conservative exposure assumptions to evaluate potential risks associated with the operation of the SCA and to address community concerns. Estimates were designed to represent two hypothetical future scenarios: 1) exposure to contaminants that could migrate from the site in air during the operation of the SCA and 2) exposure to sediments within the SCA post-closure if the SCA were to fail, sediments were released, and people would come onto Wastebed 13 and come into contact with the sediment on or near the SCA. Both of these potential future scenarios were intended to represent the reasonable maximum exposure potential and both assume individuals of all ages could be exposed. As such, these risk estimates are likely higher than risks that would likely be experienced by most receptors.

All resulting risk estimates and target organ-specific hazard indices were within levels identified by EPA as acceptable. The finding of acceptable risk estimates through application of these health protective assumptions, indicates that the SCA will not result in unacceptable risks for the surrounding community. Nevertheless, the SCA will be closely monitored to ensure that sediments are managed with care and secured appropriately and that offsite migration of chemicals in air is limited or prevented.

This HHRA can also be used as a tool for risk managers during the implementation of the remedy and management of the SCA. The exposure scenarios evaluated in this HHRA are future hypothetical situations, so the outcome can be used to help assess the effectiveness of the remedy. For example, the air concentrations modeled in the residential areas are based on work zone perimeter concentrations that reflect the maximum annual average concentrations for all chemicals. It is highly unlikely that every volatile chemical would be present at that concentration for a one year period of time to result in that exposure scenario. During remedy implementation, if monitored air concentrations indicate a trend towards chemicals reaching this maximum annual average concentration for a sustained period of time, risk managers can modify site operations to reduce these concentrations so that the actual risks are much lower than those estimated here. Risk managers can also use this HHRA to assist in managing risks in the unlikely event of a failure of the SCA. If sediments are released as a result of a failure of the SCA, measures would be implemented to address the release in accordance with site management plans (e.g.. Spill Contingency Plan) to be developed. The measures may include additional sampling and characterization, for example, speciating potential risk-driving chemicals such as mercury and chromium, to ensure that the actual exposures that would occur once the interim controls are implemented are not greater than the exposures in the scenarios defined in this HHRA.

1. Introduction

A Baseline Human Health Risk Assessment (HHRA) (TAMS 2002a) and Baseline Ecological Risk Assessment (BERA) (TAMS 2002b) were performed for the Lake Bottom Subsite of the Onondaga Lake Site in 2002. The HHRA estimated risks exceeding acceptable levels related to consumption of fish that had accumulated contaminants from sediments and surface water. The BERA estimated potential for chemical waste in the lake to produce adverse ecological effects to ecological receptors present in and near the lake. A remedial action was proposed to address these risks and, after public review and comment, a remedy was selected. The remediation includes dredging sediments from the lake and placing them in a Sediment Consolidation Area (SCA) located near the lake.

In response to a recent request from the community and elected officials, EPA has prepared this supplemental HHRA to identify any risks posed by implementing the remedial action for the lake. This remedy includes hydraulically dredging sediments from the lake, piping the water/sediment mixture up to Wastebed 13 and into geotextile tubes, collecting and treating the water that drains from the geotextile tubes, and encapsulating the geotextile tubes containing sediments in a lined cell on the wastebed, which will then be capped, maintained, and monitored to ensure that it is protective of human health and the environment. The risk assessment provided here evaluates two possible means people could be exposed to chemicals from sediments. The ways people could be exposed are called exposure scenarios and include:

1. Offsite exposure to chemicals that might volatilize from sediments and water during sediment management and dewatering in the SCA and migrate beyond the SCA.

2. Onsite exposure to chemicals in sediments in the SCA if somehow the sediment containment system was to fail and people were to come into contact with the sediments. Although this scenario is unlikely due to the design and engineering of the SCA, this hypothetical exposure, which evaluates potential risks during the time between a hypothetical failure and when the materials are again secured, was included at the request of the community. This assessment was conducted using the assumptions typically used to estimate residential exposures and is a very health-protective approach because in the unlikely event of a failure of the SCA, any potential exposure that might occur would require people coming onto Wastebed 13 and contacting sediments on or near the SCA. The exposure scenario requires that these individuals would need to contact the sediments daily for the 45 day period after the release. During this period, engineering controls such as additional fencing and/or cover material would be implemented to mitigate exposures and corrective actions would be initiated

This introduction provides a discussion of the HHRA for Onondaga Lake to provide the background for the planned remediation, then briefly describes the basis used to conduct the risk assessment for the SCA.

1.1. Background on Onondaga Lake HHRA

A Baseline Human Health Risk Assessment (HHRA) and Baseline Ecological Risk Assessment (BERA) were performed for the Lake Bottom Subsite of the Onondaga Lake Site in 2002. The reports were developed as part of the remedial investigation, as required by the National Oil and

Hazardous Substances Pollution Contingency Plan (NCP) (55 Fed. Reg. 8665-8865, March 1990) (US EPA, 1990), which states that the baseline risk assessment should "characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to ground water or surface water, releasing to air, leaching through soil, remaining in the soil, and bioaccumulating in the food chain" (Section 300.430(d)(4)). The main purpose for conducting the baseline risk assessments is to identify the potential baseline risks to human health and the environment posed by the site and for the risk managers to evaluate whether these potential baseline risks warrant a remedial action. In the baseline risk assessments for the Lake Bottom Subsite, risks were identified above the acceptable levels defined in the NCP to ecological receptors and to people who eat fish from the lake (TAMS, 2002a, and TAMS, 2002b.). These risks were sufficient to warrant a remedial action.

The remedy that was proposed, presented to the public and then selected includes dredging sediment from the lake and placing it in a sediment consolidation area located near the lake. Wastebed 13 was identified as the preferred location following completion of the siting evaluation in September 2006 as documented in the NYSDEC's October 2006 Fact Sheet. Following review of public comments, Wastebed 13 in the Town of Camillus was selected as the location for the SCA (NYSDEC, NYSDOH, and US EPA, 2010).

In considering the supplemental risk assessment presented in this document, it is important to clarify the purpose and outcome of the baseline risk assessments for Onondaga Lake. The purpose was to determine the potential risks posed by the Lake site as it currently exists and to evaluate whether these risks justify a remedial action. The reports identified that the only unacceptable risks as defined by the NCP were to ecological receptors, and to people consuming fish caught from Onondaga Lake. Although direct contact (inadvertently ingesting small amounts of sediment or having sediment contact the skin) with lake sediments to humans was evaluated in the HHRA, exposure to these lake sediments did not result in unacceptable cancer risks[1] or noncancer hazards[2].

1.2. Overview of the Sediment Containment Area

The Onondaga Lake Bottom Subsite of the Onondaga Lake Site includes the contaminated surface water and sediments in the 4.5-square mile lake. Industrial waste and municipal sewage have been discharged to the lake for over 100 years. Mercury contamination is found throughout

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[1] In an HHRA, exposures are evaluated based on the potential risk of developing cancer and the potential for non-cancer health hazards. The likelihood of an individual developing cancer is expressed as a probability. For example, a 10^{-4} cancer risk means a "one-in-ten-thousand excess cancer risk," or one additional cancer may be seen in a population of 10,000 people as a result of exposure to site contaminants under the conditions explained in the Exposure Assessment of the HHRA. Current federal Superfund guidelines for acceptable exposures are "generally concentration levels that represent an excess upper bound cancer to an individual of between 10^{-4} to 10^{-6}" (40 CFR § 300.430[e][2][A][2]) (corresponding to a one-in-ten-thousand to a one-in-a-million excess cancer risk). The 10^{-6} risk is used as the point of departure for determining remediation goals and cancer risk estimates greater than 10^{-4} represent unacceptable risks.

