FINAL

HUMAN HEALTH RISK ASSESSMENT

Nyanza Superfund Site
Operable Unit IV
Sudbury River Mercury Contamination

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1. INTRODUCTION

1.1 PURPOSE AND APPROACH

This Supplemental Baseline Human Health Risk Assessment for the Nyanza Chemical Waste Dump Superfund Site, Operable Unit IV- Sudbury River (OU IV SBHHRA) documents the potential mercury exposure and consequent risk to individuals who catch and eat fish from the Sudbury River. This SBHHRA represents an addendum to a previous report, *Nyanza Chemical Waste Dump Superfund Site, Supplemental Baseline Human Health Risk Assessment,* prepared by Roy F. Weston, Inc. in 1999 (Weston, 1999a) that assessed the human health risks due to exposure to mercury in the Sudbury River through several pathways including:

1) Incidental ingestion of mercury in surface water;
2) Incidental ingestion of mercury in sediment; and
3) Ingestion of mercury through fish consumption.

The reader is referred to that document for a comprehensive treatment of the technical approach, contaminant data, and the evaluation of the risk posed through these pathways. In summary, the Weston report concluded that potential human exposure to mercury in surface water and sediment in the Sudbury River was well-below any level of concern. However, exposure to mercury through the catch and consumption of fish from Reservoir 2 and the Great Meadows National Wildlife Refuge posed an unacceptable level of risk to subsistence fishermen.

Subsequent evaluation of the report by EPA concluded that there were insufficient fish tissue data for a number of reaches to adequately assess the risk associated with fish consumption for the entire 60 km of the Sudbury River, beginning at the headwaters (upgradient of the Nyanza site) and extending to the confluence of the Sudbury and Assabet Rivers.

In July 2003, the U.S. Fish & Wildlife Service (USFWS) collected several species of game and panfish from each of 10 reaches of the Sudbury River (Figure 1-1) for subsequent total mercury and methylmercury analyses. These recently-collected data were used in this revised assessment to address several objectives:

1) Evaluate and identify the human health risk associated with consumption of fish from each of the reaches of the Sudbury River;

2) Evaluate the exposure and the consequent risk for those reaches that were not previously assessed; and

3) For those reaches that were previously assessed, identify changes in the levels of mercury in the edible tissue of fish collected in 1993/1994 and again in 2003, and by extension, changes in the potential human health risk during that period.

This SBHHRA was conducted in accordance with the approach outlined in the *Final Risk Assessment Work Plan: Nyanza Superfund Site, Operable Unit OU IV, Sudbury River Mercury Contamination* (Avatar, 2005) and attendant comment documents.

1.2 SITE HISTORY

The Nyanza Chemical Waste Dump Superfund Site (hereafter Nyanza Site) was occupied from 1917 through 1978 by several companies that manufactured textile dyes and dye intermediates. Additional products manufactured on-site included various colloidal solids and acrylic polymers. During the period of operation, large volumes of chemical waste were disposed in burial pits, below ground containment structures, and various lagoons scattered throughout the "Hill" section of the site. Wastes contained in these disposal areas included partially treated process water, chemical sludge, solid process wastes (chemical precipitate and filter cakes), solvent recovery distillation residue, numerous organic and inorganic chemicals (including mercury), and off-specification products. Process chemicals that could not be reused or recycled, such as phenol, nitrobenzene, and mercuric sulfate, were also disposed of on-site or discharged into the Sudbury River mainly through a small stream referred to as Chemical Brook.

Mercury and chromium were used as catalysts in the production of textile dyes from 1917 to 1978. Approximately 2.3 metric tons (2,300 kg) of mercury were used per year from 1940 to

1970 (JBF Scientific Corp., 1972), with approximately 45 to 57 metric tons of mercury released to the Sudbury River during this period (JBF Scientific Corp., 1973). From 1970 until the facility closed in 1978, wastes were treated on-site and wastewater was discharged to Ashland's town sewer system. These revised treatment practices reduced the quantity of mercury released to the Sudbury River to between 23 and 30 kg per year or about 0.2 metric tons during that eight-year period.

Nyanza, Inc. was cited for several waste disposal violations by the Massachusetts regulatory agencies from 1972 to 1977. In 1981, most of the property was acquired by MCL Development Corporation, which leased a large portion of the site to Nyacol Products, Inc. In 1982, the Nyanza Site was placed on the National Priorities List (NPL) by the U.S. EPA. Four other small property owners currently operate or lease facilities to various light industries and commercial concerns including Ashland Industrial Fuel Corporation, Middlesex Equipment, Ashland Excavating Co., A Auto Body, and Environmental Restoration Engineering Company. Table 1-1 presents a chronology of key activities that have occurred at the site just prior to and since its placement on the NPL. A more detailed presentation of the investigations conducted at the site and their findings can be found in the *Final Remedial Investigation Report: Nyanza Operable Unit III-Sudbury River Study* (NUS, 1992).

To expedite remediation, the RI/FS for the Nyanza Site was originally divided into the following three Operable Units (OUs):

- OU I — addressed on-site surficial soil, sediment and sludges (ROD signed and most remedial construction activities have been completed).
- OU II - "Nyanza II - Groundwater Study" — addresses groundwater contamination from the site and determines the presence of off-site migration. The investigation is ongoing.
- OU III - "Nyanza III - Sudbury River" — originally addressed contamination of the Sudbury River by discharges of wastewater and sludge from the site; OU III has since been additionally focused on addressing mercury contamination in soils and surface water in the continuing source areas, which are the Eastern Wetlands, Trolley Brook, Outfall Creek, and the Lower Raceway.

- OU IV - "Sudbury River Proper" — As a result of the findings in the OU III RI, EPA determined that the potential risk to both human health and ecological receptors could be attributed principally to mercury contamination of the Sudbury River. To further evaluate the nature, extent, and potential impacts of chemical contamination in the river, EPA established an additional operable unit (Operable Unit IV - Sudbury River) specifically to address mercury contamination within the river proper. Table 1-2 presents a list of studies, including their researchers and objectives, conducted as part of the OU IV assessment. OU IV was further subdivided into 10 Reaches (Figure 1-1) in an effort to refine the extent of mercury contamination and the associated risk potential to both human and ecological receptors.

1.3 SITE DESCRIPTION

The Nyanza Site is located in Ashland, Massachusetts approximately 35 km west of Boston. The Nyanza Site, which covers approximately 35 acres, is situated in an industrial area 0.4 km south of the Sudbury River. Surface water runoff and groundwater discharged from the site drains into Trolley Brook, Chemical Brook, and the Eastern Wetland (Figure 1-2). Trolley Brook, which drains the Eastern Wetlands, and Chemical Brook are the primary site drainages. Trolley Brook merges with Chemical Brook and continues through a culvert that discharges to Outfall Creek, a small man-made channel approximately 60 m long. Outfall Creek flows to the Lower Raceway, which joins the Sudbury River 240 m downstream from the site.

Whereas the OU III RI (NUS, 1992) included the wetlands and surface water drainages of the Nyanza Site and the Sudbury River, for this risk assessment, the study area (OU IV) consists primarily of the Sudbury River proper, selected drainage areas that provide input to the Sudbury River, and reference areas that can provide information regarding background conditions. The study area consists of an approximately 60 km stretch of river that begins in the river's headwaters and extends to where the Sudbury and the Assabet Rivers converge to form the Concord River (Figure 1-1).

The Sudbury River flows in a northerly direction through rolling, hilly terrain and consists of a series of impoundments, flowing reaches, and extensive wetland areas. A majority of the land surrounding the study area is suburban residential, consisting of several closely spaced urban centers connected by arterial commuting routes. The watershed area of the Sudbury River is approximately 165 square miles. In the OU III RI (NUS, 1992), the Sudbury River was divided into ten reaches (i.e., river segments), which were based on changes in river configuration, impounding structures, and stream junctures (Figure 1-1). The same geographical convention, i.e., reaches, was also used in the more recent investigations conducted specifically to evaluate potential mercury impacts within OU IV and continues to be used as part of the current assessment. A detailed description of reaches, boundaries, and characteristics is provided in the OU III RI (NUS, 1992).

1.3.1 Sudbury River Reach Descriptions

The following discussion presents a brief description of each reach.

- Reach 1— this reference area extends from the headwaters of the Sudbury River in Cedar Swamp to the Pleasant Street impoundment.

- Reach 2—extends from the Pleasant Street Impoundment to the Union Street Bridge (Route 135) in Ashland. Reach 2 is directly impacted by site discharges in and downstream of Mill Pond, the only impoundment located in this reach. The OU III surface water bodies (i.e., Trolley Brook, Chemical Brook, Outfall Creek, and Lower Raceway) and wetlands (i.e., Eastern Wetlands) discharge into the Sudbury River within Reach 2. In addition, contaminated groundwater underlying the Site discharges to Mill Pond.

- Reach 3—extends from the Union Street Bridge to the Reservoir No. 2 dam. Reach 3 contains Reservoir No. 2 (47 ha, mean depth 3.1 m, maximum depth 4.9 m) and receives discharge from Cold Spring Brook. Reservoir No. 2 is the first major sediment depositional area downstream of the site. This reservoir was developed in 1879 to supply water to Boston.

- Reach 4—extends from the Reservoir No. 2 dam to the Reservoir No. 1 dam. Reach 4 contains Reservoir No. 1 (49 ha, mean depth 2.2 m, maximum depth 4.0 m) which is the second major impoundment downstream from the site. Reservoir No. 1 receives discharge from the Framingham Reservoir No. 3 reference impoundment; in turn, Reservoir No. 3 receives source water from the Sudbury Reservoir. Neither the Sudbury Reservoir nor Reservoir No. 3 receives surface drainage from the site. Reaches 3 and 4 are similar in that they consist primarily of impounded areas with slow moving water.

- Reach 5—extends from the Reservoir No. 1 dam at Winter Street to the Massachusetts Turnpike (Interstate 90) overpass, where the Sudbury River widens. The upper portion of this reach is typically narrow with high stream velocity and only minor depositional areas. In the lower portion of this reach, the river broadens as a result of water retention in Saxonville Reservoir and the water velocity diminishes. Sediment deposition is expected to occur in this portion of the reach.

- Reach 6—extends from the Turnpike overpass to the Saxonville Dam. This reach includes a small section of flowing river and a ponded depositional area behind the Saxonville Dam (Saxonville Reservoir).

- Reach 7—extends from the Saxonville Dam downstream to the Route 20 overpass in Wayland. Reach 7 has a low stream gradient (<1 foot drop per mile) resulting in a slow, meandering river with increased potential for deposition. This reach also includes Heard Pond, which, although not an impoundment of the Sudbury River, lies within the Sudbury's floodplain and at times of high water receives overflow from the river.

- Reach 8—extends from the Route 20 overpass to the Route 117 overpass, before the Fairhaven Bay inlet. This reach includes the Great Meadows National Wildlife Refuge (GMNWR). The river channel within Reach 8 meanders through an extensive wooded and emergent wetland complex that has a high depositional potential.

- Reach 9—extends from the inlet area to Fairhaven Bay to the Fairhaven Bay outlet. Fairhaven Bay is a large pond-like feature in the Sudbury River (27 ha, mean depth 1.5 m, maximum depth 3.4 m) that is the last major depositional area before the Sudbury/Assabet River confluence.

- Reach 10—extends from the Fairhaven Bay outlet to the Sudbury/Assabet River confluence. This portion of the Sudbury River has a flow regime similar to that of Reach 8, with slightly less meander.

1.3.2 Reference Area Descriptions

Portions of the Sudbury River lie within the Boston-Sudbury Lowland and Eastern Plateau hydrologic provinces of eastern Massachusetts (Motts and O'Brien, 1981). Reference areas located within these provinces were used to provide data on background levels of mercury for the field investigations. The primary reference areas include Reach 1 (headwaters of the Sudbury River), the Charles River in the vicinity of Millis, and the Sudbury Reservoir west of Framingham.

1.3.2.1 Reach 1 – Headwaters of the Sudbury River

Reach 1 extends from the headwaters of the Sudbury River in Cedar Swamp to a small dam (referred to as the Pleasant Street Impoundment), just upstream of Mill Pond in Ashland. Reach

1 contains several sampling locations, including Whitehall Reservoir (233 ha, mean depth 2.0 m, maximum depth 9.8 m). The flowing portion of Reach 1 serves as a reference area for Reaches 2, 5, 7, and 10.

1.3.2.2 Charles River

The Charles River reference area lies within the Boston-Sudbury Lowland hydrologic province. This province represents a small irregularly-shaped area of low relief in eastern Massachusetts. It consists mainly of broad plains interrupted by numerous low hills and ridges. The lowland in the vicinity of the site and reference areas is drained by the Charles and Sudbury Rivers. The surficial geology of the region consists mostly of stratified drift surrounding drumlins and isolated till-covered bedrock hills. Glaciolacustrine sediments occupy much of the lowland around the Sudbury River (Motts and O'Brien, 1981**.** The habitat of the Charles River near Millis is similar to that of the Sudbury River especially in the vicinity of the GMNWR. Flow characteristics, open water, emergent wetlands and adjacent scrub-shrub areas are similar and are expected to support fish and wildlife species that have been observed in the Great Meadows and other meandering portions of the Sudbury River watershed. The Charles River was selected to serve as a reference for portions of the slower flowing areas of the Sudbury River, including GMNWR (Reach 8) and Reach 9.

1.3.2.3 Sudbury Reservoir

The Sudbury Reservoir is a man-made impoundment located with the Eastern Plateau province. This province is characterized as low-lying region, sloping gently seaward. Elevations in this province are generally less than 500 ft above sea level. In addition to the Sudbury River, this region is drained by the Concord, Charles, and Assabet Rivers, among others. Surface waters reflect poorly-integrated drainage due to disruption by glaciation. Surface topography in the province reflects stratified drift of sand and gravel deposits (Motts and O'Brien, 1981). The Sudbury Reservoir was selected to serve as a reference for the impounded areas of the Sudbury River, including Mill Pond (Reach 2), Reservoirs 1 and 2 (Reaches 4 and 3, respectively), and the Saxonville Reservoir (Reach 6). Although lacking the substantial industrial, commercial and residential development surrounding many of the Sudbury River reservoirs, it is, nevertheless, expected to provide a suitable reference area for ambient mercury levels in fish.

1.4 SUMMARY OF PREVIOUSLY CONDUCTED HHRAS

The *Supplemental Baseline Human Health Risk Assessment* (Supplemental Baseline HHRA) conducted previously (Weston, 1999a) supplemented the assessment presented in the *Final Remedial Investigation Report: Nyanza Operable Unit III-Sudbury River Study* (OU III RI) (NUS, 1992). As a result of the findings presented in the OU III RI (NUS, 1992), EPA determined that the potential risks to both human and ecological receptors are attributed principally to mercury contamination in the Sudbury River. To further evaluate the nature, extent, and potential impacts of the mercury contamination in the Sudbury River, EPA organized a multi-disciplinary task force. The Sudbury River Task Force includes representatives from EPA-New England, the U.S. Fish and Wildlife Service (USFWS), the U.S. Geological Survey (USGS), the Army Corps of Engineers (ACOE), the National Oceanic and Atmospheric Administration (NOAA), and the Framingham Advocates for the Sudbury River, as well as members of several academic and private research concerns.

Based on a review and 'information gaps' evaluation of the 1992 assessment related to the nature and extent of contamination in the Sudbury River, the Task Force was directed to develop information necessary to produce a scientifically defensible ecological risk assessment associated with mercury contamination in the Sudbury River. In an effort to facilitate this investigation, EPA established Operable Unit IV – 'Sudbury River' specifically to address mercury contamination within the river proper. The primary objectives of the Sudbury River Task Force were to:

1) Establish the extent of mercury contamination within the Sudbury River;
2) Determine the contribution of the Nyanza Site to any identified mercury contamination; and
3) Provide information necessary to refine remediation objectives for ecological and human health.

Toward that end, the Supplemental Baseline HHRA incorporated the additional data collected from the Sudbury River since the OU III RI. In addition, the assessment was based on the current and potential designated uses projected for the Sudbury River (MADEP, 1996) and as such, was limited to an evaluation of the potential risk associated with exposure to mercury resulting from fish consumption, recreational use of the Sudbury River (e.g., swimming), and ingestion of water as a drinking water source. This Task Force information was used to further refine the previous human health risk estimates. However, data gaps in the river-wide coverage of mercury in fish made it impossible to accurately estimate risks to anglers throughout the Sudbury River.

This SBHHRA for fish consumption was conducted based on the general approach outlined in the *Final Risk Assessment Work Plan, Nyanza Superfund Site, Operable Unit IV, Sudbury River Mercury Contamination* (Avatar, 2005). This assessment supplements the fish ingestion risk assessment performed previously by using reach-specific fish data to estimate exposure. Consequently, the methodology used in the prior assessment has been followed to maintain consistency. However, where more recent data suggest the need to modify the approach (e.g., publication of updated default exposure assumptions), these changes have been made.

Note also that discussions of the results of previous assessments are incorporated by reference in this document. As such, the reader is referred to those earlier documents for a comprehensive discussion of those studies.

1.5 RISK ASSESSMENT REGULATORY FRAMEWORK AND GUIDANCE DOCUMENTS

As noted previously the Nyanza Site was placed on the NPL in 1982; therefore, this investigation is being performed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 under the authority of EPA Region 1.

The primary risk assessment guidance documents used in the current evaluation are presented below. Supplementary risk assessment guidance documents will be cited in the individual sections of this risk assessment as appropriate.

- EPA Region 1 Risk Updates: No. 2 (August, 1994), No. 3 (August, 1995), No. 4 (November, 1996), and No. 5 (November, 1999) (EPA New England).
- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A) Interim Final* (EPA, December 1989).
- *Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"* (EPA, March 1991).
- *Guidance for Data Useability in Risk Assessment, Part A* (EPA, May 1992a).
- *Guidelines for Exposure Assessment*. Federal Register. Volume 57 (EPA, 1992b).
- *Exposure Factors Handbook* (EPA, August 1997).
- *Child-Specific Exposure Factors Handbook (Interim Report)* (EPA, September 2002).
- *Mercury Study Report to Congress: Volumes I – VIII – SAB Review Draft* (EPA, June 1996a).
- *Risk Assessment Guidance for Superfund:* Volume 1, *Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments). Final.* (EPA, December 2001a).

