7. HUMAN HEALTH RISK ASSESSMENT

This chapter presents a summary of the quantitative baseline human health risk assessment (HHRA) (TAMS, 2002b) for the remedial investigation (RI) and feasibility study (FS) for Onondaga Lake. The objective of the HHRA is to evaluate the potential for adverse human health effects associated with current or potential future exposures to chemicals present in Onondaga Lake surface water, fish, and certain nearshore sediments, wetlands sediments, and dredge spoils soils, in the absence of any action to control or mitigate those chemicals (i.e., under the no action alternative).

As defined in the Consent Decree, the site includes Onondaga Lake, its outlet, and tributaries that may have been directly affected by Honeywell operations. The tributaries directly affected by Honeywell include Ninemile Creek and its tributaries, Geddes Brook and the West Flume; Tributary 5A; the East Flume; and Harbor Brook. As discussed below, these tributaries are not included in the HHRA since they are being covered as part of other investigations. NYSDEC has also required that Wetlands SYW-6 and SYW-12 be included in the site.

In addition to the areas of the site listed above, the HHRA includes an evaluation of limited data that were collected in Wetlands SYW-10 and SYW-19 and an upland area associated with the dredge spoils area located north of the mouth of Ninemile Creek. Human health risks associated with Wetlands SYW-10 and SYW-19 and the dredge spoils area will be further evaluated as part of separate sites and, therefore, the risk analysis associated with these areas in the HHRA is considered preliminary, pending the finalization of the HHRAs associated with these other sites. Specifically, Wetland SYW-10 will be further evaluated as part of the RI/FS for the Geddes Brook/Ninemile Creek site; Wetland SYW-19 will be further evaluated as part of the RI/FS for the Wastebed B/Harbor Brook site; and the dredge spoils area will be further evaluated as a separate site with its own investigation.

Thus, the areas and media covered by the HHRA include Onondaga Lake fish, surface water, and sediments and shoreline areas directly abutting the lake – specifically, four New York State-regulated wetland areas (Wetlands SYW-6, 10, 12, and 19), and the dredge spoils area situated on the west side of the lake, north of Ninemile Creek between Wetlands SYW-6 and 10 (collectively, the "Onondaga Lake Study Area"). Studies of other Onondaga Lake sites, including the LCP Bridge Street Operable Unit 1 (OU-1) and OU-2 sites (including the West Flume), the Wastebed B/Harbor Brook site (including Harbor Brook and the East Flume), the Willis Avenue Chlorobenzene site (including Tributary 5A), the Willis Avenue Ballfield site, the Mathews Avenue Landfill site, and the Geddes Brook/Ninemile Creek site are the subject of completed or ongoing investigations and have been or will be addressed in separate site-specific reports. The Onondaga Lake HHRA addresses risk associated with contamination within the Onondaga Lake Study Area, without regard to the source of the contamination.

The HHRA follows the US Environmental Protection Agency (USEPA) Risk Assessment Guidance format and sequence. The HHRA consists of the following chapters and appendices:

- Chapter 1, Introduction – Discusses the general framework and format of the document.

- Chapter 2, Background – Provides background information on the site, such as site history, features, and climate.

- Chapter 3, Identification of Contaminants of Potential Concern – Discusses the available data for all site media (e.g., fish tissue, sediment, water) for each exposure area (e.g., northern basin); discusses the results of the contaminant screening process, and identifies the contaminants that are considered contaminants of potential concern (COPCs) in each site medium after the screening.

- Chapter 4, Exposure Assessment – Presents the exposure setting and exposed populations (receptors); in other words, what types of people may be exposed to contaminants in various site media (e.g., adult construction workers exposed to subsurface contaminants in soil by dermal contact and incidental ingestion). Next, the exposure is quantified (estimates of how much of a contaminated medium to which each receptor may be exposed). Finally, the calculations of the exposure point concentrations (EPCs) of each COPC in each contaminated medium are discussed.

- Chapter 5, Toxicity Assessment – Discusses the chemical-specific cancer risk and non-cancer hazard toxicity data used to calculate the potential adverse health effects from exposure to site COPCs.

- Chapter 6, Risk Characterization – Presents the results of the quantitative risk assessment, including estimates of both cancer risks and non-cancer hazards for each medium and each receptor population.