[2] For non-cancer health effects, a "hazard quotient" (HQ) is calculated for each contaminant. An HQ represents the ratio of the estimated exposure to the corresponding reference doses (RfDs). The sum of the HQs is termed the "hazard index" (HI). The key concept for a non-cancer HI is that a "threshold level" (measured as an HQ or HI of 1) exists, at or below which non-cancer health effects are not expected to occur.

the lake. Other contaminants present in lake sediments include benzene, toluene, ethylbenzene, xylenes, chlorinated benzenes, polycyclic aromatic hydrocarbons, PCBs, and polychlorinated dibenzo-*p*-dioxins/polychlorinated dibenzofurans.

A Record of Decision (ROD) selecting a remedy for the Lake Bottom subsite was issued in July 2005. The selected remedy includes dredging up to an estimated 2.65 million cubic yards of contaminated sediments, isolation capping of an estimated 425 acres in the littoral zone (water depths ranging from 0 to 30 feet), thin layer capping of an estimated 154 acres, an oxygenation pilot study for the water in the deeper portion of the lake, and monitored natural recovery in the profundal zone (water depths exceeding 30 feet). While the most highly contaminated materials will be treated and/or disposed of off-site, the dredged sediment will be placed in a nearby SCA. Wastewater generated by the dredging/sediment handling processes as a result of dewatering of the sediments at the SCA will be treated prior to being discharged back to the lake (NYSDEC and US EPA, 2005). A draft Explanation of Significant Differences which describes a change to a portion of the remedy required by the ROD in the southwest portion of the lake was approved in December 2006. The change was necessary to ensure the stability of the adjacent causeway and the adjacent area which includes a portion of I-690, and is supported by extensive sampling of the area which indicates that the pure phase chemical contamination is significantly less extensive than estimated in the ROD.

In October 2006, NYSDEC made available for public review and comment an SCA Siting Evaluation Report which assessed Solvay Wastebeds 1 – 15 and B as potential locations for the SCA based on accessibility, estimated capacity, current and future site use, geotechnical considerations, and distance from residences (Parsons, 2006). Based on the evaluation results, Wastebed 13 in the Town of Camillus was selected as the location for the SCA (see Figure 1 in Appendix A). This decision was documented in the Consent Decree between Honeywell and NYSDEC for the Lake Bottom subsite (United States District Court, Northern District of New York, 2007) (89-CV-815).

The dewatering method for the dredged material presumed during the development and issuance of the ROD was a large open settling basin; however, the local community raised concerns pertaining to potential odor generation using this dewatering method. In response to these community concerns, an extensive evaluation comparing the geotextile tube and settling basin dewatering methods based on 10 site-specific dewatering objectives was conducted (Parsons and Geosyntec, 2009). Based on this evaluation, it was determined that there are many site-specific benefits of using geotextile tubes as compared to settling basins. These benefits include:

- The potential for significantly reduced odors and emissions;
- Primary containment of the dredged sediments within the geotextile tubes;
- Reduction in required berm height and preloading requirements as compared to an open settling basin, thereby reducing scale of construction activities and associated truck traffic and noise levels;
- Reduction in required footprint as compared to an open settling basin because of lower SCA perimeter dike height, thereby reducing the visibility of the SCA and related construction activities;

- Improved ability to maintain geotechnical stability and SCA liner integrity as a result of the lower hydraulic head and flexibility related to tube placement as compared to an open settling basin; and
- Reduction in time to closure.

As a result of this evaluation, use of geotextile tubes for dewatering has been incorporated into the design documents. The design presently calls for the construction of a 72-acre SCA within Wastebed 13 to store the approximately 2.2 million cubic yards of material to be dredged from the lake. The layout, as shown on Figure 2 in Appendix A, was developed to maintain the buffer zones requested from the community (i.e., a 500-ft buffer along the western boundary of Wastebed 13) and an additional 200-ft buffer zone from the northern boundary of Wastebed 13. For dewatering the Onondaga Lake sediment, it is anticipated that geotextile tubes 80 to 90 ft in circumference and 200 to 300 ft in length would be used within the lined SCA. Slurry would be pumped into the tubes via ports along the top of the tubes, and the filtrate (water) would drain through the openings of the geotextile. Solids would be retained within the geotextile tubes (Parsons, 2009).

1.3 Method Used to Calculate Risks for the SCA

Consistent with EPA risk assessment guidance, a four-step process was utilized for assessing potential human health risks for the SCA:

1. Hazard Identification – identifies the contaminants of potential concern associated with site-related contaminants based on several factors such as toxicity, frequency of occurrence and concentration.
2. Exposure Assessment – estimates the magnitude of actual and/or potential human exposures, the frequency and duration of these exposures and the exposure pathways (i.e., ingesting contaminated sediment) under future exposure scenarios and under the reasonable maximum exposure anticipated.
3. Toxicity Assessment – determines the types of adverse health effects associated with chemical exposures, and the relationship between magnitude of exposure (dose) and severity of adverse effects (response).
4. Risk Characterization – summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of site-related risks and hazards, and presents a discussion of the uncertainties of the process.

As indicated above, for the SCA, two potential exposure scenarios were identified: exposures to contaminants in offsite air; and exposure to contaminants in sediments in the hypothetical case of a breach of the SCA. These two exposure scenarios are discussed in detail in Section 2.

2. Conceptual Site Model and Human Exposure Pathways

As stated above, this HHRA was developed in response to concerns raised by the community and elected officials that exposures to site-related contaminants might occur during the process during which the dredged sediments are pumped into the geotextile tubes and once the geotextile tubes are encapsulated in place in the SCA located in Wastebed 13. This section describes the possible sources, receptors, and exposure pathways included in the HHRA through development of a conceptual site model and identification of possible human exposure pathways. The conceptual site model and exposure pathways are also summarized in Table 1 of Appendix B.

A conceptual site model was developed to evaluate potential exposure pathways for chemicals of concern within SCA sediments during remediation and in the unlikely event of a future failure of the SCA. Exposure pathways are defined as the course a chemical takes from a source to an exposed receptor. Exposure pathways consist of the following four elements: 1) a source; 2) a mechanism of release, retention, or transport of a chemical to a given medium (e.g., air, water, soil); 3) a point of human contact with the medium (i.e., exposure point); and 4) a route of exposure at the point of contact (e.g., incidental ingestion, dermal contact). If any of these elements is missing, the pathway is considered incomplete (i.e., it does not present a means of exposure) (US EPA, 1989). A conceptual site model examines the range of potential exposure pathways and identifies those that are present and that may be important for human receptors, and it eliminates those pathways that are either incomplete or that constitute negligible exposures (i.e., exposures consistent with background or below a risk-based threshold). Exposure pathways are grouped into exposure scenarios as described above.

Two scenarios were identified to characterize the potential exposures associated with the following: 1) placement and dewatering of sediment in the SCA and 2) exposures that could occur in the event of hypothetical failure of the SCA. The first scenario evaluates potential exposures that could occur during remediation. Specifically, chemicals may volatilize from sediments and from the water seeping from the geotextile tubes. Volatilized chemicals then could migrate from the SCA towards nearby residents. The second scenario assesses potential onsite exposures to sediments that may be released from a hypothetical failure of the SCA.

2.1. Potential Human Exposure Pathways Related to Sediment Remediation

Inhalation of volatilized chemicals is the only exposure pathway considered potentially complete during the disposal and dewatering of sediment in the SCA. The sediments, in the form of a slurry (a mixture of approximately 90% water and 10% solids) will be transported to the SCA via a double-walled pipe and pumped into the geotextile tubes in place in the SCA. Due to the engineering of this process, there is no reasonably anticipated exposure of sediments to the community or to people other than those workers trained and skilled in the handling of this type of material. Remediation workers will be protected from physical and chemical hazards through implementation and adherence to a site health and safety plan. Once the wet sediment material is pumped into the geotextile tubes, filtrate (water) will drain from the slurry, leaving behind dewatered sediments that will ultimately remain inside the geotextile tubes.