1.6 REPORT OVERVIEW

The remainder of this report describes the comprehensive SBHHRA process, which includes a number of technical components. A summary of each key component is provided below:

- Hazard Identification (Subsection 2)—This subsection provides a brief overview of the biological investigations used to support the SBHHRA, data usability, data validation and the guidelines for data reduction for risk assessment purposes; and outlines the data evaluation approach.
- Toxicity Assessment (Subsection 3)—This subsection identifies toxicological criteria and how they were used for the quantitation of noncancer health effects from exposure to inorganic mercury and methylmercury. The criteria, sources, and the rationale for their use are presented.

- Exposure Assessment (Subsection 4)—A discussion of the exposure setting and local land and water uses is provided in this subsection, as well as potentially exposed human populations. A conceptual site model, methods for estimating the contaminant EPCs, and identification of exposure models and assumptions are also presented.

- Risk Characterization (Subsection 5)—The methods that were used to estimate noncancer health effects associated with mercury exposure, as well as the results are presented.

- Uncertainty Analysis (Subsection 6)—This subsection describes an estimation of the level of uncertainty and its impact on the risk results.

2. HAZARD IDENTIFICATION

2.1 INTRODUCTION

The Hazard Identification presents the mercury data used in this BHHRA to assess risks to mercury exposure through fish consumption. Mercury data for a variety of media have been compiled in a comprehensive database to support both the HHRA and the ecological risk assessment. This database interfaces with a geographical information system and contains information on the physical and chemical properties of the media.

The objectives of the Hazard Identification for this assessment include:

- Review and summarize the analytical data for fish tissue sampled in the Sudbury River reaches potentially impacted by the migration of mercury from past operations and activities at the Nyanza Site.
- Select the chemicals of potential concern (COPCs) to be evaluated in the risk assessment. Note that for this BHHRA, the focus is solely on mercury (as total mercury and methylmercury) as the chemical of concern.
- Select the data and data treatment approach(es) to be used in this updated fish consumption risk assessment.

2.2 AVAILABLE DATA

This section presents a summary of existing information relating to the nature and extent of mercury contamination in fish tissue within the Sudbury River drainage. It deals with a description of the primary sources of data and an overview of data collection and handling procedures.

Fish tissue data were collected for the OU III RI (NUS, 1992), for the Task Force food chain transfer study from 1993-1994 (Haines et al., 1997), and during 2003/2004 Supplemental Investigation field efforts. Each data set is discussed below.

2.2.1 OU III RI Data Set

Due to differences in handling techniques and analytical procedures for fish tissue, it was determined that fish tissue analyses conducted for the OU III RI lacked the analytical precision of the Task Force and 2003 supplemental investigation data (e.g., the detection limits for OU III RI data were not sufficiently low to detect mercury at the concentrations present in fish because of sample dilution necessary to correct for matrix interference). In addition, questions were raised regarding the ability to meet data quality objectives in the analytical procedures. Consequently, mercury data in fish tissue collected prior to 1992 were excluded from the analysis of risk in both the Supplemental Baseline HHRA (1999a) and this BHHRA.

2.2.2 Food Chain Transfer Study Data Set

Fish samples collected during 1993-1994 for the food chain transfer study (Haines et al., 1997) consisted of both edible portion (i.e., fillet or whole body less gut or stomach) and whole body analysis. Fish tissue samples were collected only from Reach 1, Reach 3, and Reach 8 and analyzed for total mercury only. These results were used in the Supplemental Baseline HHRA. Given that only two potentially affected reaches were sampled (Reach 1 is considered background), the Supplemental Baseline HHRA had substantial gaps in river coverage. Because the food chain transfer study data are 8-10 years older than the 2003 supplemental investigation data, the former were not included in the assessment of current risk through fish consumption. However, for those reaches where comparable data were obtained, comparisons were made to identify changes in the levels of mercury in the edible fish tissue of fish collected in 1993/1994 and again in 2003, and by extension, changes in the potential human health risk during that period.

2.2.3 2003/2004 Supplemental Investigation Data Set

The *Supplemental Investigation Work Plan Addendum, Nyanza Superfund Site, Operable Unit IV, Sudbury River Mercury Contamination* (Avatar, 2003a) and Appendix A.15 – Standard Operating Procedure for Fish Collection and Processing of the *Field Sampling*

Plan, Nyanza Superfund Site, Operable Unit IV, Sudbury River Mercury Contamination (September 2003b) present the data collection and analytical requirements for the supplementary investigation conducted in 2003/2004. The reader is referred to the Field Sampling plans for details of the sampling methodology and the sample requirements.

The large fish collection program for this supplemental investigation consisted of fish greater than or equal to 15 cm total length. Species targeted included largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*), and brown bullhead (*Ameiurus nebulosus*). During the large fish collection effort, any small fish collected that met the small size class fish collection objectives were kept and processed. As part of the USFWS effort, yellow perch were targeted in both the large and small fish sampling and were classified into the following 4 size classes: ≥5 to < 10 cm (size class A), ≥10 to < 15 cm (size class B), ≥15 to < 20 cm (size class C), ≥20 cm (size class D).

Fish of all size classes were collected from each of the 9 site-impacted reaches and 3 reference areas.

In establishing reference areas for the Sudbury River, several areas were chosen to represent three types of riverine characteristics:

1) a lotic environment characterized by shallow water (i.e., < 3 ft) segments of moderate to fast flowing water.

2) a lotic environment characterized by somewhat deeper water segments (i.e., > 3 ft) of relatively slow flowing water,

3) a lacustrine environment characterized by a reservoir

Comprehensive discussions of the analytical procedures used to obtain the data presented in this assessment can be found in the *Quality Assurance Project Plan, Nyanza Superfund Site, Operable Unit IV, Sudbury River Mercury Contamination* (Avatar, September 2003c). A summary of the fish that were collected for use in this BHHRA are presented in Table 2-1.

Both fillet and whole body analysis results were used in the BHHRA. Note that fish tissue collected as part of this study was analyzed for total mercury, with a subset analyzed for methylmercury. Numerous studies have indicated that the predominant form of mercury in biological tissue is methylmercury. The proportion of total mercury in biota that exists as methylmercury has been shown to increase with trophic level as well as with age and size of fish within a given trophic level, e.g., tertiary consumer such as largemouth bass (EPA, 1996b). It is estimated that 95 to 99 percent of the mercury contained in fish exists as methylmercury (Huckabee et al., 1979; Bloom et al., 1990; EPA, 1996b). Analytical data specific to this most recent fish collection were used to determine site-specific methylmercury to total mercury ratios. Ratios were calculated using paired concentration data (i.e., methyl- and total mercury) for an individual fish. These data indicate that, within a species, the mean methylmercury to total mercury ratio ranges from 0.89 to 0.99 (Tables 2-2 through 2-4). For this assessment, it is conservatively assumed that all total mercury detected in fish tissue is methylmercury.

2.3 DATA USABILITY AND DATA VALIDATION

EPA Region 1 discusses data usability issues that should be considered in the risk assessment process in its Risk Update 3 (EPA Region 1, 1995). Data usability is defined as the process of ensuring that the quality of the data meets the intended uses and satisfies the data quality objectives (DQOs) established for sampling and analysis. Data usability involves assessing both the analytical quality, sampling methodology, and field errors that may be inherent in the data. Factors evaluated include the level of validation (data validation tier) and data quality indicators such as completeness, comparability, precision and accuracy, and analytical detection limits.

EPA Region 1 recommends that all data used in the human health risk assessment process be validated to Tier II or Tier III. In a Tier II validation, quality control (QC) checks are conducted and analytical procedures are assessed, then the data are qualified accordingly. In a Tier III validation, in addition to meeting the Tier II requirements, the raw data are examined to check for calculation errors, compound misidentification, and transcription errors. A Data Validation report is produced by the validator for both Tier II and Tier III validations. All fish data newly collected for this investigation were validated to at least a Tier II level.

2.4 GUIDELINES FOR DATA REDUCTION

The following guidelines for data reduction were used to produce the data summaries for fish tissue in each area. These approaches are consistent with *Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual (Part A)* (EPA, 1989).

- All mercury data with "J" qualifiers were assumed to be positive identifications. "J" indicates that the numerical value is an estimated concentration (e.g., is reported below the minimum confident sample quantitation limit).
- If a sample duplicate was collected and analyzed, the average of the two reported concentrations was used for subsequent calculations unless there was a greater than 50% difference in tissue concentrations, in which case the higher of the two concentrations was used.

2.5 DATA EVALUATION

The objectives of the data evaluation are to summarize the data by medium and exposure scenario and to evaluate the usability of the data for the risk assessment. For this assessment, mercury concentrations in fish tissue were summarized by species within each river reach to provide information on the geographic distribution of mercury throughout the river.

For the scenarios evaluated in this risk assessment (see Section 4 for detailed discussion), two different data sets per species per reach were needed: fillet data and whole body data. In addition, there are size requirements for legally keeping certain species of fish. For the species within the Nyanza data set, the requirements are as follows (MDFW, 2005):

– Small and Largemouth Bass ≥30.48 cm (12 inches)

- All other species – no size limit. Note: Smallest filleted fish was a 18.3 cm (~7 ¼ inch) yellow perch.

2.5.1 Fillet Data Sets

The fillet data sets consist of only fillet data of legal size limits (as noted above), segregated by species within each reach.

2.5.2 Whole Body Data Sets

The whole body fish data sets consist of all whole body fish greater than 15 cm (~ 6 inches) in length (i.e., size classes C and D) as designated in the site-specific Field Sampling Plan; Avatar, 2003b) and of "reconstructed" whole body concentrations also from fish size classes C and D. Many of the larger fish were filleted and oftentimes analyzed with the associated offal sample. To obtain a "reconstructed" whole body concentration, the procedures below were followed. Note that during this procedure the size limit restrictions for bass were still observed.

- When only the fillet from an individual fish was analyzed, it was assumed that the fillet concentration represents the whole body fish concentration. This is a conservative assumption given that mercury is expected to be found in higher concentrations in muscle tissue (i.e., fillet) as opposed to fatty tissue (i.e., offal). (This assumption will be discussed in detail in the Uncertainty Section.)

- When both fillet and offal concentrations are available, the following equation was used to "reconstruct" the whole body fish concentration:

$$C_{wb} = \frac{C_f \times W_f + C_o \times W_o}{W_f + W_o}$$

Where:

C_{wb} = Concentration in whole body
C_f = Concentration in fillet
W_f = Weight of fillet
C_o = Concentration in offal
W_o = Weight of offal

Note: If a fillet was split and analyzed as a primary and duplicate sample (instead of analyzing both the left and right fillets together as a primary), the fillet concentration was determined using the averaging technique noted above and the fillet weight equaled the sum of the primary and duplicate samples.

2.5.3 Data Set Summaries

Summary tables were prepared for each species within each reach in RAGS D format (EPA, 2001a) that present the following information:

- Frequency of detection.
- Range of detected concentrations.
- Range of sample quantitation limits. (Note all samples had detectable concentrations of mercury; therefore, these columns are blank.)

Odd numbered tables in the series of Tables 2-5 through 2-27 present summaries of the total- and methylmercury concentrations of the fillet samples collected from the Sudbury River and background locations by fish species. In addition to the tabular presentation of data, Figure 2-1 presents box-plots of the mercury distribution in fillet fish tissue.

Fillet data for bullheads, largemouth bass, and yellow perch are available for each sampling location with the exception of Reach 2, which has data for largemouth bass and yellow perch only. Reach 9 has the maximum reported mercury levels in a fillet sample, followed by Reach 3, Reach 8, and Reach 10. Reach 3 has the highest median fillet concentration followed by Reach 4 and Reaches 2 and 9. Largemouth bass have the highest reported mercury concentrations in each reach, except Reach 1, where the highest concentration is found in a bullhead sample. For the site-related data (i.e., Reaches 2 through 10), the largemouth bass concentrations range from 0.0889 (Reach 7 – Heard Pond) to 1.83 mg/kg fresh weight (fw) (Reach 9). For the same dataset, the bullhead concentrations range from 0.0241 (Reach 7 – Heard Pond) to 1.48 mg/kg fw (Reach 3). The yellow perch concentrations range from 0.0217 (Reach 7 – Heard Pond) to 0.911 mg/kg fw (Reach 3).

For the fillet background data (i.e., Reach 1, Charles River, and Sudbury Reservoir), the largemouth bass concentrations range from 0.194 (Sudbury Reservoir) to 0.616 mg/kg fw

(Sudbury Reservoir). The bullhead concentrations range from 0.0844 (Sudbury River) to 0.847 mg/kg fw (Reach 1). The yellow perch concentrations range from 0.0338 (Reach 1) to 0.365 mg/kg fw (Reach 1).

Even numbered tables in the series of Tables 2-6 through 2-28 present summaries of the total- and methylmercury concentrations of whole body fish (as submitted and reconstructed) from the Sudbury River and background locations by fish species. In addition to the tabular presentation of data, Figure 2-2 presents box-plots of the mercury distribution in whole body tissue.

Whole body data for bullheads, largemouth bass, and yellow perch are available for each sampling location. In addition, white sucker data is available for Reaches 1 and 2 and bluegill data is available for Reach 8. Reach 3 has the maximum reported mercury levels, followed by Reach 2 and Reach 9. Reach 3 has the highest median whole body concentration followed by Reach 4 and Reaches 6 and 10. Like the fillet data, largemouth bass have the highest reported mercury concentrations in each reach except for Reach 1, where the highest concentration is found in a bullhead sample. For the site-related data, the concentrations in largemouth bass range from 0.0889 (Reach 7 – Heard Pond) to 1.76 mg/kg fw (Reach 3). The concentrations in bullheads and white sucker range from 0.0241 (Reach 7 – Heard Pond) to 1.48 mg/kg fw (Reach 3). The yellow perch and bluegill concentrations range from 0.0212 (Reach 7 – Heard Pond) to 0.911 mg/kg fw (Reach 3).

For the whole body background data, the largemouth bass concentrations range from 0.155 (Sudbury Reservoir) to 0.616 mg/kg fw (Sudbury Reservoir). The bullheads and white sucker concentrations range from 0.04 to 0.555 mg/kg fw (Reach 1). The yellow perch concentrations range from 0.0332 (Sudbury Reservoir) to 0.365 mg/kg fw (Reach 1).

2.6 CHEMICALS OF POTENTIAL CONCERN SELECTION

As noted in Section 1.2, Operable Unit IV - "Sudbury River Proper" was created as a result of the findings in the OU III RI (NUS, 1992), in which EPA determined that the potential risk to both human health and ecological receptors could be attributed principally to mercury contamination of the Sudbury River. OU IV specifically addresses only mercury contamination within the river proper. The Task Force and Supplemental Investigation chemical analyses were limited to total and methylmercury to refine the extent of mercury contamination and the associated risk potential to both human and ecological receptors. As such, mercury as the methylmercury species (see Section 2.2.3) is the only chemical of potential concern addressed in this risk assessment.

3. TOXICITY ASSESSMENT

3.1 INTRODUCTION

The Toxicity Assessment presents the available information on the potential human health effects associated with varying degrees of human exposure to inorganic mercury and methylmercury. This assessment identifies the toxicity values for both forms of mercury that may be used in conjunction with the exposure doses associated with the consumption of fish to evaluate potential human health effects. In addition, it provides the supporting data, the methodology, and the underlying assumptions with which these toxicity values were derived. Excessive exposure to any chemical potentially can produce adverse noncancer health effects, while the potential for causing cancer is limited to carcinogens, i.e., chemicals that have evidence of causing cancer. In the risk assessment process, the EPA develops cancer and noncancer toxicity values that reflect the potential for a dose of a chemical to produce cancer and adverse noncancer effects. Cancer toxicity values are referred to as cancer slope factors (CSFs). EPA classifies chemicals in one of five categories based on their weight-of-evidence for causing cancer in humans (EPA, 2005a). These categories have been assigned by EPA's Carcinogen Risk Assessment Verification Endeavor (CRAVE) Work Group. The categories include:

- Carcinogenic to humans
- Likely to be carcinogenic to humans
- Suggestive Evidence of Carcinogenicity, but Not Sufficient to Assess Human Carcinogenic Potential
- Data Are Inadequate for An Assessment of Human Carcinogenic Potential
- Not likely To Be Carcinogenic To Humans

EPA's Integrated Risk Information System (IRIS) lacks the current cancer classification descriptors for mercuric chloride and methylmercury described above under the revised cancer guidelines. As such, the descriptors for mercury and methylmercury under the previous carcinogenic classification system (EPA, 1989) are presented below and are discussed for both chemicals in their respective sections.

- Group A – the chemical is a known human carcinogen, based on sufficient human evidence;
- Group B1 – the chemical is a probable human carcinogen, based on sufficient animal evidence and limited human evidence;
- Group B2 – the chemical is a probable human carcinogen, based on sufficient animal and inadequate or no human evidence;
- Group C – the chemical is a possible human carcinogen, based on limited animal evidence and inadequate or no human data;
- Group D – the chemical is not classifiable as to human carcinogenicity (both human and animal evidence is inadequate or there are no data);
- Group E – there is evidence of noncarcinogenicity in humans (there are adequate data demonstrating noncarcinogenicity).

Noncarcinogenicity is a generic description for a variety of toxic effects, such as organ damage, physiological alterations, and reproductive effects. These types of toxicity share one point in common: the apparent occurrence of a toxicological threshold. Below this threshold, factors such as the body's protective mechanisms (e.g., metabolism, elimination) can limit the chemical effects, preventing the expression of adverse effects.

A chronic RfD is an estimate (with uncertainty spanning perhaps an order of magnitude), of a daily intake of a chemical that is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure. The RfD is developed to be protective of sensitive subgroups. It is assumed when deriving RfDs that a threshold dose exists below which there is no potential for adverse effects. An RfD is expressed as a daily intake in units of milligrams (mg) of chemical per kilogram (kg) of body weight per day (i.e., mg/kg-day). As the RfD decreases in value, the more toxic the chemical is in producing noncancer health effects.

Because inorganic mercury represented up to ~ 10 % of the total mercury in some fish tissue samples collected at the site (see Section 2.2.3), the following sections discuss the derivation of the chronic RfDs for both inorganic mercury and methylmercury. The weight-of-evidence carcinogenicity categorizations for inorganic mercury and methylmercury also are discussed. The weight-of-evidence carcinogenicity categorizations also were obtained from IRIS. These categorizations have been assigned by EPA's CRAVE Work Group.