- Chapter 7, Uncertainty Assessment – Discusses aspects of the HHRA that are likely to overestimate or underestimate site risks.

- Chapter 8, Conclusions.

- Chapter 9, References.

- Appendix A, Summary of Site Data Used in the HHRA – Includes discussion and tabulation of data collected by Honeywell and NYSDEC that are used in the HHRA.

- Appendix B, RAGS Part D Tables.

- Appendix C, USEPA Region 3 and Region 9 Screening Values.

- Appendix D, Comparison of ProUCL and Default Data Distributions for Calculation of Exposure Point Concentrations and Risks.

- Appendix E, Toxicological Profiles for Contaminants of Potential Concern.

7.1 Introduction

This HHRA was conducted in accordance with the Onondaga Lake RI/FS Work Plan (PTI, 1991c) approved by the NYSDEC, as amended, and with applicable guidance documents (see Chapter 1, Section 1.1 of the HHRA for details) from the USEPA. As science and policy evolve over time, some of the guidance documents used in the HHRA were superseded or supplemented during the time the HHRA was being prepared. To the extent practical, the most current USEPA guidance documents and data have been utilized. For example, all of the USEPA screening values were updated in 2002 prior to performing the screening for the HHRA (Appendix C of the HHRA), and the toxicity files on USEPA's Integrated Risk Information System (IRIS) were all accessed in 2002 to verify that current peer-reviewed toxicity data were being used in the HHRA (Chapter 5 and Appendix E of the HHRA). The only known exception to this approach involves the format of the RAGS Part D tables presented in Appendix B of the HHRA. In June 2002, USEPA indicated that the December 2001 revision of RAGS Part D was to be used for all new risk assessments (superseding the January 1998 version of RAGS Part D). However, RAGS Part D is merely a standardized reporting format (utilized by USEPA to generate consistency among risk assessments at different sites and in different regions), and does not affect how risks are calculated. This risk assessment was initiated prior to issuance of the new guidance and, therefore, the 1998 version was used for the HHRA with USEPA's concurrence; however, not utilizing the December 2001 revision has no impact on the findings of the HHRA.

Risk assessments conducted for regulatory purposes, such as the HHRA, are designed to be protective of human health and consistent with requirements for risk assessment provided by USEPA. Two different types of exposure scenarios are presented in the HHRA – the reasonable maximum exposure (RME) scenario, and the central tendency (CT; sometimes referred to as the "typical") scenario. For the RME scenario, two or three of the most sensitive input parameters (typically the intake rate, such as the amount of fish consumed) are set to the 90^{th} or 95^{th} percentile values, while the rest of the inputs to the risk calculation are set to the average or median (50^{th} percentile) value. As such, the RME is not a "worst case" scenario. Although the cumulative impact of the 95^{th} percentile exposure and toxicity assumptions used in the RME scenario may overestimate risks for many site users (receptors), there could be some receptors for whom exposure and risks are underestimated even in the RME scenario.

For the CT scenario, all variables in the risk calculations are set to the average or median values. (The same toxicity values and EPCs are almost always used for both the RME and CT scenarios.) Factors that may overestimate or underestimate risks are discussed in Chapter 7, Uncertainty Assessment, in the HHRA.

7.2 Background

The background chapter of the HHRA summarizes the physical attributes of the sites, the history of contamination, and the regulatory history. This information is presented in greater detail in Chapters 1 through 4 of this RI.

7.3 Contaminants of Potential Concern

The HHRA uses a screening process to select COPCs that is structured to minimize the likelihood of eliminating contaminants from further analysis that could be of concern. "COPC" is a specific risk assessment term that has a different meaning than "CPOI," or chemical parameter of interest, which is discussed elsewhere in this RI (see Chapter 1, Section 1.6). COPCs for the HHRA were developed using available contaminant concentration data for lake fish (fillets only; limited to species likely to be consumed by humans), and for water and sediments in the northern and southern basins of the lake, for sediments in four adjacent wetlands, and for dredge spoils area soils. Lake sediments at water depths of more than about 6.5 ft (2 m) were not included, as it is unlikely that humans would have much, if any, direct contact with such sediments.