The water will be collected, treated appropriately within an enclosed on-site water treatment plant to remove any site-related contaminants that are dissolved in the water, and discharged to the Onondaga County Metropolitan Wastewater Treatment Plant (METRO) plant for further treatment and thus there are no complete exposure pathways related to the geotextile tube filtrate water from this process. During the process by which the water is drained from the geotextile tubes and collected, certain chemicals may volatilize into the air and be dispersed into surrounding air, migrating from the SCA and resulting in lower concentrations in surrounding areas. These potential air concentrations are evaluated within this risk assessment. The list of chemicals that are being evaluated in this scenario is discussed in Section 3.2.

The populations near the SCA and who could potentially be exposed to these volatile chemicals include people living in neighborhoods near the facility and workers at the Town of Camillus' construction and demolition landfill at Wastebed 15, which is shown in Figure 2 of Appendix A. However, because the workers are exposed less frequently (fewer days per year and fewer hours per day), their potential exposures would be less than exposures evaluated in this HHRA (i.e, for residents living in the neighborhoods near the SCA). Therefore, offsite workers are evaluated qualitatively, meaning that their potential risks will be discussed in the risk characterization section of this HHRA. The residents who live near the SCA will be evaluated quantitatively, meaning that their potential risks will be conservatively estimated, based on an assumed hypothetical exposure to the sediment chemicals that could volatilize into the air. For this evaluation, all chemicals present in sediments that could volatilize and that had toxicity values were included in the risk assessment. This list is further discussed in Section 3.2.

In order to conservatively estimate the maximum concentration of these chemicals that might migrate into the community, concentrations at the work zone perimeter were used as a starting point. These concentrations, which are health-based air concentrations developed by either EPA or NYSDEC to be protective of commercial exposures over a 5 year duration, are discussed in detail below and in Appendix C. Control measures will be implemented to ensure that these criteria are met. An air dispersion model was then used to estimate the chemical concentrations at community receptors assuming the maximum allowable concentrations were present at the site boundary. A significant level of conservatism is built into this approach because it assumes that site boundary concentrations are at the maximum level for all chemicals, when in reality the worst case is that one or a select few chemicals may be approaching this level while the vast majority of chemical concentrations would be significantly below the criteria. This dispersion modeling is discussed more thoroughly in Appendix C.

The maximum allowable site perimeter concentrations used in this modeling are based on criteria established by NYSDEC's DAR-1 guidance ("Guidelines for the Control of Toxic Ambient Air Contaminants"), and US EPA's Regional Screening Levels (RSL) (NYSDEC, 2007) (US EPA, 2010a), which are typically developed for both industrial and residential settings. The use of the DAR-1 and RSL levels establish risk-based concentrations designed to protect public health from effects which may be associated with long-term (70 year) exposure to these contaminants. These criteria have been modified to account for the duration of the project (5 years). For the purposes of this evaluation, the lower (more conservative) of either the modified DAR-1 values or the industrial RSLs have been selected as the maximum allowable site perimeter concentrations. These concentrations will form the basis of air quality criteria that will be specified for this project, and enforced at the workplace perimeter and for this reason they provide a good means to evaluate the potential exposures that could occur during the course of the sediment remediation.

The air exposure scenario considered that offsite residents of all ages could be exposed by breathing contaminants in the air. Figure 3 of Appendix A shows the location where the sediment consolidation area is located, and the two boundaries utilized for this modeling analysis. This figure shows the work zone perimeter (green line), at which the above referenced maximum allowable site perimeter concentrations will be enforced, as well as the nearest residential receptor boundary (blue line). This line was developed using aerial photographs, maps, and driving reconnaissance, and identifies the closest residential location in every direction from the SCA. For this analysis, residential locations (houses) as well as publicly accessible non-residential areas (e.g., parks, churches, etc.) were included. The modeling analysis calculated the average concentration along every point of this receptor boundary, assuming these maximum allowable concentrations were present at the site boundary. As an additional level of conservatism, the HHRA used the highest modeled air concentrations along this receptor boundary to estimate risks to people in this scenario. Table 3-2 in Appendix B shows the modeled air concentrations used in the risk assessment.

2.2. Potential Human Exposure Pathways Related to Hypothetical Release of Sediment at the SCA

Once the dredging is complete, the sediments have drained, and the SCA is properly closed, a post-closure monitoring plan will be implemented to ensure ongoing maintenance of the facility and to confirm that the facility remains intact and no material has been released.

The community has asked that a risk assessment be performed to determine what the potential risks to the community would be in the event that the SCA containment somehow failed and there was potential for people in the community to enter the site to come into contact with the sediments. This HHRA evaluates the risks to the community in the hypothetical scenario in which there is potential for people of all ages to be exposed to sediment at chemical concentrations in the SCA for a 45 day period before sediments were again contained. The 45 day response time to repair any damage to the SCA is considered the maximum amount of time it would take to make necessary repairs, recover any sediments released within the berm, and perform sampling to ensure no material had migrated from the point of release. It should be noted that interim measures such as fencing, cover material, or other engineering controls would be implemented shortly after any release to limit the potential for any exposure, and it is not likely that people would be in daily contact with sediments released from the SCA for the entire 45 day period; however, this is evaluated to provide a very conservative estimate of the hypothetical exposure.

This exposure scenario considered that adult, adolescent (ages 6 – 16 years) and child (ages 6 years and under) residents could potentially be exposed by daily incidental ingestion of and dermal contact with contaminated sediments at the SCA during the 45 day period for the hypothetical release from the SCA. However, note that such a scenario is considered unlikely for the following reasons: the SCA contains four layers of containment (geotextile tubes, a lined cell, a newly constructed berm, and the final cover system) one or more of which would need to fail, and some way for individuals to access the sediment at the SCA, where the nearest residence is approximately 1500 feet from the SCA, which is shown on Figure 3 in Appendix A. Such exposure potential is considered unlikely, but is evaluated here for hypothetical purposes.

3. Hazard Identification

This section outlines the data used in the risk assessment, how data were collected, the criteria for selecting the chemicals of potential concern (COPCs), and the calculation of the exposure point concentrations (EPCs).

3.1. Data Collection and Evaluation

This HHRA is focused on implementation of the remedy in the Consent Decree (United States District Court, Northern District of New York, 2007) (89-CV-815) for the Lake Bottom sediments: dredging the sediments and placing them in the SCA in Wastebed 13. Many samples have been collected from the areas of the lake that will be dredged during the remedial investigation and the pre-design investigation. Dredging will occur to varying depths of up to 4 meters, so only cores that represented these depths were included. In total, 329 locations from the areas targeted for dredging are used in this HHRA, including samples collected at 290 locations over the past 5 years as part of the pre-design investigation. Although many other samples have been collected, this subset of the data is considered the most representative because they were collected from areas to dredged and are most representative of the entire depth of the area to be dredged. Figure 4 in Appendix A illustrates the sample locations that are included in this HHRA. Samples were taken from different lengths along the depth of the core sample and sediments will be extensively mixed during remediation (e.g, they will be pumped as a slurry), so a length weighted average (LWA) approach was used to estimate the concentration of each contaminant for each sample location. In summary, the LWA concentration for each chemical was calculated by averaging the concentration detected for each core segment for the length of the core up to the anticipated depth of dredging for that location. These length weighted average concentrations were then combined to derive exposure point concentrations for each contaminant of potential concern.

A detailed explanation of the procedure for calculating the LWA and a list of all sample locations are included in Appendix D. It should also be noted that not all chemicals were analyzed in every sample. Some samples were only analyzed for a smaller suite of chemicals. There are several reasons for this, such as certain areas were identified in the remedial investigation as not containing specific types of chemicals, so there was no need to look for them in those areas during the pre-design investigation. The LWA concentrations are representative concentrations for each sediment core from areas that will be dredged. It should be noted that all analytical methods used were approved by EPA and NYSDEC and followed proper quality assurance/quality control procedures.