3.2 INORGANIC MERCURY

Most of the information regarding the oral toxicity of inorganic mercury to humans comes from case studies of acute exposure (i.e., the ingestion of a large single dose). Since this risk assessment evaluates chronic, not acute exposures, acute toxicity data is not summarized herein.

3.2.1 Derivation of Toxicity Values

The toxicity values and the weight-of-evidence carcinogenicity categorization for inorganic mercury are discussed in the following sections.

3.2.1.1 Oral Reference Dose

The chronic oral RfD for inorganic mercury (i.e., mercuric chloride) was obtained from IRIS (EPA, 2005b). IRIS is the preferred source of toxicity values as these values have undergone extensive EPA review and have been verified by EPA's Reference Dose/Reference Concentration (RfD/RfC) Work Group.

The chronic oral RfD for mercuric chloride, which is expressed as a daily dose of mercury (i.e., mg Hg/kg body weight per day), is 3.0E-04 mg/kg-day (EPA, 2005b). This value was derived using the traditional EPA NOAEL/LOAEL approach. In this approach, RfDs are derived from either a no-observed-adverse-effect level (NOAEL) or a lowest-observed-adverse-effect level (LOAEL) obtained from human or animal studies. A NOAEL is that dose of a chemical at which there are no statistically or biologically significant increases in the frequency or severity of adverse effects between the test population and its appropriate control. A LOAEL is the lowest dose in a study that produces a statistically or biologically significant increase in the frequency or severity of adverse effect between the exposed population and its appropriate control (Dourson and Stara, 1983). A LOAEL is used to derive an RfD in the absence of a suitable NOAEL.

The chronic oral RfD for mercuric chloride, expressed as a daily intake of mercury, was back-calculated from a Drinking Water Equivalent Level (DWEL) of 0.010 mg/L that was adopted by EPA. The DWEL was based on three studies using the Brown Norway rat in which mercuric chloride was administered orally or subcutaneously, as well as on limited human tissue data. The decision by EPA to base the RfD on the DWEL, however, took into account a review of the entire mercury database (EPA, 2005b).

The most sensitive toxic endpoint used as the basis for the DWEL (and RfD) is autoimmune glomerulonephritis, as evidenced by the deposition of immunoglobulin G (IgG) antibodies on the glomerular basement membrane of the rat kidneys. The IgG deposition was considered to be an initial stage of autoimmune glomerulonephritis. The DWEL was calculated from a LOAEL, applying an uncertainty factor of 1000. The uncertainty factor incorporates a factor of 10 to extrapolate from a LOAEL to a NOAEL, a factor of 10 for the use of a subchronic study, and a factor of 10 to extrapolate from animals to sensitive human populations. The DWEL of 0.010 mg/L was converted to the oral RfD using the standard assumptions of a consumption of 2 liters of water per day and a body weight of 70 kg:

$RfD_{chronic}$ = 0.010 mg/L x 2 L/day/70 kg body weight

= 0.0003 or 3.0E-04 mg/kg-body weight-day) (EPA, 2005b).

A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfD for mercuric chloride conducted in September 2002 did not identify any critical new studies (EPA, 2005b).

3.2.1.2 Carcinogenicity Classification

Mercuric chloride is classified by EPA in Group C, a possible human carcinogen. The classification is based on inadequate data for carcinogenicity in humans, and limited evidence in rats and mice. In a study conducted by the National Toxicology Program (NTP), thyroid and forestomach tumors were observed in males after treatment with mercuric chloride for two years. As discussed in the Toxicity Profile for Mercury (see Appendix A), these results were considered questionable. Therefore, EPA has not developed a slope factor from these data (EPA, 2005b).

3.3 METHYLMERCURY

Methylmercury is a highly toxic substance with a number of adverse health effects associated with its exposure in humans and animals. Human exposure following high-dose poisonings in Japan and Iraq resulted in effects that included mental retardation, cerebral palsy, deafness, blindness, and dysarthria (i.e., speech disorder) in individuals who were exposed *in utero* and sensory and motor impairment in exposed adults. Chronic, low-dose prenatal methylmercury exposure from maternal consumption of fish has been associated with more subtle endpoints of neurotoxicity in children. Results from animal studies also show effects on cognitive, motor, and sensory functions (EPA, 2005b).

3.3.1 Derivation of Toxicity Values

The toxicity values and the weight-of-evidence carcinogenicity categorization used in the risk assessment for methylmercury are discussed in the following sections.

3.3.1.1 Oral Reference Dose

The current reference dose has been determined for the most sensitive toxicity endpoint; i.e., neurological effects in infants following maternal exposure to methylmercury. Recently, the Agency reviewed the results of studies in which populations whose diet is predominantly fish and thus, is at risk of elevated methylmercury exposure. These studies, principally of populations in the Faroe Islands in the North Atlantic Ocean and in New Zealand, include more subjects than the Iraqi study on which the previous RfD was based, are prospective in design, and used endpoints that are anticipated to be more sensitive than the clinical symptoms of mercury poisoning observed in Iraq. Based on the integrative analysis of all three studies, the RfD was calculated to be 0.1 µg/kg/day. This RfD is the same as that derived in 1995. In addition, experimental studies in monkeys support the quantitative estimate of the RfD based on a NOAEL/LOAEL approach. Because of the number of epidemiological and experimental studies that converge on the derived RfD of 0.1 µg/kg/day, confidence in the RfD for methylmercury is high (EPA, 2005b).

The studies included developmental studies in the Seychelles, Faroe Islands, and in New Zealand. These areas support large fish-eating populations in which potential exposure to methylmercury in fish may be elevated. The Seychelles study yielded scant evidence of impairment related to in utero methylmercury exposure, whereas the other two studies found dose-related effects on a number of neuropsychological endpoints.

The Faroe Islands study was a longitudinal study of mother-infant pairs where the main independent variable was umbilical cord-blood mercury with maternal-hair mercury also being measured. At 7 years of age, children were tested on a variety of tasks designed to assess function in specific behavioral domains.

The New Zealand study was also a prospective study in which children of mothers with hair mercury levels during pregnancy greater than 6 ppm were matched with children whose mothers had lower hair mercury levels. At 6 years of age, the children were assessed on a number of neuropsychological endpoints (EPA, 2005b).

EPA chose a benchmark dose approach (BMD) to use rather than a no-observed-adverse-effect level/lowest-observed-adverse-effect level (NOAEL/LOAEL) approach to analyze the neurological effects in children as the response variable. The BMD approach is a relatively new approach that has been developed for application to developmental toxicity endpoints. A BMD is calculated by fitting a mathematical dose-response model to dose-response data and reflects the lower confidence bounds on a predetermined level of risk (ATSDR, 1999). The BMD approach has been proposed as superior to the use of "average" or "grouped" exposure estimates when dose-response information is available.

In the EPA dose-response assessment, emphasis was placed on the results of the Faroe Islands study, the larger of the two studies that identified methylmercury-related developmental neurotoxicity (EPA, 2005b). The biomarker of choice for the Faroes data was cord blood, and the BMD levels (BMDLs) were reported in units of ppb mercury in cord blood. In order to calculate an RfD, it was necessary to convert this figure to an ingested daily dose of mercury that would result in exposure to the developing fetus at the BMDL of ppb mercury in umbilical cord blood (EPA, 2005b). EPA chose the one-compartment model for dose conversion for this RfD. This model has shown reasonably good fit to data on mercury blood-level changes in human subjects during and after consumption of methylmercury-contaminated fish (EPA, 2005b). Rather than choose a single measure for the RfD critical endpoint, EPA based the RfD on several scores from the Faroes measures, with supporting analyses from the New Zealand study

A variety of tests were conducted on the Faroes subjects (i.e., BNT = Boston Naming Test; CPT = Continuous Performance Test; CVLT = California Verbal Learning Test; and finger tap test) to measure indications of neuropsychological processes involved in a child's ability to learn and process information. The BMDLs for these scores are all within a relatively close range and were converted using a one-compartment model to an ingested dose of methylmercury that would result in the cord-blood level. The calculated RfD values converge at the same point, 0.1 µg/kg/day. For the New Zealand study, the results of the McCarthy Perceived Performance test yielded an RfD of 0.05 µg/kg/day, and the McCarthy Motor Test yielded an RfD of 0.1 µg/kg/day. Based on the integrative analysis of the Faroes and New Zealand studies, the RfD was calculated to be 0.1 µg/kg/day. This RfD is the same as that derived in 1995 based on a study of a poisoning episode in Iraq. As noted by EPA, "experimental studies in monkeys also support the quantitative estimate of the RfD based on a NOAEL/LOAEL approach. Thus, there is a wealth of data from both epidemiological and experimental studies that converges on the derived RfD of 0.1 µg/kg/day" (EPA, 2005b).

3.3.1.2 Carcinogenicity Categorization

Methylmercury is classified by EPA in Group C, a possible human carcinogen. The classification is based on inadequate data for humans and limited evidence of carcinogenicity in animals. Both positive and negative results have been obtained in carcinogenicity studies. There also are both positive and negative genotoxicity data (EPA, 2005b).

An increase in renal tumors in response to the dietary administration of methylmercury was observed in three mouse studies. As discussed in the Toxicity Profile for Mercury (see Appendix A), the relevance of the results of the studies is questionable. Methylmercury seemed to be carcinogenic only at high doses, at or above a maximum tolerated dose. Because the linearized multistage model (a model commonly used by EPA to derive cancer slope factors) assumes linearity at low doses, and the data suggest the possibility of a threshold dose for tumors, the use of this model to derive a cancer slope factor may not be appropriate. The Agency noted that nontoxic effects have been produced in animals after the chronic administration of methylmercury at daily doses an order of magnitude lower than those required for tumor formation (EPA, 2005b).

3.4 TOXICITY VALUES USED IN THIS HHRA

For this assessment, it is assumed that total mercury concentrations are comprised 100% of methylmercury. Therefore, the methylmercury toxicity values will be applied to the EPCs calculated for total mercury (see Table 3-1).

4 EXPOSURE ASSESSMENT

4.1 INTRODUCTION

The objectives of this exposure assessment are to characterize human populations potentially exposed to mercury in the Sudbury River, to identify actual or potential exposure pathways, and to determine the extent of that exposure.

The exposure assessment involves several key elements including:

- Identification of potential routes of exposure;
- Identification of the potential receptors/exposure scenarios;
- Estimation of exposure point concentrations; and
- Estimation of daily doses.

The following narrative discusses each of the key technical elements in relation to potential human exposure to mercury in the Sudbury River downstream of the Nyanza Site.

4.2 IDENTIFICATION OF POTENTIAL RECEPTORS/EXPOSURE SCENARIOS

This initial step of the exposure assessment includes the description of the current and potential future uses of the Sudbury River that may expose individuals to site-related mercury contamination. A description of the Sudbury River Operable Unit was provided in Subsection 1.3. Additionally, this step of the assessment involves the prediction of the activity patterns of potentially exposed populations, the identification of subpopulations of concern, and the selection of the current and future receptors based on current and potential future use of the Sudbury River. As identified in Section 1, *Introduction*, this risk assessment updates and augments the evaluation of risk posed by the consumption of fish from the Sudbury River based on the collection of additional data in 2003. The human health risk posed by other pathways, namely, the incidental ingestion of mercury in sediment and surface water was addressed in a previous assessment (Weston 1999a). Based on the results of that assessment, exposure to mercury through these pathways does not pose a risk to human health.

4.2.1 Potential Routes of Exposure

The Sudbury River study area consists of the river headwaters at Cedar Swamp; Whitehall Reservoir which drains into the Sudbury River approximately 17 km upstream of the site; and a series of reservoirs, impoundments, flowing reaches, wetlands, and tributaries that comprise the Sudbury River drainage until it joins the Assabet River approximately 40 km downstream from the site (Figure 1-1). The Sudbury River from its source to its confluence with the Assabet River to form the Concord River is designated by the Massachusetts Department of Environmental Protection as a Class B Inland Water (MADEP, 1996).

As such,

> *"these waters are designated as a habitat for fish, other aquatic life and wildlife, and for primary and secondary recreation. Where designated they shall be suitable as a source of public water supply with appropriate treatment. They shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good water quality."*

where 'primary contact recreation' represents

> *"any recreation or other water use in which there is prolonged and intimate contact with the water with a significant risk of ingestion. These include, but are not limited to, wading, swimming, diving, surfing and water skiing."*

and 'secondary contact recreation' represents

> *"any recreation or other water use in which contact with the water is either incidental or accidental. These include but are not limited to fishing, boating, and limited contact incident to shoreline activities."*

A fish advisory has been posted for the Sudbury River since 1986 due to the potential risk associated with unsafe levels of mercury in fish. Nevertheless, as a protected use and considering the possibility that the warnings are not adequate deterrents from catching and consuming fish from the river, a quantitative analysis of the risk due to fish consumption is evaluated.

Potential recreational contact with surface water and sediments, and the use of the Sudbury River as a drinking water source have been evaluated previously; consequently, the fish consumption exposure route is the only route by which human exposure to mercury in the Sudbury River based on current or potential future is evaluated in this risk assessment.

4.2.2 Potential Receptors

Human receptors that have the potential for exposure to mercury in the Sudbury River include those individuals who may be engaged in fishing either at the present time or at some time in the future. Based on existing fisheries data as well as designated uses throughout the River, notwithstanding the consumption advisories, it is assumed that fishing is possible in all reaches of the river with a few exceptions. Reservoirs No.1 and No.2, maintained by the Massachusetts Metropolitan District Commission (MDC) are not open to fishing. Nevertheless, the existence of residential development along the reservoir shorelines, as well as the possibility of trespassing to fish cannot be ruled out. Moreover, observations (i.e., bait containers, lures, fishing line) made during the 2003 fish collection effort indicated that recreational fishing was occurring from the shoreline of the reservoirs.

Prior to its posting, the Sudbury River had been a popular and actively fished waterway. The river is classified as a warm-water fishery by the Massachusetts Department of Environmental Protection (MADEP). The Sudbury River provides sportfishing for a variety of common warm-water game and pan fish including largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*), pickerel (*Esox spp.*), crappie (*Pomoxis spp*.), and sunfish (*Lepomis spp.*) In addition, brown and yellow bullhead, (*Ameiurus spp*.) may also be caught. The Massachusetts Division of Fisheries and Wildlife stock trout in the river for 'catch and release' fishing. The Sudbury River is not suitable to the development and maintenance of a trout fishery due to unfavorable habitat conditions, specifically high water temperatures and low dissolved oxygen (NUS, 1992).

Although a fishing advisory has been posted throughout the river system, indications are that fishing is still ongoing, although it is not known if the fish that are caught are consumed. Much of the fishing that occurs in the Sudbury River can be classified as recreational angling, i.e., fishing that is done for sport or hobby where a portion or all of the catch may be consumed by the angler or by the family and friends of the angler.

An additional classification of fishing is subsistence fishing in which most, if not all, of the individual's dietary protein is derived from fish caught locally. Subsistence fishing is often associated with populations exhibiting strong ethnic and cultural behavior, such as certain Native American populations (e.g., Columbia River Tribes). There currently are no data regarding the likelihood of subsistence fishing on the Sudbury River. In addition, no creel surveys have been conducted to estimate the fishing habits of anglers on the Sudbury River (MDFW, 1997). Suggestions that subsistence fishing may in fact occur on the river appear to be largely anecdotal. Nevertheless, since the possibility of current or future subsistence fishing on the Sudbury River cannot be ruled out entirely, an assessment of the risk to a subsistence fisher, as well as a recreational angler is evaluated.

In addition to the recreational angler and the subsistence fisher, who consume only the edible portion of the fish, a third scenario that involves ethnic populations that may cook and consume the entire fish is evaluated. Because of the possible presence of such an ethnic group using the river for fishing and the cultural differences in fish preparation and consumption, it was prudent to evaluate this scenario.

Because of differing behavioral patterns as well as body weights, children and adolescents often tend to have a greater intake of chemical per unit body weight than an adult, and therefore, might be at higher risk for effects from mercury exposure than adults. For this reason, the risk to dependent children consuming fish from the Sudbury River caught by adult recreational and ethnic anglers is evaluated in addition to the adult recreational and ethnic anglers. Dependent children of the subsistence angler are not evaluated due to a lack of exposure parameter data. Moreover, it seems highly unlikely that children, who have opportunities to consume food outside the home environment, e.g., school, would obtain their entire complement of protein from fish caught in the Sudbury River. A semi-quantitative assessment of the potential effects to this receptor is discussed in the uncertainty analysis.

4.3 CONCEPTUAL SITE MODEL

A conceptual site model describes the chemical sources, release mechanisms, transport and receiving media, exposure media, exposure routes, and potentially exposed populations. One objective of the conceptual site model is to identify complete and incomplete exposure pathways. A complete exposure pathway has all of the above-listed components, whereas an incomplete pathway is missing one or more. Table 4-1 illustrates the potential exposure pathways for the ingestion of fish from the Sudbury River.

4.4 EXPOSURE POINT CONCENTRATIONS

The EPCs calculated in the risk assessment are scenario-specific as follows:

- Recreational Angler – Fillet Data Set
  - adult and child
- Subsistence Angler – Fillet Data Set
  - adult
- Ethnic Angler – Whole Body Data Set
  - adult and child

Note that as the highest concentrations of mercury in fish occur in the axial muscle (i.e., the fillet tissue), the dependent child of a subsistence angler would be expected to represent the theoretical maximum exposure. However, given the demographics of the Sudbury River drainage area, the existence of a child of a "non-ethnic" subsistence angler who consumes fish from the Sudbury River as her sole source of dietary protein is highly unlikely. Therefore, the dependent child of a subsistence angler is not quantitatively evaluated, but discussed in the uncertainty analysis.

Consistent with EPA guidance, the EPCs for the reasonable maximum exposure (RME) and central tendency exposure (CTE) evaluations were calculated for each data set for each river reach based on the 95% upper confidence limit (UCL) of the mean concentration, using the appropriate equation for data distribution recommended by the ProUCL program. If the 95% UCL concentration exceeded the maximum detected concentration for a chemical, or if the 95%

UCL was not able to be calculated by ProUCL, the maximum detected concentration was used as the EPC. The 95% UCL of mercury and methylmercury concentrations for each species were calculated using EPA's ProUCL software as this program allows the user to calculate distribution-specific UCLs, as well as UCLs for data that do not exhibit a specific distribution (EPA, 2004).