Site concentration data were compared with risk-based concentrations (RBCs) developed by USEPA Regions 3 and 9. For the screening, the highest concentration of a contaminant in a specific medium (e.g., southern basin sediments) was compared to the more conservative of the Region 3 or Region 9 screening criteria. The published screening criteria for carcinogens are set at a cancer risk level of 10^{-6}; these criteria were used as published. However, USEPA Region 2 (along with many other risk assessors) utilizes a hazard index (HI) of 0.1 for screening non-cancer hazards; as the Region 3 and Region 9 screening criteria are based on a HI of 1.0, the published values were divided by 10 prior to use in screening non-carcinogenic effects for the risk assessment.

In addition to mercury (including methylmercury), which was identified in the RI/FS Work Plan (PTI, 1991c) as one of the principal COPCs to be evaluated in the HHRA, a total of 60 other contaminants were identified as COPCs (as chemicals or chemical mixtures) in one or more site media and were retained for further analysis in the HHRA and are listed on Table 7-1.

7.4 Exposure Assessment

Onondaga Lake is surrounded by lands used for industrial, commercial, and recreational purposes. No residential property directly abuts the lake. Recreational visitors to Onondaga Lake are the receptors with the greatest potential for exposure to COPCs. Thus, the HHRA focuses mainly on recreational visitors to the site, although it also evaluates potential exposures to construction workers who may contact contaminated media during work in these areas. Under current conditions, potential exposures for recreational visitors to the site are limited by the lack of public swimming areas. The New York State Department of Health (NYSDOH) has also issued specific, restrictive fish consumption advisories for Onondaga Lake. The HHRA, however, assesses risk in the absence of institutional controls under both current and future use scenarios. As a result, the baseline HHRA evaluates current and potential future uses under the assumption that there are no restrictions, advisories, or limitations in place. Human health risks associated with Wetlands SYW-10 and SYW-19 and the dredge spoils area will be further evaluated as part of separate sites and, therefore, the risk analysis associated with these areas in the HHRA is considered preliminary, pending the finalization of the HHRAs associated with these other sites. Figure 7-1 illustrates the exposure areas evaluated in the HHRA. Exposure pathways quantitatively evaluated are shown on Table 7-2 and include the following:

- Consumption of fish from Onondaga Lake.

- Incidental ingestion of and dermal contact with COPCs in nearshore surface sediments in the northern and southern basins of the lake and surface sediments in the four wetlands adjacent to the lake that are of concern in the HHRA.

- Incidental ingestion of and dermal contact with COPCs in surface and subsurface soil in the dredge spoils area located along the shoreline of the lake north of Ninemile Creek.

- Incidental ingestion of and dermal contact with COPCs in Onondaga Lake surface water.

An initial PSA conducted for Onondaga Lake by NYSDEC (NYSDEC, 1989a, as cited in PTI, 1991c) concluded that there was little potential for releases of contaminants to air. The data for volatile organic compounds (VOCs) in surface water and near-surface soils and sediments were reviewed as part of the HHRA, and the initial conclusion by NYSDEC is considered to still be appropriate for recreational users and nearby residents. In addition, there are currently no structures on the site nor are any likely to be built, due to regulatory restrictions (e.g., zoning and wetlands) and the nature of the area (e.g., much of the lake shoreline area is owned by or under the jurisdiction of the Onondaga County Parks Department [OCPD], and the wetlands areas are generally unsuitable for construction, even absent regulatory restrictions). Therefore, the inhalation pathway was considered to be incomplete for all media and was not assessed further in the HHRA.

The RME and CT scenarios were evaluated for each of the complete pathways summarized above and listed in Table 7-2. Consumption of fish from the lake was determined to be the pathway with the highest potential for exposure to COPCs.

As site-specific information was not available for all the input parameters for exposure assessment or risk calculation, assumptions based on professional judgment or USEPA-recommended generic default values were used in the exposure assessment. For example, the RME fish consumption rate of 25 grams per day (g/day) applied in the RME risk calculations is the default 95th percentile recommendation in the USEPA Exposure Factors Handbook (1997a). This fish consumption rate is equivalent to approximately 40 eight-ounce meals from Onondaga Lake per year. The uncertainties associated with the use of this fish consumption rate and other exposure assumptions are discussed in Chapter 7, Uncertainty Assessment, of the HHRA.