3.2. Criteria for Selecting COPCs

Table 2-1 in Appendix B summarizes the analytical data for concentrations for sediments to be dredged that were used to determine the COPCs for the scenario that evaluates exposure to sediments in this risk assessment. Table 2-1 includes sediment data from the areas to be dredged. Table 2-2 identifies the chemicals that are included in the scenario to evaluate inhalation of volatile chemicals migrating from the SCA. Essential nutrients calcium, magnesium, potassium, and sodium were not evaluated due to low toxicity, which is consistent with EPA Region 2 protocols. Consistent with EPA guidance for risk assessment, chemicals identified as tentatively identified compounds (TICs) were not included in the analysis. TICs are chemicals for which either the identity or the concentration cannot be accurately reported. EPA guidance also recommends that chemicals that are detected infrequently (i.e., detections in less than 5% of the samples) should not be included. This approach assures that the data used are of sufficient quality to be appropriate for risk assessment (US EPA, 1989).

In Table 2-1, the maximum detected concentration for each chemical for all sample locations was compared to the corresponding risk-based screening value for residential soils, from the Regional Screening Level (RSL) table (US EPA, 2010a). The RSL values represent an excess cancer risk of one in one million ($1x10^{-6}$) or a hazard quotient of 1. The non-cancer hazard quotients from the RSL table were adjusted to 0.1 prior to comparison to account for potential exposures to multiple chemicals. If the maximum LWA concentration of the chemical exceeded its respective RSL value, the chemical was retained for quantitative analysis. If the concentration of a chemical was below its respective RSL value, that chemical was determined unlikely to cause adverse effects and was not included for quantitative analysis in the HHRA.

The RSL for methyl mercury was used to screen mercury in order to be health-protective; this is a health-protective approach since very little of the mercury in the sediments is present in the form of methyl mercury. Based on data from the RI, the maximum percentage of methyl mercury was 1.4% of the total mercury (TAMS, 2002c). However, all mercury was assumed to be methyl mercury for this HHRA.

The RSL for hexavalent chromium was used to screen chromium in order to be health-protective; this is a health-protective approach since most of the chromium in the sediments is likely present in less toxic toxic forms. Based on data collected in 2008, 21 sediment samples from 7 locations near the Crucible Pump Station were analyzed for hexavalent chromium and no hexavalent chromium was detected (Environmental Data Services, Inc., 2008). Only four of the 7 locations were in areas to be dredged. Since the data confirmed no hexavalent chromium was present in these four locations, chromium results from these four location are evaluated as trivalent chromium. It should be noted that the maximum detected trivalent chromium concentration from these four locations of 4,830 mg/kg (from location OL-VC-20139) is less than the RSL value for trivalent chromium of 12,000 mg/kg (adjusted by 0.1 as described above) and therefore trivalent chromium is not included in this HHRA. All other chromium results were conservatively assumed to be hexavalent chromium for this HHRA.

For lead, the screening values recommended by EPA of 400 mg/kg for residential was used without adjustment and was compared with an average concentration in sediments; this is consistent with EPA guidance, as the value of 400 mg/kg is not based on a hazard quotient and so no adjustment is needed (US EPA, 2003b).

Table 2-2 identifies the chemicals that are identified as COPCs for the exposure scenario that evaluates volatilization from sediments, including water draining from the geotextile tubes, and inhalation of airborne site-related chemicals. The list of COPCs was generated differently than the list for sediments. All chemicals identified in sediments were considered for this scenario. Chemicals were included if they had each of the following: 1) chemicals that are considered volatile (i.e., having a molecular weight less than 200 g/mole and a Henry's Law Constant greater than 1×10^{-5} atm-m^3/mole [US EPA, 2010b]) were retained based on the categorization provided within the EPA RSL tables; 2) chemicals identified as volatile were retained for evaluation in the risk assessment if they had a toxicity value for use in risk assessment.

This method provides a health protective means to determine which chemicals to evaluate for the volatilization pathway. The volatilization pathway was considered in evaluating the remedial operations for Onondaga Lake sediments. Specifically, a series of three tests, including wind tunnel testing, was run to identify the chemicals that are likely to have the potential to volatilize. A detailed discussion of the testing can be found in Appendix E. Table 2-2 of Appendix B shows the identification of COPCs for the volatilization pathway. As indicated there, only some of the chemicals that were identified as COPCs were detected in the wind tunnel testing. The more comprehensive set of chemicals were included here (i.e., all chemicals in sediments that were identified as volatile and had toxicity values for use in risk assessment) in order to provide a more conservative estimate of potential risks.

Polychlorinated biphenyls (PCBs) were not included in the assessment of inhalation of volatile chemicals migrating from the SCA since there were no detections of PCBs in the Phase I PDI wind tunnel air samples and based on the concentrations of PCBs in the sediments that will be dredged, PCBs are not expected to contribute significantly to the risks associated with inhalation of volatile chemicals.

3.3. Calculation of the Exposure Point Concentration

Exposure point concentrations (EPCs) for sediments were calculated using chemical analyses of sediment samples for materials that will be deposited in the SCA. The EPCs for the volatilization of chemicals from sediments were estimated through dispersion modeling.

Sediment EPCs were calculated for chemicals with concentrations that exceeded their screening values in Table 2-1 of Appendix B (i.e., sediment COPCs) using ProUCL, version 4.0 (US EPA, 2007). The EPC is the 95% Upper Confidence Limit (UCL) on the arithmetic mean of a LWA chemical concentration, and provides a 95% level of confidence that the true mean will not be greater. It is based upon the distribution of the data. The ProUCL program tests the normal, lognormal, and gamma distributions of each data set and recommends the appropriate statistic using parametric and non-parametric statistical methods. If analytical data indicated a non-detect result for a chemical, a value of ½ of the detection limit was used in calculating the UCL. For chemicals with a data set that is too small to calculate this statistical upperbound average concentration, the maximum detected concentration was used. The only chemicals for which this happened were 1,2,3/4,5-tetrachlorobenzene and pentachlorobenzene. The EPCs for the sediments are shown in Table 3-1 of Appendix B, and the ProUCL outputs showing all of the statistics for each chemical, can be found in Appendix F.

For the exposure scenario that considered inhalation of airborne volatile chemicals, EPCs were estimated through dispersion modeling. As explained in Section 2.1, maximum allowable air concentrations at the work zone perimeter were identified, based on consideration of air quality values set by USEPA and NYSDEC. These criteria (DAR-1 values) and regional screening values are risk-based concentrations designed to protect against adverse human health effects which may be associated with long-term exposure to these contaminants. It should be noted that workers at the SCA facility are skilled and trained in the handling of this type of material and are protected by OSHA and by adherence to a site health and safety plan. These maximum allowable site-perimeter concentrations were fixed at the site perimeter, and an air dispersion model was then used to estimate the chemical concentrations at community receptors. A detailed explanation of the modeling can be found in Appendix C, while Table 3-2 in Appendix B presents the EPCs for air.

4. Exposure Assessment

The exposure assessment evaluates pathways by which people are or can be exposed to the contaminants of concern in different media (e.g., sediment, soil, air). This exposure assessment considers only hypothetical future exposure scenarios. The quantification of exposure is based on factors including, but not limited to, the concentrations that people are or can be exposed to, the potential frequency (number of days per year), and the duration of exposure (number of years). The exposure assessment is based on the maximum site-specific parameters that can reasonably be expected at the site, which is termed the reasonable maximum exposure or RME.