The first step in computing a UCL of a population mean is to test for the data distribution. ProUCL tests for normal, lognormal, and gamma distributions (EPA, 2004). There are a number of procedures to test for data distribution:

(1) Graphical test based upon a Q-Q plot.

(2) Lilliefors test (tests for normalilty or lognormality for data sets with samples sizes greater than or equal to 50).

(3) Shapiro-Wilk W test (tests for normalilty or lognormality for data sets with samples sizes less than 50).

(4) Anderson Darling test (tests for gamma distribution).

(5) Kolmogorov-Smirnov test (tests for gamma distribution).

ProUCL recommends that the graphical Q-Q plot test should always be accompanied by other more powerful tests (i.e., Lilliefors, Shapiro-Wilk, Anderson Darling, and Kolmogorov-Smirnov tests). Because the sample sizes are less than 50 for the Reach and species-specific datasets, the Shapiro-Wilk test was run at a 0.05 level of significance in conjunction with the Q-Q plot to test for normality or lognormality. The Anderson Darling and Kolmogorov-Smirnov tests were run to test for gamma distribution at a 0.05 level of significance. Data distributions are presented in Tables 4-2 through 4-25.

ProUCL calculates both parametric (for normal, lognormal, and gamma distributions) and non-parametric UCLs and provides recommendations on which UCL to use depending upon distributional assumptions and the skewness (as represented by the standard deviation of the data). In summary, the UCL calculation methods were selected based on the data characteristics presented below.

Summary of the UCL Calculation Methods

Data Distribution	UCL Method Used
Normal	Student's t statistic
Lognormal[1]	H-statistic 95 percent Chebyshev Minimum Variance Unbiased Estimate (MVUE) 97.5 percent Chebyshev MVUE 99 percent Chebyshev MVUE 95 percent Chebyshev (Mean, Std) 99 percent Chebyshev (Mean, Std)
Gamma[2]	Approximate gamma Adjusted gamma 95 percent based on Bootstrap-t Hall's bootstrap
Either Lognormal and Gamma	Assumed gamma distribution. See UCL calculation methods for gamma distribution.
Either Normal, Lognormal, or Gamma[3]	See UCL methods for normal, lognormal, and gamma distributions.
Non-parametric[4]	95 percent Chebyshev (Mean, Std) 97.5 percent Chebyshev (Mean, Std) 99 percent Chebyshev (Mean, Std) 95 percent Student's t or Modified t-statistic Hall's bootstrap

1 = ProUCL recommends one of six methods based on the skewness and sample size of the data set.
2 = ProUCL recommends one of four methods based on the skewness and sample size of the data set.
3 = When ProUCL indicates that the distribution of a dataset may be either normal, lognormal, or gamma, the distribution and UCL calculation method recommended by ProUCL was used.
4 = ProUCL recommends one of six methods based on the skewness and sample size of the data set.

Although data may exist for several species within a reach, a species-weighted EPC is used to calculate doses and risks for each reach. Weighting is reach-specific and based on the number of species for which there are data, assuming that anglers at the site eat an equal portion of each species collected at that particular reach. For example, if there are three species (largemouth bass, brown bullhead, and yellow perch) within a data set for a reach, the EPC is calculated as follows:

$$\text{EPC for use in dose and risk calculations} = \frac{\text{EPC}_{\text{largemouth bass}} + \text{EPC}_{\text{brown bullhead}} + \text{EPC}_{\text{yellow perch}}}{3}$$

This approach was selected because the study on which the recreational ingestion rates are based (Ebert et al., 1993) developed ingestion rates from a composite of fish species similar to those collected in the Sudbury River, and not for an individual fish species. The uncertainties associated with this approach are discussed in Section 6. A summary of the EPCs used in the risk assessment along with the data distribution and UCL calculation method are presented in Tables 4-2 through 4-25.

4.5 IDENTIFICATION OF EXPOSURE MODELS AND ASSUMPTIONS

The exposure dose is the estimated daily intake rate of a chemical that an individual receives through each exposure pathway (e.g., fish consumption). Average daily doses (ADDs), in which the doses are averaged over the exposure duration, are used to evaluate noncancer health effects. ADDs are expressed as milligrams of chemical intake, in this case mercury, per kilogram of body weight per day (mg/kg-d). In the Risk Characterization section, the ADD for mercury from each pathway is compared with the respective chemical toxicity data to determine the potential health effects.

The calculation of an exposure dose for a chemical involves numerous variables. Several types of information are used to estimate the daily intake of the chemical:

- Predicted levels of a chemical in the environment (i.e., exposure point concentrations) to which an individual is potentially exposed on a daily basis (chemical-related variables).
- Physiological and time variables affecting the rate or amount of chemical intake by the body on a daily basis, such as eating habits (e.g., fish consumption), body weight, and frequency and duration of exposure for a given activity (i.e., variable defining the exposed population).
- The time over which the dose is averaged (assessment-determined variables).

EPA guidance (EPA, 2001a) recommends the evaluation of both the reasonable maximum exposure (RME) and the central tendency exposure (CTE). The RME is the highest exposure that is expected to occur at a site and would be representative of a “high-end” risk (EPA, 1991). According to EPA (EPA, 1992b), “The high-end risk description is a plausible estimate of the individual risk for those persons at the upper end of the risk distribution. The intent of this description is to convey an estimate of risk in the upper range of the distribution, but to avoid estimates which are beyond the true distribution." The RME approach uses exposure assumptions that represent the high end of the exposure parameter distributions to arrive at an upper-bound risk estimate. The CTE is the central tendency (i.e., average) exposure, which uses average exposure assumptions to yield an average risk to the individual (EPA, 1992b).

The algorithms and exposure parameters for each of the receptor classes (recreational, subsistence, and ethnic) are presented in Tables 4-26 through 4-31. The rationale for the selection of each of the exposure parameters is discussed below.

4.5.1.1 Ingestion Rates

Recreational Angler

For the recreational angler, the absence of creel data for the Sudbury River made it necessary to look to other sources for fish ingestion rates. The Maine Angler Survey (Ebert et al., 1993; ChemRisk, 1992) was selected as the most appropriate basis for the fish consumption rate.

Ebert et al. (1993) estimated adult consumption rates of recreationally caught freshwater fish in Maine based on data from a statewide mail survey of licensed resident anglers (n=2,500). Less than 1% of riverine environments in Maine were subject to fish consumption advisories at the time of the survey; therefore, the consumption rates calculated from this study should not be biased low due to reduced angling.

Ebert et al. calculated the consumption rate of fish for each of three consumption patterns for fish caught in various flow regimes:

<u>Consumption Patterns</u>

- All household fish consumers eat an equal share of consumed fish.
- Only adults in the household consume fish.
- Only the angler consumes fish.

Flow Regimes

- River and stream – generally characterized by waters with moderate to fast-flowing waters; shallow to moderate depth
- Lake and pond – generally characterized by waters with little to no flow; depth varies
- All waters – water stretches that incorporate elements of both regimes described above

For this assessment and for each reach of the Sudbury River, it was conservatively assumed that an individual's fish consumption is solely from that reach of the Sudbury River. Adult ingestion rates were based on the assumption that anglers consume all of their catch rather than share it with others. A child consumption rate for sport-caught freshwater fish was not specifically available from the Ebert et al. (1993) paper. Instead, the child ingestion rates were assumed to be equal to that indicated by "all household consumers share."

Since the characteristics of the individual reaches of the Sudbury River vary, each reach was classified according to the flow regime that best characterized it:

- Reach 1 – River and Stream (flowing)
- Reach 2 – All Waters
- Reach 3 – Lake and Pond (standing)
- Reach 4 – Lake and Pond (standing)
- Reach 5 – River and Stream (flowing)
- Reach 6 – Lake and Pond (standing)
- Reach 7 – River and Stream (flowing)
- Reach 7 – Heard Pond – Lake and Pond (standing)
- Reach 8 – River and Stream (flowing)
- Reach 9 – All Waters
- Reach 10 – River and Stream (flowing)
- Charles River – River and Stream (flowing)
- Sudbury Reservoir – Lake and Pond (standing)

For each flow regime, adult and child ingestion rates were selected using the aforementioned criteria, using the 90^{th} percentile value for the RME scenarios and the mean value for the CTE scenarios as follows:

Receptor/Flow Regime	RME Ingestion Rate (g/day)	CTE Ingestion Rate (g/day)
Adult		
All Waters	32	15
Rivers and Streams (flowing)	14	8.9
Lakes and Ponds (standing)	18	6.1
Child		
All Waters	13	6.4
Rivers and Streams (flowing)	6.1	3.7
Lakes and Ponds (standing)	6.9	2.7

Subsistence Angler

Fish consumption rates for subsistence populations are limited. Much of the subsistence fishing data are derived from studies of Native American populations of the Pacific Northwest. No data specific to subsistence fishing in the northeast U.S. were found. In the absence of more site-specific data, the consumption rates used in the assessment of subsistence fishing on the Sudbury River were taken from the EPA recommend values for subsistence fishers.

For the RME, EPA recommends a subsistence fishing ingestion rate of 142.4 g/day based on the 99^{th} percentile value for freshwater and estuarine ingestion for adults, as derived from the U.S. Department of Agriculture's *Continuing Survey of Food Intakes by Individuals* (CSFII) for the years 1994 to 1996. This value is used in the *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* (EPA, 2000). This value is more recent than the 170 g/day value used in the previous risk assessment, which was based on studies of Native American and low-income subsistence fishing populations (Wolfe and Walker, 1987; CRITFIC, 1994) as presented in EPA's *Exposure Factors Handbook* (1997). No updated CTE value has been recommended; therefore, the subsistence fish ingestion rate for the CTE scenarios of 70 g/day (representing the 50^{th} percentile of the dataset) is used (EPA, 1997).

As discussed earlier in this section, although the dependent child of a subsistence angler would be expected to represent the theoretical maximum exposure, it is not quantitatively evaluated herein because the existence of a child of a subsistence angler who consumes fish from the

Sudbury River as her sole source of dietary protein is highly unlikely. The potential risks to the dependent child of a subsistence angler are presented in the uncertainty analysis.

Ethnic Angler

For the ethnic angler scenario, the consumption rate of the subsistence fisher is used with the only modification being the use of the whole body fish tissue data to derive the exposure point concentration. Therefore, the adult consumption rate is 170 g/day and 70 g/day for the RME and CTE exposures, respectively. A dependent child of a subsistence angler was not evaluated and EPA has not recommended ingestion rates for a child of a subsistence angler from which to adopt ingestion rates for the dependent child of an ethnic angler.

Examining the ingestion rates used for the recreational angler scenario (Ebert et al., 1993; Tables 4-26 and 4-27), it is observed that the child ingestion rates were approximately 40% of that of the adult. Assuming that the ratio of a child to adult ingestion rate would be the same between the ethnic and recreational angler scenarios, a 40% value was applied to the ethnic angler adult ingestion rates of 142.4 and 70 g/day (for RME and CTE, respectively); to yield RME and CTE ingestion rates for the child of the ethnic angler of 57 and 28 g/day, respectively. As with the dependent child of the subsistence angler, it seems unlikely that children, who have opportunities to consume food outside the home environment (e.g., school), would obtain their entire complement of protein from fish caught in the Sudbury River. However, because of potential socio-economic factors associated with the ethnic angler, it was assumed the dependent child of an ethnic angler was assumed a more likely receptor than a dependent child of a subsistence angler and was quantitatively evaluated herein.

4.5.1.2 Fraction Ingested

The FI represents the fraction of fish consumed that is obtained from the contaminated source. In the absence of other areas available for recreational fishing, the contaminated water body is generally assumed to be the source of 100 percent of the recreationally obtained fish which equates to an FI of 1. When other fishable waters are available from which to catch fish, the FI is generally less than 1.

The Sudbury River watershed is completely within Middlesex County in Massachusetts. The Sudbury River joins the Assabet and the Concord Rivers to form the SuAsCo watershed that is tributary to the Merrimac River in Middlesex County. Although the Sudbury River provides an outstanding resource for recreational fishing, it, nevertheless, competes for angling with numerous other freshwater streams, rivers, ponds and lakes in the County and surroundings. Within Middlesex County, there are several thousand acres of fishable waters. Moreover, the proximity to the Atlantic coast provides the recreational angler with the opportunity to catch and consume a variety of saltwater fish species through surf- and boat-fishing. In addition, fishing is prohibited in Reservoirs #1 and #2 which are the two large lacustrine waterbodies on the Sudbury River evaluated in this study. These reservoirs are owned and operated by the Massachusetts Water Resources Authority (MWRA) as emergency water supply for the city of Boston. Although some illegal fishing in these reservoirs has been observed, lake fishing, for the large part, is done elsewhere. For these reasons, it is unlikely that all fish caught and consumed by an angler over a duration of several years would come exclusively from the Sudbury River.

In addition, according to Ebert et al., 1993, 80% of anglers fish at least 2 bodies of water. Based on this data and the availability of other fishing locations in the area, an estimated fraction ingested (FI) from the Sudbury River is assumed to be 0.5 for all scenarios.

4.5.1.3 Exposure Frequency

An EF of 350 days/year was used for all receptors in both the RME and CTE scenarios (EPA, 2001b).

4.5.1.4 Exposure Duration

The total dose of a chemical an individual receives depends on the duration of exposure. Consequently, the ages of the receptor populations (i.e., child, adult) selected for evaluation are important. In this risk assessment, the following ages and durations of exposure are evaluated.

- RME Scenarios
  - Adult angler (recreational, subsistence, and ethnic) – 30 years (EPA, 2001b)
  - Dependent child of angler (recreational and ethnic) – 6 years (ages 1 to 6)
- CTE Scenarios
  - Adult angler (recreational, subsistence, and ethnic) – 9 years (EPA, 2001b)

- Dependent child of angler (recreational and ethnic) – 2 years (EPA, 2001b)

Note that in the calculation of the ADD, the exposure duration is essentially "cancelled out" by dividing by the averaging time (i.e., exposure duration times 365 days/ year), consequently, the noncancer dose of mercury is not affected by changes in the exposure duration. Therefore, the 30-year duration is protective of sensitive subpopulations (e.g., pregnant women) and receptors exposed during shorter time frames than what were used in this assessment.

4.5.1.5 Body Weight

Daily chemical doses (i.e., exposures) are expressed as the daily dose of the chemical relative to body weight (i.e., mg Hg/kg BW- day). This is done to ensure uniformity in characterizing the chemical exposure in individuals with differing body weights. For each scenario, average body weights of 70 kg and 15 kg were used for the adult and the 1- to 6-year-old child, respectively (EPA, 1989).

4.5.1.6 Averaging Time

For noncancer hazards, the averaging time is based on the exposure duration (ED * 365 days/year). For the RME scenarios, this equates to an averaging time of 10,950 and 2,190 days for the adult and child, respectively. For the CTE scenarios, this equates to an averaging time of 3,285 and 730 days for the adult and child, respectively.

4.5.2 Average Daily Dose Presentation

The estimated exposure doses are presented for consumption of recreationally caught fish from the Sudbury River by an adult and dependent child in Tables 4-32 through 4-35. Estimated exposure doses of mercury to adult subsistence anglers are presented in Tables 4-36 and 4-37 and to adult and dependent children of ethnic fisherman are presented in 4-38 through 4-41.

5. RISK CHARACTERIZATION

5.1 INTRODUCTION

The risk characterization for this HHRA evaluates the likelihood of adverse health effects occurring from exposure to mercury in fish caught and consumed from the Sudbury River. The risk characterization integrates the dose-response data for mercury presented in the toxicity assessment (Section 3) with the estimated daily dose developed in the exposure assessment (Section 4) to estimate the risk. As previously noted, only fish consumption was evaluated in this HHRA.

The general approach used to characterize the potential for health effects from mercury exposure is presented in the following subsection (Subsection 5.2).

5.2 POTENTIAL FOR MERCURY-RELATED HEALTH EFFECTS

The potential for noncancer health effects was evaluated by the calculation of hazard quotients (HQs). For this assessment, the HQ is the ratio of the estimated average daily dose (ADD) of mercury through the consumption of fish and the chronic, oral RfD for mercury. The relationship is illustrated by the following equation:

$$HQ = ADD_{Hg}/RfD_{oral}$$

Where:

HQ = Hazard quotient.

ADD = Average daily dose; estimated daily intake averaged over the exposure period (mg/kg-day).

RfD_{oral} = Chronic Oral Reference dose (mg/kg-day).

The risk of mercury exposure through the consumption of fish from the Sudbury River was evaluated for three exposure scenarios:

1. Recreational angler (both adult and child) (Tables 5-1 through 5-4)

2. Subsistence angler (adult) (Tables 5-5 and 5-6)

3. Ethnic angler (both adult and child) (Tables 5-7 through 5-10).

For each scenario, the risk was calculated for both the reasonable maximum exposure (RME) and the central tendency exposure (CTE). For both the RME and CTE, with each of their attendant exposure parameters and assumptions, exposure to mercury in fish and the consequent risk was greatest for the child of the ethnic angler. For the other angler scenarios evaluated, the order of greatest to smallest risk was the subsistence angler > ethnic angler adult receptor > recreational angler child receptor > recreational angler adult receptor. For all scenarios, the risks based on CTE assumptions were approximately one-half that of the RME. Tables 5-11 and 5-12 summarize the HQs by reach for the RME and CTE conditions, respectively. The risk, as expressed by the HQ, associated with mercury exposure through fish consumption for all of the exposure scenarios is discussed for each reach in the subsections below.

5.2.1 Site Impacted Reaches

5.2.1.1 Reach 2 (Pleasant Street Impoundment to Union Street Bridge)

For assumptions made for the RME, the exposure to mercury levels in fish caught and consumed from Reach 2 (the Pleasant Street Impoundment to Union Street Bridge) represents a potential risk to individuals for all fish consumption scenarios evaluated. The highest RME exposure and consequent risk was posed to the subsistence angler whose average daily dose was approximately 8-times higher than the oral reference dose for methylmercury (HQ 8.1). In addition to the subsistence angler, the child of the ethnic angler (HQ 7.5), the adult ethnic angler (HQ 4.0), and the child of the recreational angler (HQ 3.5) would be expected to be exposed to mercury at levels ranging from approximately 4- to 7-fold above the reference dose. By contrast, the lowest exposure was posed to the adult recreational angler whose daily dose was about twice the reference dose (HQ 1.8).