7.5 Toxicity Assessment

Risk estimates for all COPCs were based on use of toxicity values, including carcinogenic slope factors (CSFs) to assess potential carcinogenic effects and reference doses (RfDs) to assess potential non-cancer effects, that were derived by USEPA and published on its peer-reviewed IRIS database and the USEPA Health Effects Assessment Summary Tables (HEAST), and were supplemented by additional guidance from the USEPA National Center for Environmental Assessment (NCEA), USEPA Region 2, NYSDOH, and NYSDEC. The three COPCs (or COPC groups) responsible for a majority of estimated site risks are PCBs, polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/PCDFs), and methylmercury.

- PCBs – RME carcinogenic risk estimates for PCBs were based on the CSF of 2 $(mg/kg\text{-}day)^{-1}$, which is the highest of a range of upper-bound CSFs derived from studies in rats. This value is recommended by USEPA for evaluating food chain exposures, sediment or soil ingestion, and dermal contact exposures (if a dermal absorption factor is used) for all Aroclors (except for certain PCB mixtures with very low chlorine content; however, such mixtures were not detected in samples included in the HHRA). CT carcinogenic risk estimates for PCBs were based on the CSF of 1 $(mg/kg\text{-}day)^{-1}$, which is the central estimate CSF cited in IRIS. Non-cancer effects for PCBs were evaluated for the two groups of Aroclors – less chlorinated PCBs (using the toxicity data for Aroclor 1016) and highly chlorinated PCBs (using the toxicity data for Aroclor 1254) – for which USEPA has published RfDs.

- PCDD/PCDFs – Carcinogenic risk estimates for PCDD/PCDFs were based on a toxicity equivalent (TEQ) approach. USEPA does not currently have any quantitative toxicity factors (e.g., oral RfD) for the non-cancer health effects of PCDD/PCDFs; therefore, no quantitative assessment of non-cancer health hazards associated with PCDD/PCDFs is provided in the HHRA. However, a qualitative assessment is provided in Chapter 7, Uncertainty Assessment, of the HHRA, along with alternate cancer risks estimates based on the current peer-review draft of USEPA's dioxin reassessment document.

- Methylmercury – USEPA's RfD for methylmercury of 0.0001 mg/kg-day has been applied in estimates of non-cancer hazards for the fish consumption pathway and for Onondaga Lake surface water and sediments in which methylmercury was detected and for the fraction of total mercury in the wetlands sediments that is assumed to be methylmercury. The USEPA RfD of 0.0003 mg/kg-day has been applied for evaluation of non-cancer hazards of mercury (as inorganic mercury) in other media. Methylmercury/mercury has not been assessed quantitatively for cancer risks in the HHRA as no oral CSFs have been established by USEPA.

7.6 Risk Characterization

USEPA toxicity values (i.e., CSFs or RfDs) were combined with exposure estimates to derive estimates of potential health risks related to exposure to COPCs in Onondaga Lake media. Cancer risk estimates were compared to a target risk range of 1×10^{-4} to 1×10^{-6}. A 1×10^{-6} excess cancer risk represents an additional one-in-one-million probability that an individual may develop cancer over a 70-year lifetime as a result of the exposure conditions evaluated. Non-cancer effects are expressed as the ratio of the estimated exposure, or intake rate over a specified exposure period, to the RfD derived for a similar exposure period. This ratio is termed a hazard quotient (HQ). HQs for multiple COPCs or pathways are summed to generate an HI for a specific exposure route or receptor. Exposures resulting in an HI less than or equal to 1.0 are unlikely to result in non-cancer health effects. Estimated cancer risks and non-cancer hazards for both RME and CT scenarios for the 31 pathways evaluated in the HHRA are summarized in Table 7-3.

7.6.1 Cancer Risks

The RME cancer risks for fish ingestion ranged from 2.4×10^{-4} for young children to 7.8×10^{-4} for adults, all of which exceed the upper end of the target risk range (1×10^{-4}). RME cancer risks for older child exposure to Wetland SYW-6 sediments also exceed 1×10^{-4}. With these exceptions, the cancer risk estimates for the other exposure pathways and scenarios, both RME and CT (including the CT scenario for fish ingestion), were less than 1×10^{-4}, although cancer risk estimates exceeded 10^{-6} for many pathways, as summarized on Tables 7-3 and 7-4. The CT cancer risk for the fish consumption pathway scenario for all recreational anglers (adults and children) is about 4.5×10^{-5}, and RME risks to at least one receptor for each of the sediment and dredge spoils exposure areas exceeded 10^{-6}. Cancer risks associated with the fish ingestion pathways were due primarily to exposure to PCBs, PCDD/PCDFs, and, to a lesser extent, arsenic, as shown on Table 7-5.