The goal of this HHRA is to estimate the RME expected to occur during operation of the SCA and if the SCA sediments somehow were released in the future and there would be potential for area residents to enter onto Wastebed 13, come onto or near the SCA, and come into contact with these materials. In other words, the RME is the greatest exposure that is reasonably expected to occur. As a result, the risk assessment provides upper-bound estimates of the risks and hazards for people living near the SCA facility using health-protective exposure assumptions so that these risks and hazards are not underestimated. The exposure assumptions for each receptor can be found in Tables 4-1 through 4-4 in Appendix B. Following is a description of the exposure parameters used for each receptor in this assessment.

4.1. Exposure Assumptions

Child Resident
The child resident (up to 6 years old) could be exposed to contaminants in the air and in the sediments. When evaluating the scenario that considers potential exposure to sediments that will be placed in the SCA, the child resident is assumed to be coming onto Wastebed 13 and contacted sediments at or near the SCA, with exposure through dermal contact and incidental ingestion. The child is assumed to have an exposed skin surface area of 2,800 cm^2, which includes head, forearms, hands, lower legs, and feet. For the soil to skin adherence factor (the factor that relates how much soil sticks to the skin and is available for absorption across the skin), a value of 0.2 mg/cm^2 is used. The child is assumed to weigh 15 kg (approximately 33 pounds). The clean up of any sediment released is assumed to be 45 days. These exposure assumptions are shown in Table 4-2 of Appendix B (US EPA, 1989; US EPA, 1991a; US EPA, 1997a; US EPA, 2002a; US EPA, 2004a; US EPA, 2009).

Adolescent Resident: Appendix B, Table 4-3 provides a summary of the exposure terms used to estimate exposures for adolescents ages 6-16. As indicated there, the surface area ranges from 2949 to 5386 cm^2 which includes head, forearms, hands, and lower legs. A soil to skin adherence factor of 0.2 mg/cm^2 is used for ages 6-12 and a factor of 0.07 mg/cm^2 is used for ages 13-16. The adolescent is assumed to weigh from 22 to 58 kg. Because the exposure time is 45 days within one year the exposure estimate is a single average estimate for all of the ages from age 6 to age 16 years (Appendix B, Table 4.3) (US EPA, 1989; US EPA, 1991a; US EPA, 1997a; US EPA, 2002a; US EPA, 2004a; US EPA, 2009).

Adult Resident
The adult resident (greater than 16 years old) could be exposed to contaminants in the air and in the sediments. When evaluating the scenario that looks at exposure to sediments after a release at the SCA, the adult resident is assumed to be on Wastebed 13, be at or near the SCA, and be exposed through dermal contact and incidental ingestion. The adult is assumed to have an exposed skin surface area of 5,700 cm^2, which includes head, forearms, hands, and lower legs. For the soil to skin adherence factor value of 0.07 mg/cm^2 is used. The adult is assumed to weigh 70 kg (approximately 155 pounds). The cleanup of any sediment released is assumed to be 45 days. These exposure assumptions are shown in Table 4-1 of Appendix B (US EPA, 1989; US EPA, 1991a; US EPA, 1997a; US EPA, 2002a; US EPA, 2004a; US EPA, 2009).

Inhalation Exposure
Inhalation exposure is evaluated differently from exposure through dermal contact and ingestion. While exposure through these two pathways requires each age-specific population to be assessed independently, the evaluation of inhalation does not. When age-specific populations are exposed through similar scenarios, such as residential scenarios, certain toxicological considerations need to be addressed when quantifying this exposure. Therefore, adults and children residents are evaluated together. As shown in Table 4-4 of Appendix B, inhalation exposure is assumed to occur over 350 days per year for 5 years, the length of time estimated for the dredging to last (US EPA, 2009).

Age-Dependent Adjustment Factors (ADAFs)
Certain carcinogenic chemicals are known to act through a mutagenic mode of action for carcinogenicity. This means that some ages are particularly susceptible to the carcinogenic potential of these chemicals, and this increased susceptibility must be accounted for when quantifying the risks. In this assessment no chemicals included in the inhalation exposure are known to act through this mode of action. For the sediment exposure scenario, only PAHs are considered to have this mode of action. To account for the mode of action of PAHs, Table 4-3 was created showing the age-adjusted exposure parameters used for the age groupings requiring adjustment to the cancer risk calculations. These age groups include children ages 0-2 and 2-6; adolescents ages 6-16; and adults ages 16 and up. Because the exposure period is less than one year, the exposure estimates used in this assessment are presented as an average exposure over each of these age periods (Appendix B, Table 4-3) (US EPA, 2005a; US EPA, 2005b).

4.2. Estimating Exposure

Dermal Exposure to Soil
To calculate dermal exposure to soil, Exhibit 1-3 in *RAGS, Part E, Supplemental Guidance for Dermal Risk Assessment* (EPA, 2004a) was followed. Cancer risks and non-cancer hazards for arsenic, cadmium, dioxins (as TCDD Equivalents), PCBs, hexachlorobenzene, benzo(a)pyrene and other PAHs were calculated using the dermal absorption factors in Exhibit 3-4 of *RAGS, Part E* (EPA, 2004a).

Incidental Ingestion of Soil
The incidental ingestion pathway was assessed following the exposure model presented in Exhibit 6-14 in *RAGS, PART A, Volume I Human Health Evaluation Manual* (EPA, 1989). Cancer risks and non-cancer hazards were estimated for all chemicals for which toxicity information was available.

Inhalation of Volatiles
For estimating the cancer risk and non-cancer hazard from inhalation of volatiles, Equations 10 and 11 presented in *RAGS, Part F, Supplemental Guidance for Inhalation Risk Assessment* were used when inhalation toxicity values were available (EPA, 2009).

Mutagenic Mode of Action
As stated in Section 4.1, when carcinogenic chemicals are identified as acting through a mutagenic mode of action, quantification of risk from exposure to these chemicals must address the susceptibility of certain populations of certain ages. This approach, using the Age Dependent Adjustment Factors (ADAFs), follows the *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (EPA, 2005b). In summary, a 10-fold adjustment to the toxicity of a chemical is necessary when assessing risks to children in the first 2 years of life, a 3-fold adjustment is used to account for the susceptibility of children aged 2 to less than 16, while no adjustment is needed for exposures that occur to people over the age of 16. These factors are shown in Tables 6-1 and 6-2 in Appendix B. This is discussed in more detail in Section 5.2.

5. Toxicity Assessment

The toxicity assessment conservatively estimates the types of adverse health effects potentially associated with exposures to contaminants at the site and the relationship between the magnitude of exposure (dose) and severity of adverse effects (response). In December 2003, EPA's Office of Solid Waste and Emergency Response (OSWER) issued a directive outlining the hierarchy of toxicity values to be used for risk assessment purposes. Values that come from the Integrated Risk Information System (IRIS), which represents EPA's consensus database for cancer and non-cancer toxicity information, belong in Tier I of the hierarchy. Tier II is the Provisional Peer-Reviewed Toxicity Values (PPRTV). Tier III includes other sources of toxicity information such as California EPA, the Agency for Toxic Substances and Diseases (ATSDR), and the Health Effects Assessment Summary Table (HEAST). For this assessment, IRIS values were used when they were available. PPRTVs were used in the absence of IRIS values if they were available. All toxicity values from Tier III have been approved by the EPA Office of Research and Development, National Center for Environmental Assessment (NCEA), Superfund Technical Support Center. (US EPA, 2003a).

5.1. Health Effects Criteria for Non-Carcinogens

Tables 5-1 and 5-2 in Appendix B provide data on non-cancer health effects associated with the COPCs. The toxicity values presented are the oral reference dose (RfD), the absorbed RfD for dermal exposure, and the inhalation reference concentrations (RfC). The non-cancer health endpoint (i.e., the target organ) associated with the chemical can also be found on these tables.