Under assumptions of central tendency (CTE), mercury exposure presented a potential risk to individuals eating fish from Reach 2 for the subsistence angler, the child of the ethnic angler, the adult ethnic angler, and the child of the recreational angler. The subsistence angler received the highest exposure to mercury through fish consumption with a daily dose 4-times the reference dose for methylmercury (HQ 4). The child of the ethnic angler would be expected to receive a daily dose of mercury approximately 4-fold above the reference dose (HQ 3.7). Under the CTE assumptions, the adult ethnic angler and the child of the recreational angler would be expected to receive a daily dose of mercury approximately 2-fold above the reference dose (HQ 2.0 and 1.7, respectively). The estimated mercury dose to the adult recreational angler receptor was below the reference dose and therefore the HQ did not exceed 1 (i.e., unity). Under assumptions of central tendency, fish consumption is not expected to pose a human health risk to the adult recreational angler.

5.2.1.2 Reach 3 (Reservoir No. 2)

For assumptions made for the RME, the exposure to mercury levels in fish caught and consumed from Reach 3 (Reservoir No. 2) represents a potential risk to individuals for all fish consumption scenarios evaluated. The highest RME exposure and consequent risk was posed to the child of the ethnic angler whose average daily dose was approximately 15-times higher than the oral reference dose for methylmercury (HQ 15). In addition to the child of the ethnic angler, exposure to mercury for the subsistence angler (HQ 9.1), adult ethnic angler (HQ 8.0), and the child of the recreational angler (HQ 2.1) would be expected to pose a human health risk. The lowest exposure was posed to the adult recreational angler whose daily dose was marginally above the reference dose (HQ 1.2).

Under assumptions of central tendency (CTE), mercury exposure to the child of the ethnic angler, the subsistence angler, and the adult ethnic angler presented a potential risk to individuals eating fish from Reservoir No. 2. As expected, a child of the ethnic angler received the highest exposure to mercury through fish consumption with a daily dose 7 times the reference dose for methylmercury (HQ 7.4). Under the CTE assumptions, the subsistence and adult ethnic angler receptors would be expected to receive a daily dose of mercury approximately 4-fold above the reference dose (HQ 4.5 and 3.9, respectively). The estimated mercury doses to adult and child recreational angler receptor were below the reference dose (i.e., HQ <1). Under assumptions of central tendency, fish consumption from this reach does not pose a human health risk to the adult and child recreational anglers.

5.2.1.3 Reach 4 (Reservoir No. 1)

For assumptions made for the RME, the exposure to mercury levels in fish caught and consumed from Reach 4 (Reservoir No. 1) represents a potential risk to individuals in all scenarios evaluated except for the adult recreational angler scenario. The highest RME exposure and consequent risk was posed to the child of the ethnic angler whose average daily dose was approximately 9-times higher than the oral reference dose for methylmercury (HQ 8.9). Consumption of fish from Reservoir 1 by the subsistence angler is expected to result in a methylmercury dose almost 6-times higher than the oral reference dose (HQ 5.6) and the adult ethnic angler would be expected to receive a daily dose of mercury approximately 5-fold above the reference dose (HQ 4.8). The estimated mercury dose to the adult recreational angler receptor and the child of this angler was either marginally above the reference dose (child HQ – 1.3) or was below the reference dose. Under assumptions for the RME, the consumption of fish from Reservoir 1 is not expected to pose a health risk to adult recreational anglers.

Under assumptions of central tendency (CTE), only mercury exposure to a child of the ethnic angler, the adult ethnic angler, and the subsistence angler, present a potential risk to individuals eating fish from Reservoir No. 1. As expected, a child of the ethnic angler received the highest exposure to mercury through fish consumption with a daily dose 4 times the reference dose for methylmercury (HQ 4.4). Under the CTE assumptions, the subsistence angler would be expected to receive a daily dose of mercury approximately 3 times the reference dose for methylmercury (HQ 2.8) and the adult ethnic angler would be expected to receive a daily dose of mercury approximately 2-fold above the reference dose (HQ 2.4). The estimated mercury doses to adult and child recreational angler receptor were below the reference dose and therefore the HQ did not exceed 1 (i.e., unity). Under assumptions of central tendency, fish consumption by these individuals is not expected to pose a human health risk.

5.2.1.4 Reach 5 (Reservoir No. 1 Dam to the Massachusetts Turnpike)

For assumptions made for reasonable maximum exposure (RME), mercury exposure to the child of the ethnic angler, the subsistence angler, and the adult ethnic angler presented a potential risk to individuals eating fish caught from Reach 5 (the Sudbury River between the Reservoir No. 1 Dam at Winter Street and the Massachusetts Turnpike, Route 90). The highest RME exposure and consequent risk was posed to the child of the ethnic angler whose average daily dose was approximately 7-times higher than the oral reference dose for methylmercury (HQ 7.2). In addition, the subsistence and adult ethnic angler receptors had average daily doses approximately 4-times higher than the oral reference dose (HQ of 4.5 and 3.9, respectively). The estimated mercury doses to the adult and child recreational angler receptors were below the reference dose (HQ <1), and therefore, consumption of fish from Reach 5 by recreational anglers is not expected to pose a human health risk.

Under assumptions of CTE, mercury exposure to the child of the ethnic angler, the subsistence angler, and the adult ethnic angler presented a potential risk to individuals eating fish from Reach 5. As expected, a child of the ethnic angler received the highest exposure to mercury through fish consumption with a daily dose 3.5 times the reference dose for methylmercury (HQ 3.5). Under the CTE assumptions, the subsistence and adult ethnic angler receptors would be expected to receive a daily dose of mercury approximately 2-fold above the reference dose (HQ of 2.2 and 1.9, respectively). The estimated mercury doses to adult and child recreational angler receptors were below the reference dose (HQ < 1). Consumption of fish from Reach 5 by recreational anglers is not expected to pose a human health risk.

5.2.1.5 Reach 6 (Massachusetts Turnpike to Saxonville Dam)

For assumptions made for the RME, the exposure to mercury levels in fish caught and consumed from the Reach 6 (Massachusetts Turnpike to Saxonville Dam) represents a potential risk to individuals in all scenarios evaluated except for the adult recreational angler scenario. The highest RME exposure and consequent risk was posed to the child of the ethnic angler whose average daily dose was approximately 9-times higher than the oral reference dose for methylmercury (HQ 9.3). Consumption of fish from Reach 6 by the subsistence and adult ethnic angler is expected to result in methylmercury doses of 5-6 times higher than the oral reference dose (HQ of 5.9 and 5.0, respectively). The estimated mercury dose to the adult recreational angler receptor and the child of this angler was either marginally above the reference dose (child HQ – 1.3) or was below the reference dose and therefore the HQ did not exceed 1 (i.e., unity). Under assumptions for the RME, the consumption of fish from Reach 6 is not expected to pose a health risk to adult recreational anglers.

Under assumptions of central tendency (CTE), mercury exposure to the child of the ethnic angler, the subsistence angler, and the adult ethnic angler presented a potential risk to individuals eating fish from Reach 6. As expected, the child of the ethnic angler received the highest exposure to mercury through fish consumption with a daily dose 4.5 times the reference dose for methylmercury (HQ 4.5). Under the CTE assumptions, the subsistence and adult ethnic angler receptors would be expected to receive a daily dose of mercury approximately 2-3 times higher above the reference dose (HQ of 2.9 and 2.4, respectively). The estimated mercury doses to adult and child recreational angler receptor were below the reference dose (HQ < 1) and therefore consumption of fish is not expected to pose a risk to either the child or adult recreational angler.

5.2.1.6 Reach 7 (Saxonville Dam to the Route 20 Overpass in Wayland)

For assumptions made for the RME, mercury exposure to the child of the ethnic angler, the subsistence angler, and the adult ethnic angler presented a potential risk to individuals eating fish from Reach 7 (the Saxonville Dam to the Route 20 overpass in Wayland). The highest RME exposure and consequent risk was posed to the child of the ethnic angler whose average daily dose was approximately 8-times higher than the oral reference dose for methylmercury (HQ 8.3). In addition, the subsistence and adult ethnic angler receptors had an average daily dose of mercury approximately 5 times higher than the oral reference dose (HQ of 4.9 and 4.5, respectively). The estimated mercury doses to the adult and child recreational angler receptors were at or below the reference dose (HQ ≤ 1) and therefore, consumption of fish from Reach 7 by recreational anglers is not expected to pose a human health risk.

Under assumptions of CTE, mercury exposure to the child of the ethnic angler, the subsistence angler, and the adult ethnic angler presented a potential risk to individuals eating fish from Reach 7. As expected, the child of the ethnic angler received the highest exposure to mercury through fish consumption with a daily dose 4 times the reference dose for methylmercury (HQ 4.1). Under the CTE assumptions, the subsistence and adult ethnic angler receptors would be expected to receive a daily dose of mercury approximately 2-fold above the reference dose (HQ of 2.4 and 2.2, respectively). The estimated mercury doses to adult and child recreational angler receptors were below the reference dose and therefore the HQ did not exceed 1 (i.e., unity).

Heard Pond

For assumptions made for the RME, mercury exposure to the child of the ethnic angler, and the subsistence angler presented a potential risk to individuals eating fish from Heard Pond. The highest RME exposure and consequent risk was posed to the child of the ethnic angler whose average daily dose was approximately 2-times higher than the oral reference dose for methylmercury (HQ 1.8). In addition, the subsistence angler receptor had an average daily dose of mercury approximately 1.2 times higher than the oral reference dose (HQ of 1.2). The estimated mercury doses to the adult and child recreational angler and adult ethnic angler receptors were at or below the reference dose (HQ ≤ 1) and therefore, consumption of fish from Heard Pond by recreational anglers is not expected to pose a human health risk.

Under assumptions of CTE, mercury exposure to all of the receptors were below the reference dose and therefore the HQs did not exceed 1 (i.e., unity).

5.2.1.7 Reach 8 (Great Meadows National Wildlife Refuge, Route 20 Overpass to the Route 117 Overpass)

For assumptions made for reasonable maximum exposure (RME), the exposure to mercury levels in fish caught and consumed from Reach 8 (the Sudbury River in the Great Meadows National Wildlife Refuge) represents a potential risk to individuals in all scenarios evaluated except for the adult recreational angler scenario. The highest RME exposure and consequent risk was posed to the child of the ethnic angler whose average daily dose was approximately 9-fold above the oral reference dose for methylmercury (HQ 8.6). Consumption of fish from GMNWR by the subsistence and adult ethnic angler receptors resulted in methylmercury exposure that was approximately 5-7 times above the reference dose (HQ of 6.7 and 4.6, respectively). The estimated mercury dose to the adult recreational angler receptor was below the reference dose (HQ < 1) and therefore, the consumption of fish caught in the GMNWR is not expected to pose a risk to adult recreational anglers. Estimated mercury exposure to the child recreational angler consuming fish from GMNWR was marginally above the oral reference dose for methylmercury (HQ 1.3).

Under assumptions of central tendency (CTE), mercury exposure to the child of the ethnic angler, subsistence angler, and adult ethnic angler presented a potential risk to individuals eating fish from GMNWR. As expected, the child of the ethnic angler received the highest exposure to mercury through fish consumption with a daily dose approximately 4 times the reference dose for methylmercury (HQ 4.2). Under the CTE assumptions, the subsistence and adult ethnic angler receptors would be expected to receive a daily dose of mercury approximately 2-3 times above the reference dose (HQ of 3.3 and 2.3, respectively). The estimated mercury doses to adult and child recreational angler receptor were below the reference dose (HQ <1) and therefore, assumptions of central tendency, consumption of fish from GMNWR is not expected to pose a risk to either the child or adult recreational angler.

5.2.1.8 Reach 9 (Fairhaven Bay)

For assumptions made regarding the consumption of fish for RME, the exposure to mercury levels in fish caught and consumed from Reach 9 (Fairhaven Bay) represents a potential risk to individuals for all fish consumption scenarios evaluated. The highest RME exposure and consequent risk was posed to the child of the ethnic angler whose average daily dose was approximately 10-times higher than the oral reference dose for methylmercury (HQ 10.1). Estimated mercury exposure to subsistence, and adult ethnic anglers, and children of recreational anglers consuming fish from Fairhaven Bay resulted in doses approximately 3-7 times higher than the oral reference dose (HQ of 6.7, 5.4, and 2.8, respectively). The lowest exposure was posed to the adult recreational angler whose daily dose was marginally above the reference dose (HQ 1.5).

Under assumptions of CTE, mercury exposure presented a potential risk to individuals eating fish from Fairhaven Bay to the child of the ethnic angler, subsistence angler, adult ethnic angler, and child of the recreational angler. As expected, the child of the ethnic angler received the highest exposure to mercury through fish consumption with a daily dose approximately 5-times the reference dose for methylmercury (HQ 5.0). Under the CTE assumptions, the subsistence and adult ethnic angler would be expected to receive a daily dose of mercury approximately 3-fold above the reference dose (HQ 3.3 and 2.7, respectively). The dose resulting from fish consumption for the child of the recreational angler was marginally above the reference dose (HQ 1.4). The estimated mercury dose to the adult recreational angler receptor was below the reference dose and therefore using assumptions of central tendency, consumption of fish from Fairhaven Bay is not expected to pose a health risk to adult recreation anglers.

5.2.1.9 Reach 10 (Fairhaven Bay to Sudbury/Assabet River Confluence)

For assumptions made for the RME, the exposure to mercury levels in fish caught and consumed from Reach 10 (the Fairhaven Bay to the Sudbury/Assabet River Confluence) represents a potential risk to individuals for all scenarios evaluated except for the adult recreational angler scenario. The highest RME exposure and consequent risk was posed to the child of the ethnic angler whose average daily dose was approximately 11-times higher than the oral reference dose for methylmercury (HQ 11.4). The estimated mercury doses to subsistence and adult ethnic anglers catching and consuming fish from this reach in the river were 7- and 6-fold higher than the oral reference dose for methylmercury (HQ of 7.0 and 6.1, respectively). The dose resulting from fish consumption for the child of the recreational angler was marginally above the reference dose (HQ 1.4). The estimated mercury dose to the adult recreational angler receptor was below the reference dose.

Under assumptions of CTE, mercury exposure to the child of the ethnic angler, subsistence angler, and adult ethnic angler presented a potential risk to individuals eating fish from Reach 10. As expected, the child of the ethnic angler received the highest exposure to mercury through fish consumption with a daily dose approximately 6 times the reference dose for methylmercury (HQ 5.6). Under the CTE assumptions, the subsistence and adult ethnic angler receptors would be expected to receive a daily dose of mercury approximately 3-fold above the reference dose (HQ of 3.4 and 3.0, respectively). The estimated mercury doses to adult and child recreational angler receptors were below the reference dose (HQ < 1). Under assumptions of central tendency, consumption of fish is not expected to pose a risk to either the child or adult recreational angler.

5.2.2 Reference Areas

5.2.2.1 Reach 1 (Sudbury River Headwaters to the Pleasant Street Impoundment)

For assumptions made for the RME, mercury exposure to the child of the ethnic angler, subsistence angler, and adult ethnic angler presented a potential risk to individuals eating fish from Reach 1 (the headwaters of the Sudbury River to the Pleasant Street Impoundment). The highest RME exposure and consequent risk was posed to the child of the ethnic angler whose average daily dose was approximately 5-times higher than the oral reference dose for methylmercury (HQ 5.2). In addition a potential risk to mercury exposure was determined for the subsistence angler and adult ethnic angler, with estimated average daily doses of mercury approximately 3-5 times higher than the oral reference dose (HQ of 5.0 and 2.8, respectively). The estimated mercury doses to the adult and child recreational angler receptors were below the reference dose.

Under assumptions of CTE, mercury exposure to the child of an ethnic angler, subsistence angler and adult ethnic angler presented a potential risk to individuals eating fish from Reach 1. As expected, the child of an ethnic angler received the highest exposure to mercury through fish consumption with a daily dose of approximately 3 times the reference dose for methylmercury (HQ 2.6). Under the CTE assumptions, the subsistence would be expected to receive a daily dose of mercury 2.5-fold above the reference dose (HQ 2.5). The dose resulting from fish consumption for the adult ethnic angler was marginally above the reference dose (HQ 1.4). The estimated mercury doses to adult and child recreational angler receptors were below the reference dose and therefore the HQ did not exceed 1 (i.e., unity).

5.2.2.2 Charles River

For assumptions made for the RME, mercury exposure to the child of an ethnic angler, subsistence angler, and adult ethnic angler presented a potential risk to individuals eating fish from the Charles River reference area. The highest RME exposure and consequent risk was posed to the child of the ethnic angler whose average daily dose was approximately 6-times higher than the oral reference dose for methylmercury (HQ 5.7). The other receptors that presented risk, the subsistence and adult ethnic angler, had average daily doses approximately 3-times higher than the oral reference dose (HQ of 3.4 and 3.1, respectively). The estimated mercury doses to the adult and child recreational angler receptors were below the reference dose (HQ <1). Consequently, consumption of fish by recreational anglers does not pose a health risk.

For the CTE, mercury exposure to the child of the ethnic angler, subsistence angler, and adult ethnic angler presented a potential risk to individuals eating fish from the Charles River. As expected, the child of the ethnic angler received the highest exposure to mercury through fish consumption with a daily dose approximately 3 times the reference dose for methylmercury (HQ 2.8). Under the CTE assumptions, the subsistence and adult ethnic angler would be expected to receive a daily dose of mercury approximately 2 fold above the reference dose (HQ of 1.7 and 1.5, respectively). The estimated mercury doses to adult and child recreational angler receptors were below the reference dose (HQ < 1) and consequently, consumption of fish by recreational anglers does not pose a health risk.

5.2.2.3 Sudbury Reservoir

For assumptions made for the RME, mercury exposure to the child of the ethnic angler, subsistence angler, and adult ethnic angler presented a potential risk to individuals eating fish from the Sudbury Reservoir reference area. The highest RME exposure and consequent risk was posed to the child of the ethnic angler whose average daily dose was approximately 4-times higher than the oral reference dose for methylmercury (HQ 4). In addition, a potential risk was determined for the subsistence and adult ethnic angler, who had average daily doses of mercury that were approximately twice the oral reference dose (HQ 2.1, respectively). The estimated mercury doses to the adult and child recreational angler receptors were below the reference dose. Consequently, neither of these individuals obtains a dose at a level sufficiently high to pose a health risk.