RME cancer risk estimates associated with several other exposure pathways related to lake sediments and wetland sediments in recreational scenarios were greater than 1×10^{-6}. The highest of these was about 2.6×10^{-4} for older child exposure to Wetland SYW-6 sediments, followed by risks greater than 10^{-5} for one or more recreational receptor's exposure (ingestion and dermal combined) to southern basin sediments and Wetlands SYW-6, 10, 12, and 19 (see Table 7-4). In CT scenarios, the highest excess cancer risk (other than fish consumption) was about 1.4×10^{-5} for the older child recreational exposure to Wetland SYW-6 sediments. All RME and CT risks associated with Onondaga Lake surface water pathways were below the 1×10^{-6} risk level.

7.6.2 Non-Cancer Hazards

The RME HI for the recreational angler fish consumption pathway was approximately 18 for adults, 28 for young children, and 20 for older children. CT HIs ranged from approximately 4.5 for adults to 7.0 for young children. The elevated HIs for the fish consumption pathways were primarily related to PCBs (low and high molecular weight, assessed as Aroclors 1016 and 1254), methylmercury, and, to a lesser extent, arsenic. The COPCs contributing the largest amount of non-cancer hazard for each pathway are summarized on Table 7-6, and include PCBs and methylmercury. All other HIs for pathways other than fish ingestion were less than 1.0, although the cumulative RME HI for an older child who frequently accessed all the contaminated areas (all four wetlands, northern and southern basin sediments, and the dredge spoils area) closely approaches 1.0. However, as discussed in Chapter 7, Uncertainty Assessment, of the HHRA, it is not considered likely that an individual would be exposed to all the contaminated media sites at the RME frequency.

The risks to children for the fish consumption pathway (presented above) are based on the assumption that older children consume two-thirds as much fish as adults, and young children (under age six) consume one-third as much fish as adults. As there are only limited data on which this assumption of children's fish ingestion rates could be based, it is possible that the ingestion rates for children may be higher or lower than those used in the HHRA; therefore, risks to children may be higher or lower than those presented in the HHRA and shown on Table 7-3.

Based on the exposure assumptions and toxicity values used in the risk evaluations, these results indicate the potential for adverse non-cancer health effects as a result of long-term exposures via ingestion of lake fish. This conclusion is consistent with the fact that PCB and methylmercury concentrations for some lake fish exceed US Food and Drug Administration (US FDA) action limits.

7.7 Uncertainty Assessment

As described above, the USEPA risk assessment methodology used in the HHRA is designed to be protective of human health. Thus, site risks may be less than the risks estimated using standard risk assessment methods for most, though not necessarily all, receptors. Several key factors in the risk assessment methods used are likely to result in some overestimates or underestimates of potential risks for most visitors to Onondaga Lake. These include, but are not limited to, the following:

- Application of an assumed RME fish consumption rate of 25 g/day, which is USEPA's default 95th percentile consumption rate and was derived from three key studies. Individual studies have suggested RME fish consumption rates both higher (e.g., up to 170 g/day for subsistence fishers; 32 g/day for Hudson River anglers) and lower (e.g., less than 25 g/day) than the RME fish consumption rate used in the HHRA. In addition, the consumption rate utilized is derived from studies on adults; only limited data were available for estimating fish consumption by children.

- The assumptions that all freshwater fish consumed come from Onondaga Lake (i.e., application of a fractional intake of one) and that no PCBs or PCDD/PCDFs are lost during cooking. These assumptions may overestimate risk to some receptors. However, as Onondaga Lake is a highly desirable fishing location, and it is not known to what extent persons who consume Onondaga Lake fish adhere to the NYSDOH recommendations to remove the skin and fat and not consume the drippings, it is likely that these assumptions are realistic for at least some of the potentially exposed recreational angler population.

- There is some uncertainty in the USEPA CSF of 2 $(mg/kg\text{-}day)^{-1}$ for PCBs; however, as discussed in Chapter 7 of the HHRA, it is not clear whether the uncertainty may lead to an underestimate or overestimate of cancer risks associated with PCBs.