5.2. Health Effects Criteria for Carcinogens

Tables 6-1 and 6-2 in Appendix B provide dose-response information in the form of the cancer slope factor for the ingestion, dermal contact, and inhalation routes. The weight of evidence

(WOE) for each chemical, which is used to characterize the extent to which the available human epidemiology and animal studies indicate that a chemical may cause cancer in humans, is also shown (US EPA, 1989). The WOE is categorized into six groups:

- (A) Known Human Carcinogen
- (B-1) Probable Human Carcinogen – based on limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in animals;
- (B-2) Probable Human Carcinogen – based on sufficient evidence of carcinogenicity in animals;
- (C) Possible Human Carcinogen;
- (D) Not classifiable as a human carcinogen; and
- (E) Evidence chemical is not a carcinogen in humans.

The EPA 2005 Cancer Guidelines, however, provide an update to the original 1986 Cancer Guidelines and subsequent updates. In summary, the 2005 Cancer Guidelines emphasize the value of understanding the biological changes that the chemical can cause and how these changes might lead to the development of cancer (US EPA, 2005a). They also discuss methods to evaluate and use such information, including information about an agent's postulated mode of action, or the series of steps and processes that lead to cancer formation. Mode of action data, when available and of sufficient quality, may be useful in drawing conclusions about the potency of an agent, its potential effects at low doses, whether findings in animals are relevant to humans, and which populations or life stages may be particularly susceptible. In the absence of mode-of-action information, default options are available to allow the risk assessment to proceed.

The 2005 Guidelines recommend that an agent's human carcinogenic potential be described in a weight-of-evidence narrative rather than the previously identified letter categories. The narrative summarizes the full range of available evidence and describes any conditions associated with conclusions about an agent's hazard potential. The following are the five recommended standard hazard descriptors:

- carcinogenic to humans
- likely to be carcinogenic to humans
- suggestive evidence of carcinogenic potential
- inadequate information to assess carcinogenic potential
- not likely to be carcinogenic to humans

EPA is evaluating the carcinogenic weight of evidence of chemicals through the IRIS chemical process. The requirements for in-depth analysis of mode-of-action data and the review process does not allow the equating of a chemical evaluated under the old letter system classification with the 2005 Classification narrative; rather, a full analysis of the data is required. (US EPA, 2005a)

The 2005 Cancer Guidelines also include Supplemental Guidance on the evaluation of early lifetime exposures. For example, where data are available on mutagenic mode of action for carcinogenesis, the Supplemental Guidance provides procedures for developing chemical-specific potency factors that account for early life susceptibility. In most cases, these data do not exist and standard age-dependent adjustment factors can be applied to account for early life susceptibility.

Because chemical-specific toxicity data on early life susceptibility are not available for most chemicals (vinyl chloride being the exception), cancer risks from the COPCs in this HHRA that are known to be carcinogenic by mutagenic mode of action (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene) were calculated using the general age-dependent adjustment factors recommended in the Supplemental Guidance. They are: a 10-fold adjustment to the toxicity value for ages 0 – <2 years; a 3-fold adjustment to the toxicity value for ages 2 – <16 years; and no adjustment to the toxicity value for ages 16 years and older. See Section 6 for a discussion of where these adjustments are presented in the HHRA (US EPA, 2005b).

6. Risk Characterization

In risk characterization, quantitative exposure estimates and toxicity factors are combined to calculate numerical estimates of potential health risk. In this section, potential cancer and noncancer health risks are estimated assuming exposure to chemicals detected in site media. As described in Section 4, Exposure Assessment, potential risks are estimated for two hypothetical scenarios related to chemicals in sediments that will be placed in the SCA:

1. **Potential future exposures through air that could occur during remediation:** This scenario evaluated risks associated with inhalation of COPCs that could volatilize from sediment and water during the period of sediment management and dewatering and be transported in air to offsite residents.

2. **Potential future exposures that could occur in the event of hypothetical failure of the SCA**. This scenario evaluated potential risks associated with unintentional (incidental) ingestion and skin (dermal) contact with sediments in the event of a failure of the SCA and people coming onto the SCA and into contact with sediments. Adults, adolescents, and children are evaluated in this scenario.

There are no complete exposure scenarios under current conditions since the sediment dredging activities have not started, and once these activities begin, measures will be in place to limit future exposures to acceptable levels. Thus, the hypothetical future exposure scenarios evaluated here provide a conservative means to evaluate potential risks posed by COPCs in sediment to be placed in the SCA. The risk characterization methods described in RAGS (US EPA, 1989b) were used to calculate RME excess lifetime cancer risks for carcinogens and hazard indices for contaminants with noncancer health effects. These methods and the results of the risk characterization are described below.

Tables in Appendix B show detailed results of the risk calculations for each exposure pathway, including exposure point concentrations and intakes calculated for the reasonable maximum exposure scenarios, toxicity values used in risk estimates, and potential risk estimates for each COPC in each exposure pathway.

6.1. Risk Characterization for Carcinogens

6.1.1. Methods

Quantifying total excess lifetime cancer risk requires calculating risks associated with exposure to individual carcinogens and aggregating risks associated with simultaneous exposure to multiple carcinogenic chemicals. A cancer risk estimate for a single carcinogen is calculated by multiplying the intake by its carcinogenic slope factor (CSF) for oral or dermal risk estimates or by the inhalation unit risk (IUR) for inhalation risks (US EPA, 1989; US EPA, 2009):

$$\text{Cancer Risk} = \text{Intake} \times (\text{CSF or IUR})$$

A 1×10^{-6} cancer risk represents a one in one million additional probability that an individual may develop cancer over a 70-year lifetime as a result of exposure under the conditions and scenarios evaluated. Because cancer risks are assumed to be additive, risks associated with simultaneous exposure to more than one carcinogen in a given medium are aggregated to determine a total cancer risk for each exposure pathway. Total cancer risks for each pathway are then summed for reasonable combinations of exposure pathways to determine the total cancer risk for the population of concern.

The likelihood that actual risks are greater than estimated risks is very low because of the conservative assumptions used to develop cancer risk estimates.

The findings presented here are compared with the range of acceptable risk levels cited in the NCP (U.S. EPA 1990b). The NCP states that risk levels in the range of 10^{-4} to 10^{-6} and lower are considered to be within the range of acceptable risks for Superfund sites.

6.1.2. Quantification of Carcinogenic Risks

Carcinogenic risk estimates were calculated for children, adolescents, and adults in the RME scenarios as the probability of additional cancers associated with the exposure pathways evaluated. Based on the exposure assumptions and toxicity values described above, Appendix B Table 8-1 provides a summary of risk estimates for all complete exposure pathways in the RME scenarios. This table also provides a summary of COPCs accounting for the majority of the risk estimates in each pathway. As described in Sections 4 and 5, carcinogenic PAHs are evaluated using four age groups (0-2 years, 2-6 years, 6-16 years, and over 16 years) so that modifying factors can be applied to account for assumed additional potency related to time of exposure. Detailed risk estimates are provided in Appendix B Tables 7-1 through 7-4 for all chemicals except PAHs and in Appendix B Supplement A Tables 7-1 through 7-4 for PAHs.

In Table 8-1, risk estimates for carcinogenic chemicals other than PAHs are also shown so that a total cumulative risk can be presented for each of the four age groups considered for carcinogenic PAHs. Cancer risk estimates for an adult or child exposure to carcinogenic chemicals other than PAHs (Appendix B Tables 7-1 and 7-2) were adjusted to reflect the exposure estimates within the four age groups estimated for PAHs. This adjustment was made by taking the ratio of the exposure estimate (chronic daily intake or [CDI]) for children ages 0-2 or 2-6 over the CDI for children ages 0-6 and multiplying that product times the total cancer risk estimate for chemicals other than PAHs. Cancer risk estimates for adolescents' exposure to chemicals other than PAHs were calculated as the ratio of the adolescent CDI over that for adults. The cumulative risk estimates for all carcinogens in each of the four age groups is shown in Table 8-1 in Appendix B.