Under assumptions of CTE, only mercury exposure to the child of the ethnic angler and the subsistence angler presented a potential risk to individuals eating fish from Sudbury Reservoir. The child of the ethnic angler received the highest exposure to mercury through fish consumption with a daily dose of approximately 2 times higher than the reference dose for methylmercury (HQ 1.9). The dose resulting from fish consumption for the subsistence angler was marginally above the reference dose (HQ 1.2). The estimated mercury doses to adult and child recreational angler and adult ethnic angler receptors were at or below the reference dose. Consumption of fish from the Sudbury Reservoir is not expected to pose a health risk to these individuals.

5.3 ADDITIONAL ANALYSES

To further elucidate the potential for health effects in the site-impacted reaches, two exercises were completed: 1) a comparison of individual fish concentrations to a risk-based Hg concentration; and 2) the comparison of site-impacted fish concentrations with reference fish concentrations. Both are discussed below.

5.3.1 Comparisons of Individual Fish Concentrations with Risk-based Hg Concentration

In evaluating the human health risk associated with fish consumption, an exposure point concentration based on aggregated yellow perch, largemouth bass, and bullhead fillet or whole body tissue was used to describe the representative exposure to individuals in each of the scenarios evaluated. To develop information on the actual mercury levels in fish collected more fully, the percentage of fish collected in which the mercury levels exceeded the health effect threshold concentration for the recreational angler was evaluated. The adult recreational angler was selected for this evaluation as it is this consumptive use that dominates the fishery of the Sudbury River. Individual RBCs for mercury were calculated based on the scenario- and reach-specific exposure parameter values used in this HHRA (see Table 4-26). The RBCs were based on a target hazard quotient of 1, i.e., where the average daily dose of the angler and the oral reference dose are equal. The individual RBCs were calculated using the following equation:

$$C_{fish} = \frac{THQ \times RfD_o \times BW \times AT}{IR - F \times FI \times CF \times EF \times ED}$$

Table 5-13 presents the comparisons of individual fillet concentrations by species to the scenario-specific RBCs for the recreational angler.

Note that some of the RBCs presented herein are higher than the 0.5 mg Hg/kg used by the state's Department of Public Health for issuing fish mercury consumption advisories (MADPH, 2006). These differences are the result of the calculated RBCs being based on site-specific assumptions (e.g., that 50% of the fish consumed originate from the Sudbury) and that the MADPH value incorporates general assumptions. The RBCs, or target EPCs, calculated herein are Sudbury River reach-specific and applicable only to concentrations in fish in the Sudbury River.

Based on the evaluation conducted above, with the exception of Reach 3 (Reservoir 2), none of the bullheads collected from the Sudbury River contained mercury at levels that would pose a health risk to adult recreational anglers. In Reach 3, one-half of the bullheads collected had mercury levels in axial muscle (fillet) that would pose a human health risk to recreational anglers. Note also, that of the bullhead collected in the reference areas (i.e., Sudbury River Reach 1, Charles River, or Sudbury Reservoir), none of the fish fillet samples contained mercury above the target RBC.

For largemouth bass, none of the individual fillet samples collected from Reach 5 (Reservoir 2 to Saxonville Reservoir), Reach 7 (Saxonville Dam to GM NWR), or Reach 7 – Heard Pond had mercury levels that exceeded the target RBC for the recreational angler. Fillet from all bass collected from Reach 9 (Fairhaven Bay) exceeded the target RBC and more than 70% of bass collected from Reach 2 (Mill Pond to the Union Street Bridge) contained mercury levels that exceeded the RBC for the recreational angler. Similar to the bullhead, one-half of the largemouth bass collected from Reach 3 (Reservoir 2) had mercury levels in fillet that would pose a human health risk to recreational anglers. For the remainder of the Sudbury River, 40% or fewer of the collected fish contained levels of mercury that posed a health risk to the recreational angler. Similar to the bullhead, none of the bass fillet samples collected from the reference areas (i.e., Sudbury River Reach 1, Charles River, or Sudbury Reservoir), contained mercury above the target RBC.

For yellow perch, none of the individual fillet samples collected from the Sudbury River from below Reach 3 (Reaches 4, 5, 6, 7, 8, and 10) with the exception of Reach 9 (Fairhaven Bay), had mercury levels sufficient to pose a risk to adult recreational anglers. About one-half of the yellow perch collected for fillet analysis in Reach 9, about 40% collected from Reach 2, and about 20% from Reach 3 exceeded the target RBC for adult recreational anglers. Again, none of the yellow perch collected from the reference areas had mercury levels in fillet tissue that posed a risk to human health.

Based on the analysis conducted above, the greatest risk of exposure to the recreational angler by species appears to be associated with the ingestion of fillet from largemouth bass and yellow perch from Reach 9 (Fairhaven Bay), largemouth bass and to a lesser extent, yellow perch from the reach of the Sudbury including Reach 2 (Mill Pond downstream to the Union Street Bridge), and largemouth bass and bullhead from Reach 3 (Reservoir 2).

5.3.2 Site versus Reference Concentrations

Statistical comparisons of mercury concentrations in fillet and whole body samples collected from potentially affected reaches of the Sudbury River and from appropriate reference areas were made on a species- and tissue-specific basis. Recall that the individual reaches of the Sudbury River were assigned reach-specific reference areas based on similarity of habitat conditions within the stream (Subsection 1.3.2) and statistical comparisons of fish collected from these areas were made accordingly:

- Reach 1 Reference Area – Reaches 2, 5, 7, and 10
- Charles River – Reaches 8 and 9
- Sudbury Reservoir – Reaches 3, 4, 6, and Reach 7 – Heard Pond

The results of the statistical comparisons are presented in Table 5-14.

Insufficient sample numbers were available with which to develop a statistical comparison of mercury concentrations in bullhead fillet and largemouth bass fillet and whole body tissues collected from reference Reach 1 with mercury concentrations in similar tissues in Reaches 2, 5, 7 and 10. For those sufficiently sized data sets for which comparisons could be made, the mercury concentrations in whole body bullhead, yellow perch fillet and whole body tissues collected from Reaches 5 and 7 were not statistically different from the mercury concentrations in these species and tissues collected from Reach 1. Mercury concentrations in yellow perch whole body tissue collected from Reach 2 and bullhead whole body tissue collected from Reach 10 were also not statistically different from the mercury levels in these species and tissues from Reach 1.

Comparing reaches associated with the Charles River reference location, both fillet and whole body bullhead concentrations were not statistically different from those found in the similar samples collected from Reaches 8 and 9. However, mercury concentrations in the fillet and whole body samples of largemouth bass and yellow perch from Reaches 8 and 9 were statistically greater than similar samples collected from the Charles River.

Comparing reaches associated with the Sudbury Reservoir reference location, both fillet and whole body bullhead concentrations were not statistically different from those found in the similar samples collected from Reach 4. However, mercury concentrations in the fillet and whole body samples of largemouth bass and yellow perch from Reach 4 were statistically greater than similar samples collected from the Sudbury Reservoir. For Reaches 3 and 6, the mercury concentrations in all tissue types and species were statistically greater than those found in similar samples collected from the Sudbury Reservoir. Mercury concentrations in bullhead whole body tissue collected from Reach 7 – Heard Pond were not statistically different from the mercury levels in this species and tissue from the Sudbury Reservoir. However, mercury concentrations in the fillet and whole body samples of largemouth bass and yellow perch, as well as fillet samples of bullhead from Reach 7 – Heard Pond, were statistically lower than similar samples collected from the Sudbury Reservoir.

This information is considered, along with that presented in the Uncertainty Analysis (Section 6), in the Summary and Conclusions section of this report (Section 7).

In addition to the statistical comparisons of mercury levels in tissues, a comparison was prepared of the risk of mercury exposure from fish caught and consumed from potentially site-affected reaches of the Sudbury River with fish caught and consumed from reference areas. Figures presenting site versus reference HQs are presented in Figures 5-1 through 5-9. In addition, the ratios of site-impacted versus reference area HQs are presented in Table 5-15. From these tables and figures, it can be observed that the differences between the site and reference hazard quotients range from a factor of 0.5 to 3.8. Note that, in general, the only difference in the calculation of risk between the potentially site-impacted reaches and reference areas occurs in the exposure point concentration; therefore, differences in concentrations are, by extension, the differences in the potential risk.

5.4 PRELIMINARY REMEDIATION GOALS (PRGS)

The development of PRGs will be presented in an addendum to this report.

6. UNCERTAINTY ANALYSIS

The results of this assessment are estimates of potential human health risks that are based on a number of assumptions about predicted exposure and toxicity. A principal component of any risk characterization is the identification of the assumptions, limitations and uncertainties associated with the estimates of health effects. The uncertainties incorporated in this risk analysis may have resulted in an increase or decrease in the estimated potential for adverse ecological effects; however, conservative, yet realistic, approaches were used when specific data or information were not available. While this approach to handling uncertainty may somewhat overestimate the risks, only those conservative assumptions compatible with sound scientific evidence or processes were used.

This uncertainty analysis focuses on those issues that are specific to this assessment and, at the same time, have the greatest potential impact on the overall estimation of health effects. Presented below are the principal assumptions/uncertainties in the estimates of health effects for the scenarios evaluated in this assessment.

6.1 RECEPTORS SELECTED

- The suggestion that there may be subsistence fishing on the Sudbury River is unsubstantiated. Discussions with the Massachusetts Division of Fish and Wildlife, as well as a review of available data, could not confirm the existence of any type if subsistence fishing. Nevertheless, to provide an evaluation for this receptor, if any exist, this assessment evaluated the potential for health effects associated with subsistence fishing for an adult.

- The potential for health effects from fish consumption was also evaluated for an ethnic population whose culture has traditions that include consuming whole fish. As with the subsistence fisher, the existence of this population is unsubstantiated. Although not exclusive to individuals of Southeast Asian heritage, the use of the entire fish in meal preparation dominates this culture. Based on the 2000 census for Middlesex County (U.S Census Bureau, 2000), the Asian community is second only to white population in the county, and represents 6.3 % of the populace. Assumptions about the preparation of fish caught, i.e., the use of whole fish, is largely based on information obtained from reports from ethnic populations elsewhere.

- Dependent children of subsistence anglers were not evaluated quantitatively in this risk assessment since it is assumed that the existence of these receptors is unlikely. However; in the unlikely event they do exist, the following analysis is offered. Ingestion rates for this receptor are not available. In this assessment, the ingestion rate of a child of a recreational angler was approximately 40% that of the adult. Assuming this fraction of the adult ingestion rate for the subsistence scenario, and keeping the same values for the other child exposure parameters, the exposure and subsequent risk to a dependent child is approximately twice that of the adult. Therefore, as for the adult subsistence angler, the exposure doses to the child would exceed the reference doses (i.e., HQ > 1.0) in all of the site-impacted reaches and reference areas. Ranges of the HQs are as follows:

  RME: 4.9 – 18.3
  CTE: 2.4 – 9.0

6.2 EXPOSURE AREAS

- Exposure of all receptors to concentrations in fish from Reach 3 and to all receptors except for the adult recreational angler to concentrations in fish from Reach 4 resulted in hazard quotients greater than 1. However, as noted in Section 4.2.2, Reservoirs 1 and 2 are not open for fishing and even though there are signs of illegal fishing occurring on the reservoirs, the ability of a subsistence or ethnic angler to obtain 50% of their protein intake from these limited access areas is unlikely.

- Since the reservoirs (i.e., Reaches 3 and 4) are not likely to be used for water supply in the future, there is the potential that the Massachusetts Department of Conservation and Recreation (MDC) may open these water bodies for recreational activities. Given the number of homes surrounding the reservoirs, assuming the recreational angler obtains 50% of the consumed catch from a reservoir may be an underestimate. A maximum plausible scenario for recreational anglers living on the reservoirs is that they would obtain 100% of their fish for consumption from either of the Reservoirs. Assuming that an adult or child angler would catch and consume their complete complement of fish from one of the reservoirs, the adult and child would be at risk to mercury exposure.

Receptor	**Reach 3 (RME/CTE)**	**Reach 4 (RME/CTE)**
Recreational Angler – Child	4.1/1.6	2.6/1.0
Recreational Angler – Adult	2.3/0.8	1.4/0.5

6.3 EXPOSURE POINT CONCENTRATIONS

- The exposure point concentrations for the consumption of fish are based on total mercury analyzed in the fish tissue. Because toxicity varies with the form of mercury, i.e., organic versus inorganic forms, it is important to know the form of the mercury to which a receptor may be exposed. Studies indicate that the proportion of total mercury in biota that exists as methylmercury tends to increase with trophic level, and that greater than 90% of the mercury contained in the axial muscle (i.e., fillet tissue) of higher order fish, such as largemouth bass, occurs as methylmercury (EPA, 1996a). Based on site-specific data (see Tables 2-2 through 2-4) the average methylmercury in fillet tissue of the 3 species of fish used in this assessment ranged from 89% to 100% of the total mercury present and in whole body tissues was 96%. For this assessment, it was conservatively assumed that all mercury in fish tissue is methylmercury. While this may tend to somewhat overestimate the exposure to methylmercury, it is not expected to have a significant effect on the estimate of the potential for health effects. For example, assuming that inorganic mercury represents 10% of the total mercury, and as the oral RfD for inorganic mercury is one-third that of methylmercury, this would result in about a 3% decrease in the Hazard Quotient, or an HQ of 2.0 would be 1.93.

- Aggregate species EPCs were used instead of a particular species due to the lack of site-specific information on the preferred species that anglers at the site catch and consume. However, some individuals may target particular fish, or eat a combination of fish species different from that which was used to develop the aggregate EPC. Table 6-1 shows the reach- and species-specific to aggregate EPC ratios.

  For fillet data, results indicate that depending upon the reach, bullhead concentrations can be higher or lower than the aggregate EPC by approximately the same factor (ratios of fillet to aggregate = 0.4 - 1.6 across the reaches); largemouth bass fillet concentrations are more likely to be underestimated by use of the aggregate EPC (ratios of fillet to aggregate = 0.8 – 1.9 across the reaches); in contrast, yellow perch fillet concentrations are more likely to be overestimated by the EPC (ratios of fillet to aggregate = 0.5 – 1.1 across the reaches). If the maximum fillet concentration (1.83 mg/kg from a largemouth bass from Reach 9) was used to estimate health hazards under the RME scenario, the HQs would range from 3.6 to 7.6 for the child of the recreational angler, 1.8 to 4.0 for the adult recreational angler, and 18 for the subsistence angler.

  For the whole body data, results indicate that, depending upon the reach, the bluegill, white sucker, and yellow perch concentrations are more likely to be <u>overestimated</u> by use of the aggregate EPC (ratios of whole body to aggregate = 0.4 to 0.8 across the reaches); bullhead concentrations can be higher or lower than the aggregate EPC by approximately the same factor (ratios of whole body to aggregate = 0.4 – 1.8 across the reaches); and largemouth bass concentrations are more likely to be underestimated by the aggregate EPC than overestimated (ratios of whole body to aggregate = 0.9 to 2.4 across the reaches). If the maximum whole body concentration (1.28 mg/kg from a largemouth bass from Reach 9) was used to estimate health hazards under the RME scenario, the HQs would be 23 for the child of the ethnic angler and 12 for the adult ethnic angler.

- Uncertainty associated with the estimate of exposure to the ethnic angler receptors is introduced by the use of fillet data to approximate the concentrations in whole body fish when corresponding offal data were not available with which to reconstruct whole body concentrations. As noted above, the fillet concentrations for the largemouth bass, yellow perch and bullhead can be greater than those for whole body. Therefore; the use of these data is conservative and likely to overestimate the potential for adverse health effects to the ethnic angler receptors.

- In comparing individual species and tissue type (e.g., fillet and whole body) concentrations with reference areas, it appears that concentrations in Reach 5 and 7 are not different from Reach 1. However, statistical comparisons could not be made for mercury concentrations in fillet tissue of bullhead and in fillet and whole body tissue of largemouth bass since an insufficient number of bullhead and bass samples were available from Reach 1.

6.4 EXPOSURE PARAMETERS

A matrix of the exposure parameter values and the likely direction of uncertainty (i.e., under- or overestimate) is presented in Table 6-2. A quantitative estimation of the uncertainty is provided where possible. More detailed explanations are presented below.

- Recreational Angler Ingestion Rates – For the purposes of this risk assessment, the following ingestion rates are based on ingestion rates specific to the types of water bodies that were fished as indicated:

  -Reaches 2 and 9: All Waters

  -Reaches 1, 5, 7, 8, and 10, and Charles River: Flowing Waters

  -Reaches 3, 4, 6, and 7 – Heard Pond: Standing Water

  The "All Waters" ingestion rates, used for Reaches 2 and 9, are based on individuals who consume fish caught from both flowing and standing water regimes. These ingestion rates are the highest used throughout this assessment; therefore, if an individual fishes only the flowing or standing waters within those reaches, the potential for health effects may be overestimated.

- Recreational Angler – Child Fish Ingestion Rate –The "all household consumers share" values (i.e., approximately 40% of catch) were used as the child fish ingestion rates for the various flow regimes. These were calculated by Ebert et al. (1993) by dividing the amount of fish consumed by the number of individuals within a household (approximately 2.5). This assumption requires that all household members ingest the same amount. Given that studies suggest that a 0-6 year old child ingests approximately 33-50% that of an adult, the ingestion rate is likely overestimated.

- Ethnic Angler – Child Fish Ingestion Rate – Since no data regarding the ingestion rates of children of ethnic anglers were available, the ratio of the parameter values of the child to adult recreational angler ingestion rates were applied. That is, it was assumed that the child of the ethnic angler consumes approximately 40% that of the adult. Therefore, the same uncertainties that apply to the ingestion rate of the child of the recreational angler apply to the child of the ethnic angler.

- Fraction Ingested – The fraction ingested is assumed to be 0.5 based on results of the Ebert et al. (1993) survey indicating that 80% of anglers fish at least two areas. Since this risk assessment was done on a per-reach basis, it is not known if this assumption would under- or overestimate risk. However, if an individual fishes more than one Reach within the site-impacted area of the Sudbury, and more than 50% of the mass of the fish they consume comes from these areas, their overall potential for experiencing adverse health effects from the ingestion of mercury would be underestimated.