- The application of toxicity values for PCDD/PCDFs that are currently being reassessed by USEPA may underestimate cancer risks from these compounds, if the conclusions of the preliminary reassessment are unchanged after peer-review and finalization of the reassessment.

- The lack of published non-cancer toxicity values for PCDD/PCDFs may underestimate non-cancer hazards from dioxins. The reassessment currently being conducted by USEPA suggests that there are likely non-cancer hazards from these compounds, in addition to cancer risks. Therefore, the absence of non-cancer toxicity values for PCDD/PCDFs precluded their inclusion in the quantitative HHRA and may result in an underestimate of non-cancer hazards in media in which these COPCs are present.

- The lack of peer-reviewed cancer and non-cancer toxicity values for some of the polycyclic aromatic hydrocarbon (PAH) compounds detected in Onondaga Lake sediments, wetlands, and dredge spoils may result in a slight underestimation of risks or hazards.

Derivation of appropriate and protective toxicity values for mercury/methylmercury, PCDD/PCDFs, and PCBs in human populations is the subject of extensive study and debate. The toxicity values derived by USEPA and used in the HHRA represent a protective interpretation of the available toxicological data, and incorporate uncertainty and modifying factors to account for the need to extrapolate from animal studies to humans, among other issues. Chapter 7, Uncertainty Assessment, of the HHRA provides a discussion of the basis for and the reliability of the toxicity values used in the risk assessment. In general, confidence in the methylmercury toxicity data is considered high, and the IRIS value has recently been confirmed by a study conducted by the National Research Council (NRC) (NRC, 2000).

The CSF used for PCDD/PCDFs was published in USEPA's HEAST a number of years ago, and is currently under reassessment. The preliminary dioxin reassessment, which has not yet been peer-reviewed or finalized, suggests that the CSF used in the HHRA may underestimate cancer risks from PCDD/PCDFs. The potential magnitude of this is discussed quantitatively in Chapter 7 of the HHRA. In addition, the preliminary dioxin reassessment also suggests that there are non-cancer toxicity effects from PCDD/PCDFs; the published (final) toxicity data available for the HHRA do not include a means of assessing non-cancer toxicity of dioxins and as such may underestimate non-cancer hazards to receptors in media in which dioxins are present (also discussed in Chapter 7 of the HHRA).

Although the CSFs and RfDs used for quantitative assessment of PCBs were taken from USEPA's peer-reviewed IRIS database, there is more uncertainty about the PCB toxicity data than for the methylmercury data. (For example, USEPA characterizes the confidence in the oral RfDs for Aroclors 1016 and 1254 as medium, while the confidence in the oral RfD for methylmercury is high.) A number of factors contribute to the relative uncertainty of the PCB toxicological data, including the fact that Aroclors are a mixture of many (typically 30 or more) individual chlorinated biphenyl compounds ("congeners"); the commercial mixtures studied in the laboratory are altered when released to the environment by physical, biological, and metabolic processes; there are a wide range of observed effects and concentrations at which effects were observed in laboratory studies; as well as the issues associated with most chemicals in extrapolating toxicological data from animal studies.

Although there are incidences of human exposure to PCBs, data from human exposure are only useful on a qualitative basis due to lack of information about the specific composition of the mixture to which persons were exposed, exposure concentrations, and route of exposure, as well as a lack of long-term monitoring data in a number of these cases. Recent studies also suggest that some PCB congeners have dioxin-like effects and may contribute to PCDD/PCDF-related health effects; however, the lack of PCB congener-specific data precluded any assessment of this possibility.

7.8 Conclusions

The objective of the HHRA was to evaluate the potential for adverse human health effects associated with current or potential future exposures to chemicals present in Onondaga Lake surface water, sediments, fish, certain portions of the adjacent wetlands, and the dredge spoils area in the absence of any action to control or mitigate those chemicals. Under this no remedial action scenario, the HHRA principally focused on current and future lake conditions that further assumed unrestricted recreational use of the lake and the absence of a specific, restrictive fish consumption advisory. A total of 60 COPCs or groups of COPCs (including mercury and methylmercury) were identified for further analysis in the HHRA. Consistent with USEPA guidance, RME and CT scenarios for these COPCs were evaluated for several pathways, including a recreational fish consumption pathway, as summarized below:

- Cancer risks and non-cancer hazards calculated for the consumption of Onondaga Lake fish exceeded the upper end of the target risk levels (Table 7-4), as follows:

- The calculated RME cancer risks (ranging from 2.4×10^{-4} to 7.8×10^{-4}) exceeded the high end of the target risk range (10^{-4}), and exceeded the low end of the target cancer risk (10^{-6}) by more than two orders-of-magnitude. The CT fish ingestion cancer risk (about 4.5×10^{-5} for all recreational receptors) was below the upper end of the target range.