As indicated in Table 8-1, no exposure pathways result in risk estimates greater than the 10^{-4} risk level that is the upper end of the EPA target risk range.

- **Inhalation – Adults and Children:** The hypothetical future inhalation cancer risk estimates for offsite adults and children were 4×10^{-6} with primary contributors to risk being ethylbenzene and naphthalene based on application of the California EPA unit risks for these chemicals. The risk estimates associated with the remaining carcinogenic chemicals combined were 2×10^{-6} (Appendix B Table 7-3).

- **Contact with Sediments – Adults:** The hypothetical future cancer risk estimates associated with exposure to sediments (oral and dermal exposure routes) was 1×10^{-6} for all carcinogenic chemicals combined (Appendix B Table 8-1).

- **Contact with Sediments – Children:** The hypothetical future cancer risk estimate associated with exposure to sediments (oral and dermal routes) was 3×10^{-5} for children ages zero to 2 and 1×10^{-5} for children ages 2-6 (Appendix B Table 8-1), with the primary contributors to risk being hexavalent chromium and the carcinogenic PAHs .

- **Contact with Sediments – Adolescents:** The hypothetical future cancer risk estimate associated with exposure to sediments (oral and dermal routes) was 3×10^{-6} for adolescents ages 6 to 16 (Appendix B Table 8-1) also associated primarily with hexavalent chromium and the carcinogenic PAHs.

6.2. Quantification of Hazard Indices for Effects other than Cancer

6.2.1. Methods

Unlike carcinogenic effects, other potential adverse health effects are not expressed as a probability. Instead, these effects are expressed as the ratio of the estimated exposure over a specified time period to the RfD or RfC derived for a similar exposure period (e.g., Chronic Daily Intake:chronic RfD or RfC). This ratio is termed a hazard quotient (US EPA, 1989; US EPA, 2009):

$$HQ = Intake \div (RfD \text{ or } RfC)$$

If the Chronic Daily Intake, or CDI, exceeds the RfD or RfC (i.e., the hazard quotient is greater than 1), there may be concern for noncancer adverse health effects, and as this quotient increase, the potential for noncancer health effects increases. Exposures resulting in a hazard quotient less than or equal to 1 are very unlikely to result in noncancer adverse health effects.

In initial risk calculations, hazard quotients for individual COPCs are summed for each exposure pathway to derive a hazard index. Hazard indices for each exposure pathway are then summed to determine the total hazard index for each population of concern.

In the event a total hazard index exceeds 1, the hazard index is segregated by primary target organs because adding hazard quotients of compounds that do not affect the same target organ could overestimate the potential for adverse effects. Consistent with the latest RAGS guidance (U.S. EPA 1998b), hazard quotients for individual chemicals that share the same critical effect or primary target organ as reported in IRIS (U.S. EPA 2010c) or other resources used to derive toxicity values are summed across exposure pathways to determine a total hazard index for that target organ. If the hazard index for a particular target organ exceeds 1, the hazard index for each target organ can be further evaluated by identifying the mode of action on the target organ. In this step, separate hazard indices for each mode of action for each target organ are calculated.

6.2.2. Quantification of Noncarcinogenic Risks

Detailed risk estimates are provided in Appendix B Tables 7-1 through 7-3 and Appendix B, Table 8-2 (inhalation exposure) and Table 8-3 (sediment exposure) show the hazard indices (HI) for COPCs summed based on the primary target organs (or systems) that they affect. Tables 8-2 and 8-3 also show the primary chemicals contributing to the total hazard index for each pathway-endpoint combination. For adult exposure to sediments (see Table 7-2), none of the scenarios had hazard quotients or combined hazard indices greater than 1.0. Although the total HI (approximately 2) for child exposure to sediments (ingestion and dermal contact) slightly exceeds 1 (as shown in Table 7-1), the HI values for each endpoint do not exceed 1 (as shown in Table 8-3). In addition, although the total HI (approximately 4) for the inhalation exposure exceeds 1 (as shown in Table 7-3), the HI values for all receptors for each target organ do not exceed 1 (as shown in Table 8-2).

6.3. Off-Site Workers

As stated previously, off-site workers are not quantitatively evaluated in this HHRA. Exposure from inhalation of volatile chemicals that may migrate from the SCA are quantitatively evaluated for the nearby residents, assuming a standard residential exposure typically used in risk assessments. This exposure scenario assumes that residents are exposed for 350 days per year for the duration of the project, 5 years. Off-site workers who might be working at Wastebed 15 or in other nearby areas would be exposed less frequently, up to 250 days per year, which assumes 5 days per week for 50 weeks during the year. Under this scenario, the off-site worker would have a lower exposure and therefore the cancer risks and noncancer hazards would be proportionally less. Since the risks estimated for the residents fall within the acceptable risk range, the risks and hazards to the off-site worker are also in this range.

6.4. Uncertainty Assessment

Key uncertainties in the risk assessment should be considered in order to better place the risk estimates within context. Estimates provided here are hypothetical and were derived as a means to evaluate plans for the SCA and better limit potential future risks. However, many of the assumptions applied here tend to overestimate potential future site risks. These include the following:

6.4.1. Hexavalent Chromium. Chromium can exist is several forms, and two forms are most commonly considered in an HHRA, the trivalent form and the hexavalent form. Results for samples collected from 4 locations near the Crucible Lake Pump Station site that were analyzed for both total and hexavalent chromium did not identify any hexavalent chromium; these results were therefore considered to be in the trivalent form, which is significantly less harmful, and were ultimately screened out and not considered further in this HHRA. All other chromium results were analyzed only for total chromium, and were conservatively considered to be in the hexavalent form, which is more toxic. Under this conservative assumption, hexavalent chromium risk estimates were responsible for approximately 90% of the cancer risk estimates for ingestion of sediments. This is likely an overestimate of the true risk, since hexavalent chromium is reasonably assumed only to be a small percentage of the total chromium in the sediments, and the limited data which are available indicate that the chromium is not present as hexavalent chromium. In the unlikely event of a failure of the SCA containment and a release of the sediments, measures would be implemented to address the release in accordance with site management plans (e.g., Spill Contingency Plan) to be developed. The measures may include additional sampling and characterization, including speciating potential risk-driving chemicals such as chromium.

6.4.2. Methyl mercury. Mercury is another chemical that can exist in several forms. However, these forms were not analyzed in most sediment samples, and mercury was reported as total mercury. For the hypothetical sediment exposure pathway in this HHRA, all mercury risk estimates were calculated assuming mercury was present as methyl mercury in sediments, which is the most conservative approach when assessing oral and dermal exposures. As stated previously, existing data indicate that the maximum percentage of methyl mercury is 1.4%. Nevertheless, all hazard indices for mercury for both the sediment and the inhalation exposure pathways were within acceptable levels. As stated in Section 3.2, this HHRA assumed conservatively that all mercury is present in the more toxic form. In the unlikely event of a release of sediments, measures would be implemented to address the release in accordance with site management plans (e.g., Spill Contingency Plan) to be developed. The measures may include additional sampling and characterization, including speciating potential risk-driving chemicals such as mercury.

6.4.3. Cobalt. One exposure scenario estimates potential risk from direct contact from sediments in the hypothetical event of a failure of the SCA and individuals come into contact with the sediments. Under this scenario, cobalt contributes approximately 19% to the overall hazard index to the child from exposure to sediments (the total noncancer hazard index to the adult are less than 1, so no further evaluation is necessary). The sediment data set for cobalt consists of 133 samples collected from 37 locations within the area to be dredged. A length weighted average (LWA) was calculated for each location and these 37 LWAs were used to calculate the exposure point concentration for cobalt that was used in the risk assessment. Of these 37 locations, two locations near the Crucible Lake Pump Station site have significantly higher LWA cobalt concentrations than all other locations in the area to be dredged and strongly influence the overall exposure point concentration. These two locations represent less than 2% of the overall volume of sediment to be dredged and are not representative of the cobalt concentrations in the material that will be dredged. Therefore, the noncancer hazard index for cobalt is likely overestimated.