- Exposure Frequency – The ingestion rates used in this risk assessment are average daily ingestion rates (likely calculated based on a total mass consumed per year divided by 365 days per year). Using an exposure frequency of 350 days/year may slightly underestimate the overall consumption of fish; and therefore, the potential for health effects. This is expected to have a minor impact on the HQ.

- Recreational Angler – Child Body Weight – A 15 kg (~33 lb) body weight was used. Depending upon a child's age, this value could lead to an under- or overestimate of exposure, with an overestimate being more likely the older a child is. This is expected to have a minor impact on the HQ.

- Recreational Angler – Adult Body Weight – A 70 kg (~154 lb) body weight was used. This value likely underestimates exposure for receptors aged 7 through late adolescence, and underestimates exposure for many women. This is expected to have a minor impact on the HQ.

6.5 TOXICITY ASSESSMENT

- As noted in Section 3.3.1.1, the chronic oral reference dose developed by the EPA for mercury was derived to be protective of adverse neurological effects in infants and young children based on maternal exposure. As data indicate, this represents the most sensitive toxicological endpoint for human exposure to mercury. As the reference dose reflects developmental exposure, it is not necessarily applicable to adults. EPA has not derived a chronic oral RfD for adult exposure to inorganic or methylmercury. It is probable that mercury exposure in adults would elicit a less sensitive toxicological effect than that found for infants and young children. As such the application of the chronic oral RfD used in this assessment most probably overestimates the risk of mercury exposure to adults.

7. SUMMARY AND CONCLUSIONS

This BHHRA for fish consumption supplements the fish ingestion risk assessment performed previously by using reach-specific fish data to estimate exposure. Section 7.1 – Risk by Fishing Scenario, presents a summary of the potential for scenario-specific hazards based solely on the hazard quotients calculated in the risk characterization (Section 5). Section 7.2 – Risk by Reach, presents a reach by reach summary of risk of the hazard quotients and background comparisons. A qualitative summary of risks is presented in Table 7-1.

7.1 RISK BY FISHING SCENARIO

7.1.1 Recreational Angler

7.1.1.1 Adult

- Reasonable Maximum Exposure (RME)—The risk of mercury exposure to the adult recreational angler was above a hazard quotient of 1 for fish caught and consumed from the segment of the Reach 2 (Sudbury River from Pleasant Street Impoundment to Union Street Bridge), Reach 3 (Reservoir 2) and from Reach 9 (Fairhaven Bay). Fish consumed from all other reaches were shown not to pose a risk to the adult recreational angler.

- Central Tendency Exposure (CTE)—For all reaches, there was no risk to the adult recreational angler under exposure assumptions made for central tendency, i.e., the HQ was less than 1.

7.1.1.2 Child

- RME—The risk of mercury exposure to the child recreational angler (or child of an adult recreational angler) was above a hazard quotient of 1 for fish caught and consumed by the child from Reaches 2, 3, 4, 6, 8, 9, and 10. Fish consumed from all other reaches were shown to pose no risk to the child.

- CTE—Exposure to fish under assumptions of central tendency indicated a risk to the child who consumed fish from Reach 2 and from Reach 9 (Fairhaven Bay). None of the other reaches posed a health risk to the child under CTE assumptions.

7.1.2 Subsistence Angler

As discussed in the Uncertainty Analysis, information supporting the presence of subsistence populations that obtain all of their dietary protein from the fillets of fish caught from the Sudbury River is largely anecdotal. Nevertheless, should these individuals exist, the following summarizes their potential health risk from mercury exposure.

- RME—Exposure to mercury from fish caught and consumed throughout the Sudbury River including Heard Pond and the reference reach (Reach 1; above the Nyanza Site to its confluence with the Assabet River) poses a health risk to the subsistence angler.

- CTE—As with the RME, assumptions made for the CTE also indicated a potential health risk to subsistence anglers who consume fish caught throughout the Sudbury River, except for in Heard Pond.

7.1.3 Ethnic Angler

As with the subsistence angling population, information supporting the presence of individuals who prepare and consume the entire (i.e., whole body) fish caught from the Sudbury River as their sole source of dietary protein is largely anecdotal. Nevertheless, should these individuals exist, the following summarizes their potential health risk from mercury exposure.

7.1.3.1 Adult

- RME—Exposure to mercury from fish caught and consumed throughout the Sudbury River including the reference reach (Reach 1; above the Nyanza Site to its confluence with the Assabet River), but excluding Heard Pond, poses a health risk to the adult ethnic angler.

- CTE—As with the RME, assumptions made for the CTE also indicated a potential health risk to the adult ethnic angler who consumes fish caught throughout the Sudbury River, excluding Heard Pond.

7.1.3.2 Child

- RME—Exposure to mercury from fish caught and consumed throughout the Sudbury River including Heard Pond and the reference reach (Reach 1; above the Nyanza Site to its confluence with the Assabet River) poses a health risk to the child of the ethnic angler.

- CTE—As with the RME, assumptions made for the CTE also indicated a potential health risk to the child of the ethnic angler who consumes fish caught throughout the Sudbury River, excluding Heard Pond.

7.2 RISK BY REACH

RME risks, as well as comparisons with background are presented below (also see Table 7-2):

- Reach 2 (Pleasant Street Impoundment to Union Street Bridge): The exposure to mercury levels in fish caught and consumed from Reach 2 (Pleasant Street Impoundment to Union Street Bridge) represents a potential risk to individuals for all fish consumption scenarios evaluated. The highest RME exposure and consequent risk was posed to the subsistence angler (HQ 8.1). In addition to the subsistence angler, the exposure to mercury for the child of the ethnic angler (HQ 7.5), the adult ethnic angler (HQ 4.0), the child of the recreational angler (HQ 3.5), and the recreational angler (HQ 1.8) would be expected to pose a human health risk.

  The comparable background site is Reach 1, where the RME HQs are as follows:

- Recreational Angler – Child: 1.0
- Recreational Angler – Adult: 0.5
- Subsistence Angler: 5.0
- Ethnic Angler – Child: 5.2
- Ethnic Angler – Adult: 2.8

Comparing site to background, the site-related risks are 3.4 times higher for the child of the recreational angler, 3.7 times higher for the adult recreational angler, 1.6 times higher for the subsistence angler, and 1.4 times higher for the ethnic angler (adult and dependent child).

- Reach 3 (Reservoir 2): The exposure to mercury levels in fish caught and consumed from Reach 3 (Reservoir No. 2) represents a potential risk to individuals for all fish consumption scenarios evaluated. The highest RME exposure and consequent risk was posed to the child of the ethnic angler (HQ 15). In addition to the child of the ethnic angler, exposure to mercury for the subsistence angler (HQ 9.1), adult ethnic angler (HQ 8.0), the child of the recreational angler (HQ 2.1), and the adult recreational angler (HQ 1.2) would be expected to pose a human health risk.

  The comparable background site is Sudbury Reservoir, where the RME HQs are as follows:

  - Recreational Angler – Child: 0.6
  - Recreational Angler – Adult: 0.3
  - Subsistence Angler: 2.5
  - Ethnic Angler – Child: 4.0
  - Ethnic Angler – Adult: 2.1

  Comparing site to background, the site related risks are 3.7 times higher for the recreational angler (adult and child) and the subsistence angler, and 3.8 times higher for the ethnic angler (adult and dependent child).

- Reach 4 (Reservoir 1): The exposure to mercury levels in fish caught and consumed from Reach 4 (Reservoir No. 1) represents a potential risk to individuals in all fish consumption scenarios evaluated except for the adult recreational angler scenario. The highest RME exposure and consequent risk was posed to the child of the ethnic angler (HQ 8.9). In addition to the child of the ethnic angler, exposure to mercury for the subsistence angler (HQ 5.6), the adult ethnic angler (HQ 4.8), and child of the recreational angler (HQ, 1.3) would be expected to pose a human health risk.

The comparable background site is Sudbury Reservoir, where the RME HQs are as follows:

- Recreational Angler – Child: 0.6
- Recreational Angler – Adult: 0.3
- Subsistence Angler: 2.5
- Ethnic Angler – Child: 4.0
- Ethnic Angler – Adult: 2.1

Comparing site to background, the site related risks are 2.3 times higher than background risks for all receptors.

- Reach 5 (Winter Street Dam to Massachusetts Turnpike): The exposure to mercury levels in fish caught and consumed from Reach 5 (Winter Street Dam to the Massachusetts Turnpike) presents a potential risk to the child of the ethnic angler, the subsistence angler, and the adult ethnic angler. The highest RME exposure and consequent risk was posed to the child of the ethnic angler (HQ 7.2). In addition to the child of the ethnic angler, exposure to mercury for the subsistence angler (HQ 4.5) and adult ethnic angler (HQ 3.9) would be expected to pose a human health risk. The estimated mercury doses to the adult and child recreational angler receptors were below the reference dose (HQ <1).

  The comparable background site is Reach 1, where the RME HQs are as follows:

  - Recreational Angler – Child: 1.0
  - Recreational Angler – Adult: 0.5
  - Subsistence Angler: 5.0

- Ethnic Angler – Child: 5.2
- Ethnic Angler – Adult: 2.8

Comparing site to background, the site related risks are lower than background for the recreational angler (adult and child) and the subsistence angler (site to background ratio of 0.9), but 1.4 times higher for the ethnic angler (adult and dependent child).

- Reach 6 (Massachusetts Turnpike to Saxonville Dam): The exposure to mercury levels in fish caught and consumed from Reach 6 (Massachusetts Turnpike to Saxonville Dam) represents a potential risk to individuals in all scenarios evaluated except for the adult recreational angler scenario. The highest RME exposure and consequent risk was posed to the child of the ethnic angler (HQ 9.3). In addition to the child of the ethnic angler, exposure to mercury for the subsistence (HQ 5.9), adult ethnic angler (HQ 5.0), and child of the recreational (HQ 1.3) would be expected to pose a human health risk.

  The comparable background site is Sudbury Reservoir, where the RME HQs are as follows:

  - Recreational Angler – Child: 0.6
  - Recreational Angler – Adult: 0.3
  - Subsistence Angler: 2.5
  - Ethnic Angler – Child: 4.0
  - Ethnic Angler – Adult: 2.1

  Comparing site to background, the site related risks are 2.4 times higher for the recreational angler (adult and child) and the subsistence angler, and 2.3 times higher for the ethnic angler (adult and dependent child)

- Reach 7 (Saxonville Dam to Rte 20 Bridge): The exposure to mercury levels in fish caught and consumed from the Reach 7 (Saxonville Dam to the Route 20 overpass in Wayland) represents a potential risk to the child of the ethnic angler, the subsistence angler, and the adult ethnic angler. The highest RME exposure and consequent risk was posed to the child of the ethnic angler (HQ 8.3). In addition to the child of the ethnic angler, exposure to mercury for the subsistence (HQ 4.9) and adult ethnic angler (HQ 4.5) would be expected to pose a human health risk. The estimated mercury doses to the adult and child recreational angler receptors were below the reference dose (HQ <1).

The comparable background site is Reach 1, where the RME HQs are as follows:

- Recreational Angler – Child: 1.0
- Recreational Angler – Adult: 0.5
- Subsistence Angler: 5.0
- Ethnic Angler – Child: 5.2
- Ethnic Angler – Adult: 2.8

Comparing site to background, the site related risks are equivalent to background risks for the recreational angler (adult and child) and the subsistence angler (site to background ratio of 0.9), but 1.6 times higher for the ethnic angler (adult and dependent child).

As for Heard Pond, the exposure to mercury levels in fish caught and consumed from Heard Pond represents a potential risk to the child of the ethnic angler and the subsistence angler. The highest RME exposure and consequent risk was posed to the child of the ethnic angler (HQ 1.8). In addition to the child of the ethnic angler, exposure to mercury for the subsistence angler (HQ 1.2) would be expected to pose a human health risk. The estimated mercury doses to the adult and child recreational angler and adult ethnic angler receptors were at or below the reference dose (HQ ≤ 1).

The comparable background site is the Charles River, where the RME HQs are as follows:

- Recreational Angler – Child: 0.7
- Recreational Angler – Adult: 0.3
- Subsistence Angler: 3.4

- Ethnic Angler – Child: 5.7
- Ethnic Angler – Adult: 3.1

Comparing site to background, the site related risks are approximately one-half the background risks for all receptors.

- Reach 8 (Great Meadows NWR): The exposure to mercury levels in fish caught and consumed from the Reach 8 (Sudbury River in the Great Meadows National Wildlife Refuge) represents a potential risk to individuals in all scenarios evaluated except for the adult recreational angler scenario. The highest RME exposure and consequent risk was posed to the child of the ethnic angler (HQ 8.6). In addition to the child of the ethnic angler, exposure to mercury for the subsistence (HQ 6.7), adult ethnic angler (HQ 4.6), and child recreational angler (HQ 1.3) would be expected to pose a human health risk.

  The comparable background site is the Charles River, where the RME HQs are as follows:

  - Recreational Angler – Child: 0.7
  - Recreational Angler – Adult: 0.3
  - Subsistence Angler: 3.4
  - Ethnic Angler – Child: 5.7
  - Ethnic Angler – Adult: 3.1

  Comparing site to background, the site related risks are 2.0 times higher for the recreational angler (adult and child) and the subsistence angler, and 1.5 times higher for the ethnic angler (adult and dependent child)

- Reach 9 (Fairhaven Bay): The exposure to mercury levels in fish caught and consumed from Reach 9 (Fairhaven Bay) represents a potential risk to individuals for all fish consumption scenarios evaluated. The highest RME exposure and consequent risk was posed to the child of the ethnic angler (HQ 10.1). In addition to the child of the ethnic angler, exposure to mercury for the subsistence (HQ 6.7), adult ethnic anglers (HQ 5.4), children of recreational anglers (HQ 2.8), and adult recreational angler (HQ 1.5) would be expected to pose a human health risk.

The comparable background site is the Charles River, where the RME HQs are as follows:

- Recreational Angler – Child: 0.7
- Recreational Angler – Adult: 0.3
- Subsistence Angler: 3.4
- Ethnic Angler – Child: 5.7
- Ethnic Angler – Adult: 3.1

Comparing site to background, the site-related risks are 4.2 times higher for the child of the recreational angler, 4.5 times higher for the adult recreational angler, 2.0 times higher for the subsistence angler, and 1.8 times higher for the ethnic angler (adult and dependent child).

- Reach 10 (Fairhaven Bay to confluence of Sudbury River and Assabet River): The exposure to mercury levels in fish caught and consumed from the Reach 10 (Fairhaven Bay to the Sudbury/Assabet River Confluence) represents a potential risk to individuals for all scenarios evaluated except for the adult recreational angler scenario. The highest RME exposure and consequent risk was posed to the child of the ethnic angler (HQ 11.4). In addition to the child of the ethnic angler, exposure to mercury for the subsistence (HQ 7.0), adult ethnic anglers (6.1), and child of the recreational angler (HQ 1.4) would be expected to pose a human health risk.

  The comparable background site is Reach 1, where the RME HQs are as follows:

  - Recreational Angler – Child: 1.0
  - Recreational Angler – Adult: 0.5
  - Subsistence Angler: 5.0
  - Ethnic Angler – Child: 5.2
  - Ethnic Angler – Adult: 2.8

Comparing site to background, the site related risks are 1.4 times higher for the recreational angler (adult and child) and the subsistence angler, and 2.2 times higher for the ethnic angler (adult and dependent child)

These results indicate the need for a routine monitoring of mercury in fish in the Sudbury River to evaluate the need for continued fish advisories resulting from mercury contamination.

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APPENDIX A

TOXICITY PROFILE FOR MERCURY

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TOXICITY PROFILE FOR MERCURY

This toxicity profile addresses the potential toxicity of inorganic and organic mercury. Human data are emphasized, where available. Potential toxic effects through the oral exposure route is considered.

1. TOXICOKINETICS

1.1 ABSORPTION

The gastrointestinal absorption of inorganic mercury is relatively poor. Data regarding percent gastrointestinal absorption of inorganic mercury in humans are limited. Absorption of inorganic mercuric salts may range from 2 to 38% depending upon the form (ATSDR, 1999). Increased gastrointestinal absorption of inorganic mercury has been observed in neonatal mice; a small percentage of this increase may be attributable to the milk diet (ATSDR, 1999).

Based on studies in humans, absorption of ingested methylmercury is high and not likely to vary a great deal. Methylmercury is efficiently absorbed from the gastrointestinal tract following ingestion. Approximately 94%-95% of methylmercury in fish ingested by volunteers was absorbed from the gastrointestinal tract (EPA, 2001) while a drinking water study found uptake of greater than 95% of radiolabeled methylmercuric nitrate administered in water to human volunteers (EPA, 2001; EPA, 2005). Data from animal studies on rats, cats, and monkeys support these absorption estimates (ATSDR, 1999). The absorption of organic mercury in foods such as fish and bread could potentially be inhibited by other dietary components (e.g., plant fiber) as well as the form of mercury (ATSDR, 1999).

1.2 DISTRIBUTION AND METABOLISM

In general, the highest concentrations of inorganic mercury are found in the kidney, with relatively high concentrations also present in the liver. Inorganic mercury does not readily cross the blood-brain barrier and the placenta, although it may accumulate in the placenta and it can be secreted in mother's milk (ATSDR, 1999; EPA, 1996). In neonatal mice, lower proportions of inorganic mercury partition in the kidney, with higher proportions occurring in the liver and brain (EPA, 1996). There are some data that suggest that divalent inorganic mercury can be reduced to metallic mercury (ATSDR, 1999). Mercurous mercury (Hg_2^{+2}) rapidly dissociates in the body to metallic mercury (Hg^o) and mercuric mercury (Hg^{+2}) (EPA, 1996).

Because of its high lipophilicity, organic mercury readily crosses membranes and diffusion barriers (e.g., placental barrier and blood-brain barrier) and, therefore, distributes readily to all tissues, including the brain and the fetus (ATSDR, 1999). After absorption from the gastrointestinal tract, methylmercury is readily absorbed into the blood and distributes to all tissues, including the brain and fetus (EPA, 2001). Organic mercury also may be secreted in mother's milk. Tissue levels of organic mercury approximately equal blood concentrations. As for inorganic mercury, the highest concentrations of methylmercury are found in the kidney (ATSDR, 1999; EPA, 2001). The accumulation of organic mercury in hair, which is considered to be proportional to blood levels, has been used as an indicator of mercury exposure (ATSDR, 1999). Methylmercury compounds can be converted to inorganic mercury, although the rate of metabolism varies between tissues (ATSDR, 1999). Phenylmercury is rapidly converted to inorganic mercury (ATSDR, 1999).