- The RME non-cancer HIs (ranging from about 18 to 28) exceeded the target HI (1.0) by a factor of almost 20 or more. The calculated CT non-cancer HIs (4.5 to 7 for adults and children) also exceeded the target.

- RME cancer risks for 21 of the 28 pathways other than fish ingestion equaled or exceeded the low end of the target risk range of 1×10^{-6}, with the highest of these being about 2.6×10^{-4} for older child exposure to Wetland SYW-6 sediments.

- For the CT cancer risk calculations, the low end of the 10^{-6} target range was equaled or exceeded in 8 of the 28 pathways other than fish ingestion, with a maximum CT risk of about 1.4×10^{-5} for older child exposure to Wetland SYW-6 sediments.

- None of the calculated non-cancer hazards (for both RME and CT scenarios) associated with pathways other than fish ingestion exceeded the target threshold of 1.0. The highest RME hazard other than fish ingestion was about 0.54 for young child exposure to southern basin sediments. The calculated non-cancer CT hazards for all pathways other than fish ingestion were all less than 0.1.

Cumulative risks and hazards were calculated for receptors who may be exposed to COPCs in multiple site media – for example, eating contaminated fish and being exposed to contaminated sediments. The receptors evaluated were adult recreators, young child recreators, older child recreators, and construction workers. For all cumulative risk and hazard calculations including fish ingestion, the cumulative risk or hazard was essentially the same as that associated with the fish ingestion pathway alone. Therefore, to assess the cumulative risks associated with pathways other than fish ingestion (i.e., exposure to lake sediment, wetlands sediment, dredge spoils soil, and lake surface water), the cumulative risk for each receptor was also calculated excluding the fish ingestion pathway, as summarized below:

- Cumulative RME cancer risks for adults (excluding fish ingestion) were calculated as 1×10^{-4}.

- Cumulative RME cancer risks (excluding fish ingestion) were calculated as about 3.5×10^{-5} for young children. In addition, the receptor-specific RME HI was calculated as about 0.8 for the young child.

- Cumulative RME cancer risks (excluding fish ingestion) were calculated as about 3.8×10^{-4} for older children. In addition, the calculated value of the cumulative RME HI, excluding fish ingestion, was 0.98 for the older child recreator.

- Cumulative RME cancer risks (excluding fish ingestion) were calculated as 2×10^{-5} for construction workers. In addition, the receptor-specific RME HI was calculated as about 0.8 for construction workers.

It should be noted that these cumulative estimates are probably unrealistically high, especially for the adult and older child recreational receptors, as the cumulative risk calculation assumes RME exposure frequencies summing to 218 days per year to Onondaga Lake sediments, wetlands, and dredge spoils. Cumulative RME HIs calculated in the same manner (excluding fish ingestion) generally did not exceed 1.0, although some approached 1.0, as indicated above.

Chapter 7, Uncertainty Assessment, of the HHRA provides a discussion of the reliability of the input parameters to the quantitative risk calculations, and provides a qualitative and, in some cases, semi-quantitative assessment of the effect of alternative values in risk calculations. As indicated there, actual cancer risks and non-cancer hazards may vary from those presented in the quantitative risk characterization tables.

Summary of Findings of the HHRA

Key results of the HHRA include the finding that contamination in Onondaga Lake presents risks to human health that are above USEPA guidelines. In addition, the primary sources of cancer risks and non-cancer hazards are due to mercury, PCBs, and PCDD/PCDFs as a result of the consumption of Onondaga Lake fish. The finding of elevated risk and hazard estimates for mercury and PCBs is consistent with the fact that concentrations of these chemicals in fish tissues collected from Onondaga Lake exceed US FDA action limits.