6.4.4. Toxicity Values. Significant uncertainty may be associated with the derivation of RfDs and CSFs. Toxicity values based on human epidemiological studies are not available for most chemicals, and those human studies that are available generally lack exposure data and are confounded by exposure to multiple chemicals, recall bias, and lifestyle issues. Laboratory animal studies are used to derive most toxicity values and the practice of extrapolating from effects in animals to predict human toxic response is a major source of uncertainty in risk assessment.

RfD development is a health-protective and conservative process, which uses a No Observable Adverse Effect Level (NOAEL) or a Lowest Observable Adverse Effect Level (LOAEL) from an animal study, divided by a series of 3- or 10-fold Uncertainty Factors (UFs). The UFs are intended to account for differences between humans and laboratory animals, variation in sensitivity within the human population, differences between subchronic and chronic exposures, use of a LOAEL versus a NOAEL, and the strength of the toxicology database for a particular chemical. The combination of several UFs results in RfDs that are several orders of magnitude lower than the doses that produce minimal or no effects in animals.

CSFs may also highly conservative and contain multiple sources of uncertainty, including the methods of extrapolation from high doses to low doses and from animals to humans. In addition, genetic constitution, diet, occupational and home environments, activity patterns, and other cultural factors influence human susceptibility to cancer. To compensate for this uncertainty, CSFs generally represent the 95% UCL on the probability of a carcinogenic response at a certain dose rate over a lifetime.

Many chemicals do not have peer-reviewed toxicity values available. For example, many of the PAHs do not have RfDs available to assess non-cancer health hazards. Many Class C carcinogens do not have SFs derived. This lack of toxicity information underestimates the actual risk.

6.4.5. Potential for Overestimation within Exposure Scenarios. The SCA is planned to be closely managed and maintained. Consequently, the assumed potential for exposure to sediments is hypothetical and may overestimate risks, particularly for young children (due to their increased susceptibility from exposure to chemicals acting through a mutagenic mode of action) who would be unlikely to come into contact with this material. All risk estimates for sediments for adults are within 1×10^{-6}.

6.4.6. Exposure Assumptions. There is considerable uncertainty regarding the likelihood of exposure to a given medium of concern. It is unknown whether all of the exposure pathways modeled will ever be actually complete or whether the individuals evaluated will actually be exposed to COPCs. For example, for the sediment exposure scenario to be complete, children, adolescents, and adults must enter the site and gain access to sediments released from the SCA. Although this is theoretically possible, there is no evidence that such activities would actually take place.

Exposure estimates used to calculate risks and hazards may also be relatively uncertain. Many of the exposure parameter values applied are default values determined by USEPA (1989, 1991, 1997a), or rely on professional judgment rather than site-specific values. As such, risk estimates based on these exposure parameters generally represent conservative estimates. In particular, the RME scenario relies heavily on guidance documents that may not have the most current and accurate information on exposures. For example, exposure to sediments released from the SCA is assumed to occur every day for the 45 day period it would take for the sediments to be remediated, and assuming any exposure at the SCA is consistent with the types of exposures typical in residential scenarios. Due to the distance from the SCA to the residences (the nearest residence is approximately 1500 feet from the SCA) and the likelihood of interim measures such as additional fencing, cover material, or other engineering controls to be implemented, this type of exposure is not anticipated. As a result, risks and hazards predicted under the RME scenario may potentially overestimate risks and hazards at the site. In the unlikely event of a failure of the SCA and a release of sediments, it is recommended that the actual exposures that would occur, once the interim controls are implemented, be evaluated to ensure that they are not greater than the exposures in the scenarios defined in this HHRA.

6.4.7. Inhalation of Volatilized Chemicals. The air concentrations used as a starting point in deriving offsite air estimates are all assumed to be the lower of either the DAR-1 number or the industrial RSLs after adjustment for a 5-year exposure duration for all chemicals identified in the sediments as volatile. Both bench scale testing of sediments and testing of volatilization from sediments suggest that instead approximately half of the chemicals would actually be volatilized from sediments. This assumption results in a cumulative air exposure risk estimate that is higher than what would likely occur.

6.4.8. Application of the Highest Receptor Location in Air Estimates. Workplace perimeter concentrations were used to estimate offsite air concentrations. The resulting estimates were evaluated, and the highest yearly average concentration was applied. The selection of this maximum value means that all other yearly average concentrations would be lower and thus exposure estimates for most people would be lower than this value.

6.4.9. Tentatively Identified Compounds (TICs). Standard analytical protocols for Superfund sites require that an extensive list of chemicals be analyzed and reported. This list is known as the Target Compound List (TCL)/Target Analyte List (TAL) for organic chemicals and metals, respectively. The list was developed with consideration of the chemicals most commonly found at sites. Other chemicals that are not routinely analyzed for or reported might be present at sites. These chemicals are known as tentatively identified compounds (TICs), since neither the identity nor the concentration can be reported with certainty. The TICs could present a contribution to risk that has not been quantified, however, they typically do not contribute significantly to the overall risk or hazard at a site. The extensive database of more than 33,000 samples collected at the site provides a robust data set that supports the basis for the risks identified in this assessment.

7. Conclusions

This supplemental risk assessment applied conservative exposure assumptions to evaluate potential risks associated with the establishment of the SCA and to address community concerns. Estimates were designed to represent two hypothetical future scenarios: 1) exposure to contaminants that could migrate from the site in air during operation of the SCA and 2) exposure to sediments within the SCA post-closure if the SCA were to fail, sediments were released and people would come onto Wastebed 13 and contact the sediments on or near the SCA. Both of these potential future scenarios were intended to represent the reasonable maximum exposure potential and both assume individuals of all ages could be exposed. As such, these risk estimates are likely higher than risks that would likely be experienced by most receptors.

All resulting risk estimates and hazard indices were within levels identified by EPA as acceptable. The finding of acceptable risk estimates through application of these health protective assumptions, indicates that the plans for the SCA will not result in unacceptable risks for the surrounding community. Nevertheless, the SCA will be closely monitored to ensure that sediments are managed with care and secured appropriately and that offsite migration of chemicals in air is limited or prevented.

This HHRA can also be used as a tool for risk managers during the implementation of the remedy and management of the SCA. The exposure scenarios evaluated in this HHRA are future hypothetical situations, so the outcome can be used to help assess the effectiveness of the remedy. For example, the air concentrations modeled in the residential areas are based on work zone perimeter concentrations that reflect the maximum annual average concentrations for all chemicals. It is highly unlikely that every volatile chemical would be present at that concentration for a one year period of time to result in that exposure scenario. During remedy implementation, if monitored air concentrations indicate a trend towards chemicals reaching this maximum annual average concentration for a sustained period of time, risk managers can modify site operations to reduce these concentrations so that the actual risks are much lower than those estimated here. Risk managers can also use this HHRA to assist in managing risks in the unlikely event of a failure of the SCA. If sediments are released as a result of a failure of the SCA, measures would be implemented to address the release in accordance with site management plans (e.g.. Spill Contingency Plan) to be developed. The measures may include additional sampling and characterization, for example, speciating potential risk-driving chemicals such as mercury and chromium, to ensure that the actual exposures that would occur once the interim controls are implemented are not greater than the exposures in the scenarios defined in this HHRA.

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Appendix A

Figures

Appendix B

RAGS Part D Tables

Appendix C

Air Dispersion Model Documentation

Appendix D

Length Weighted Average Procedure and Sample Locations

Appendix E

Air Quality Bench Testing Summary

Appendix F

ProUCL Outputs