1.3 EXCRETION

The main routes of excretion for inorganic mercury are the urine and feces. The urine has been reported to be the probable primary excretory route following high-level exposures to mercuric compounds. A whole body half-life of 1-2 months has been estimated for inorganic mercury in humans (ATSDR, 1999). Animal studies indicate that inorganic mercury is also excreted in breast milk (ATSDR, 1999). Unlike placenta, where methylmercury moves more easily across the placental border than inorganic mercury, inorganic mercury is more readily eliminated in milk than methylmercury (ATSDR, 1999).

The milk-to-plasma concentration ratios for total mercury after methylmercury administration in animals exposed to mercury via intravenous injection were lower than those seen with inorganic mercury. The nearly five-fold higher peak value for plasma to blood mercury levels observed for inorganic mercury reflects the more efficient migration of inorganic mercury from blood to milk compared with that for methylmercury (ATSDR, 1999). Mercury concentrations in milk also decreased more quickly for inorganic (terminal half-life of 107 hours) than for methylmercury (constant levels throughout the 9-day follow-up period postexposure) (ATSDR, 1999). The results suggest that the physiological changes during lactation alter the pharmacokinetics for methylmercury in mice, but not for inorganic mercury.

In humans, approximately 90% of the absorbed dose of methylmercury is excreted in the feces and bile as mercuric mercury, while excretion via the urine is relatively minor but slowly increases with time (EPA, 2001). Almost all of the administered organic mercury that is excreted in the feces is in the inorganic form (ATSDR, 1999; EPA, 2001). Mercury is excreted into the hair of methylmercury-exposed humans and animals. Incorporation of mercury into hair is irreversible, and hair analysis is thus a useful tool for monitoring exposure to methylmercury (EPA, 2001). Methylmercury is also excreted in breast milk with the ratio of mercury in breast milk to mercury in whole blood being approximately 1:20 in women exposed to methylmercury via contaminated grain in Iraq between 1971 and 1972 (EPA, 2001). Studies in animals indicate that the mercury content of breast milk is proportional to the mercury content of plasma (EPA, 2001). Animal studies with rat and monkey neonates indicate that excretion of methylmercury is severely limited likely due to the inability of suckling infants to secrete bile (EPA, 2001). The half-life of methyl mercury in the human body was determined to be a mean of 72 days based on the distribution of mercury along head hair (EPA, 2001). The relatively long half-life of methylmercury in the body results partly from reabsorption of methylmercury secreted into the bile (hepatobiliary cycling) (EPA, 2001).

2. HEALTH EFFECTS OF MERCURY EXPOSURE

The mechanisms for the toxic effects of inorganic and organic mercury are believed to be similar and it has been suggested that the relative toxicities of the different forms of mercury (e.g., metallic, monovalent, and divalent cations and methyl- and phenylmercury compounds) are related, in part, to its differential accumulation in sensitive tissues (ATSDR, 1999). However, because there are some significant differences in toxicity between inorganic mercury salts and organic mercury compounds, the toxic effects of these two forms are discussed separately below. These differences may be due, in part, to differences in their distribution and metabolism, as discussed in the previous section. The main target of toxicity of inorganic mercury is the kidney; the main target of toxicity of organic mercury is the central nervous system.

2.1 INORGANIC MERCURY

2.1.1 Human Health Effects

Most of the information regarding the oral toxicity of inorganic mercury to humans comes from case studies of acute exposure (i.e., the ingestion of a large single dose). The kidney appears to be the critical target organ of acute oral exposure (EPA, 1996, 2001; ATSDR, 1999). Most cases of death from oral exposure to inorganic mercury have resulted from acute poisoning with mercuric chloride ($HgCl_2$). Lethal doses for acute oral exposure to inorganic mercury have been estimated to be 10–42 mg Hg/kg for a 70-kg adult, with deaths being attributed to cardiovascular failure, severe gastrointestinal damage, and kidney failure (ATSDR, 1999). Renal failure in humans also has been associated with the chronic ingestion of mercurous chloride (ATSDR, 1999).

Extremely limited information exists regarding respiratory effects in humans after oral exposure to inorganic forms of mercury. Severe pulmonary edema, fine rales, and shortness of breath were noted in humans following oral exposure to mercuric and mercurous chloride (ATSDR, 1999).

Mercuric chloride is highly irritating to the intestinal tract. Acute oral exposure in the potentially lethal dose range has been observed to produce blisters and ulceration of the lips, mouth, and gastrointestinal tract, as well as nausea, vomiting, and diarrhea. Mercurous compounds appear to be less caustic, although symptoms of oral and gastrointestinal irritation have been reported in individuals that were administered mercurous-containing medications (dose unspecified). Effects on the liver, including liver enlargement (dose unspecified), have been seen after acute exposure to mercuric chloride. Respiratory effects (i.e., pulmonary edema, rales, shortness of breath) have been reported to occur following acute exposure to unspecified doses of inorganic mercury. Skeletal muscle degeneration was seen in an individual who ingested 2 grams of mercuric chloride in a suicide attempt (ATSDR, 1999).

Cardiovascular toxicity has been attributed to both mercuric and mercurous choride. Increased heart rate and elevated blood pressure have been reported in children who were treated for worms or teething discomfort with mercurous-containing medications (doses unspecified). An abnormal electrocardiogram was seen in an individual who had attempted suicide by ingesting approximately 20 mg/kg of mercury as mercuric choride. Information regarding hematological effects is limited to a case of anemia in an individual who ingested a lethal dose of mercuric chloride. The anemia, however, was probably a result of gastrointestinal hemorrhaging (ATSDR, 1999).

Neurotoxicity has occurred as the result of subchronic oral exposure to unspecified doses of mercurous-containing medications (e.g., teething powders and laxatives). Symptoms and signs have included irritability, fretfulness, sleeplessness, photophobia, muscle twitching and cramping, confusion, dysphagia, and impaired gait. Chronic exposure of two individuals to mercurous-containing laxatives, which eventually resulted in death, was reported to have caused dementia. The mercury dose was estimated at 0.72 mg/kg-day. The acute ingestion of a lethal dose of mercuric chloride was shown to have resulted in blurred and double vision, and seizures (ATSDR, 1999).

The kidney appears to be the critical organ of toxicity for the ingestion of mercuric salts. Renal effects in humans have been observed following acute oral exposure to inorganic mercury to include: renal failure, pale and swollen kidneys, increase in urinary protein secretion, decreased urinary output and edema (ATSDR, 1999).

A toxic effect that has primarily been observed in children, and which has been seen following oral exposure to unspecified doses of mercurous-containing medications, is acrodynia, a non-allergic hypersensitivity reaction to mercury, characterized by pruritis. Other symptoms associated with acrodynia are itching, redness, swelling, and peeling of the skin on the palms and soles, and heavy perspiration (ATSDR, 1999).

Mercury has not been determined to be carcinogenic in humans (ATSDR, 1999).

2.1.2 Animal Studies

In general, animal studies support the human toxicity data for inorganic mercury. In addition, there is evidence of an autoimmune response in some rodents, and there are limited animal data that suggest that inorganic mercury may be carcinogenic.

Numerous studies have reported kidney toxicity in rats and mice following acute, subchronic, or chronic exposure to mercuric chloride. In chronic studies, serious toxic effects on the kidney have been seen at mercury doses of approximately 2 mg/kg-day and greater. Minor effects (e.g, increased kidney weight) have been observed in subchronic studies at doses as low as 0.46 mg/kg-day (ATSDR, 1999).

Gastrointestinal effects, including inflammation and necrosis of the stomach (at a dose of 59 mg mercury/kg-day, 5 days/week for 2 weeks) and hyperplasia of the stomach (at a dose of 1.9 mg mercury/kg-day for 2 years) have been reported in gavage studies. An increase in blood pressure has been reported in rats orally exposed to mercury as mercuric chloride for 180 days at 28 mg/kg-day (ATSDR, 1999).

Data regarding the neurotoxic effects of inorganic mercury following ingestion by animals are limited. A few subchronic studies have been performed; however, no conclusions can be drawn regarding neurotoxic effects because of limitations in the studies. Similarly, there are few data addressing liver or respiratory effects. Increased liver enzymes (at a dose of 5 mg mercury/kg-day, duration unspecified) and increased liver weights (at a dose of 2.9 mg mercury/kg-day for 7 weeks) have been observed. Respiratory difficulties were seen in one study after subchronic oral exposure to inorganic mercury at 22 mg/kg-day for 3 months. Decreases in body weight or body weight gain have been observed at mercury doses as low as 0.93 mg/kg administered by gavage, 5 days/week for 6 months. Effects on thyroid function have been reported to result from oral inorganic mercury exposure at mercury doses of 2.2 mg/kg-day and higher for 3 months (ATSDR, 1999).

Administration of inorganic mercury as a single gavage dose has been reported to increase the rate of fetal resorptions in hamsters at doses of 22 mg/kg and higher, and decrease the body length of surviving embryos at doses as low as 5 mg/kg. Single gavage doses of 2.2 mg/kg and higher have been reported to increase the frequency of chromosome aberrations and abnormal cells in the bone marrow of mice (ATSDR, 1999).

The immune system response to mercury has been studied extensively in laboratory animals, and has been shown to be dependent on the dose and the genetic characteristics of the study population. Some strains of rodents develop a systemic autoimmune disease in response to mercury exposure, glomerulonephritis being a significant toxic endpoint. Immunoglobulin G (IgG) deposits in the kidney, suggestive of autoimmune disease, have been observed in Norway rats at mercury doses as low as 2.2 mg/kg-day after two months of exposure. In other rodent strains, however, no effects or immunosuppressive effects have been observed (ATSDR, 1999).

There is some evidence to suggest that mercuric chloride may induce tumors in rats and mice. An increased incidence of squamous cell papillomas of the forestomach and thyroid follicular cell adenomas were observed in male rats at a mercury dose of 3.7 mg/kg-day in a 2-year National Toxicology Program (NTP) study in which test animals were administered mercuric chloride by gavage. The relevance of the forestomach tumors were considered questionable, however, because there is no evidence that the forestomach tumors, which may have been a response to irritation, progress to malignancy. The relevance of the thyroid tumors also was questioned because these tumors usually occur secondarily to hyperplasia and hyperplasia was not observed. Therefore, the increase in thyroid tumors could not confidently be associated with mercuric chloride administration. Furthermore, the doses for male rats exceeded the maximum tolerated dose (MTD). In the same NTP study a significant positive trend was noted in male mice for kidney adenomas and adenocarcinomas. The incidence of tumors in the high-dose group (7.4 mg mercury/kg-day) was statistically significant when compared with historical controls, although not with concurrent controls (EPA, 2005).

2.2 ORGANIC MERCURY

2.2.1 Human Health Effects

Methylmercury is the most important form of mercury in terms of health effects from environmental exposures. Most information regarding clinical signs and symptoms has come from the study of epidemics in Japan and Iraq, from studies of populations eating mercury-contaminated fish, and from reports of occupational exposures (ATSDR, 1999; EAP, 2001). The main health effects are neurotoxic effects in adults and in fetuses of exposed mothers. The main source of methylmercury exposure in the general population is from fish ingestion (EPA, 2001; ATSDR, 1999).

Although death from mercury poisoning is not common, deaths were reported from the ingestion of contaminated fish in Japan, and the consumption of contaminated grain products in Iraq. Epidemics of methylmercury poisoning occurred in Japan between 1953 and 1960 as the result of the disposal of mercury into Minimata Bay and the Agano River. The mercury bioaccumulated in fish as methylmercury, and the fish were subsequently consumed by local residents (EPA, 1996; 2001). The neurological syndrome that developed, and which is known as Minimata disease, is characterized by numerous symptoms, including paresthesia (prickling, tingling sensation in the extremities), slurred speech, unsteady gait, muscle weakness, irritability, memory loss, depression, difficulty in sleeping, and impaired peripheral vision, hearing, taste, and smell. Early deaths (i.e., prior to 1970) associated with the epidemic were attributed primarily to Minimata disease and noninflammatory diseases of the nervous system, with pneumonia and ischemic heart disease reported as secondary causes of death. For individuals dying between 1970 and 1980, Minimata disease correlated with nonischemic heart disease was considered the primary cause of death, with noninflammatory central nervous system disease being a major secondary cause. No information was available concerning the dosage levels associated with the Japanese epidemics (ATSDR, 1999).

Similarly, in epidemics in Iraq in 1956, 1960, 1971, and 1972, neurological disorders and deaths were associated with the consumption of flour or bread made from grain that had been treated with ethyl- or methylmercury-containing fungicides (ATSDR, 1999). In one epidemic in which fatalities occurred, doses were estimated as ranging from 0.5 to 5.7 mg/kg-day, with the exposure period ranging from 43-68 days (EPA, 1996).

In addition to the epidemics in Iraq and Japan, other isolated cases of organic mercury poisoning have been reported, some resulting in death (ATSDR, 1999). The most sensitive neurological symptom (i.e., the symptom associated with the least severe organic mercury poisoning) is paresthesia, with additional symptoms appearing in more severe cases. There appears to be a latency period between exposure to organic mercury and symptom onset. The latency period in the 1970's Iraq epidemics ranged up to 38 days, while the latency period in the Japan epidemics ranged up to several years. The cause of the latency period is not known (EPA, 1996).

Studies performed on poisoning victims have shown nerve degeneration in the brain, particularly the cerebellum and cerebrum. There also has been some evidence of peripheral nerve damage. Data from several case studies on organic mercury poisoning provide evidence of kidney damage, as well as cardiovascular abnormalities (e.g., irregular heart beats, abnormal EKGs). The ingestion of organic mercury compounds also has been associated with gastrointestinal symptoms, including abdominal pain and vomiting, diarrhea, and irritation. Effects observed in muscle tissue (e.g., muscle wasting, muscle pain, and twitching) are thought to be secondary results of neurological effects. Respiratory effects have been reported in a few cases, but these, too, may have been secondary to other toxic effects. No dose-response information was available regarding the aforementioned effects (ATSDR, 1999).

The fetal nervous system is highly sensitive to methylmercury. Numerous instances of neurological damage, including cases associated with the previously described epidemics, have been reported in neonates that were born to women that had been exposed to organic mercury during pregnancy. A dose-response relationship, as determined by mercury levels in maternal hair, has been shown for neurological toxic effects in infants. Effects of severe brain damage (mercury levels in hair not specified) include mental retardation, seizures, lack of coordination, blindness, and neuromuscular weakness. Less severe symptoms associated with lower exposure levels include developmental delays (e.g., walking and talking). In a study on one of the Iraqi epidemics, delays in walking and talking were seen mainly in women whose mercury concentration in hair was greater than 60 µg/g. The most severe effects result from fetal exposure to organic mercury during the second trimester of pregnancy (ATSDR, 1999).

Since EPA's derivation of an RfD in 1995, three epidemiological studies have become available that identified methylmercury-related developmental neurotoxicity (EPA, 2005). The studies included developmental studies in the Seychelles Islands, the Faroe Islands, and New Zealand. These studies represent major epidemiological studies examining the neurobehavioral effects of prenatal methylmercury exposure on young children due to maternal exposure to dietary methylmercury.

One study (Grandjean et al., 1997) examined 917 7-year old children in the Faroe Islands of Denmark. Methylmercury exposure in the Faroes results primarily from the ingestion of pilot whale meat. The primary indicator of exposure in the study, and the best predictor of most neurobehavioral dysfunctions, was the mercury concentration in umbilical cord blood; maternal hair mercury concentrations also were measured. No clear associations could be demonstrated between mercury exposure and general health and the neurophysiological parameters that were tested. A number of neuropsychological dysfunctions were noted, however. These related mostly to language, attention, and memory and, to a lesser degree, to visuospatial and motor skills. These effects could be seen even when maternal hair mercury levels were less than 10 µg/g, a level previously believed to be "safe".

The second study, the Seychelles Child Development Study, was conducted on over 1500 mother-infant pairs in the Republic of Seychelles. Prenatal methylmercury exposure resulted primarily from fish consumption. Maternal hair mercury concentration was used as the indicator of the extent of mercury exposure. The results, to date, although suggestive, did not clearly indicate a correlation between methylmercury exposure and neurodevelopmental effects. No effects were seen at 6.5 months and 19 months of age. At 29 months, a decrease in activity level, a subjectively evaluated parameter, was reported in males as mercury exposure increased; the direction of the effect was unexpected, however. Maternal hair mercury levels correlated well with brain mercury concentrations, and were therefore considered to be a good indicator of fetal mercury exposure (Myers et al., 1995b). The maternal mercury hair concentrations ranged up to approximately 35 μg/g; the median mercury concentration in hair was 6.6 μg/g (Myers et al., 1995a).

The third study was conducted in New Zealand and was a prospective study in which children of mothers with hair mercury levels during pregnancy greater than 6 ppm were matched with children whose mothers had lower hair mercury levels. At 6 years of age, the children were assessed on a number of neuropsychological endpoints. This study yielded similar results as the other two studies (EPA, 2005).

At this time, no human studies have reported an association between methylmercury exposure and overall cancer rates. Three studies were identified that examined the relationship between methylmercury exposure and cancer (EPA, 2001). No persuasive evidence of increased carcinogenicity attributable to methylmercury exposure was observed in any of the studies. Interpretation of these studies, however, was limited by poor study design and incomplete descriptions of methodology and/or results (EPA, 2001).

2.2.2 Animal Studies

Numerous animal studies support the observation in humans that organic mercury is highly neurotoxic, affecting both the central and peripheral nervous systems. The biochemical mechanism of organic mercury-induced neurotoxicity is not known. Some studies show alterations in neurotransmitter metabolism in the brain, although these findings may be secondary effects (ATSDR, 1999).

Neurotoxic signs resulting from oral administration of methylmercury to rodents include muscle spasms, disturbed gait, flailing, and hindlimb crossing and paralysis. Histopathological studies have shown degeneration of neurons in the cerebellum and dorsal root ganglia, as well as peripheral nerve degeneration. Neuronal degeneration of the cerebral cortex, thalamus, and hypothalamus also has been reported. In chronic studies in mice, neurotoxic effects (e.g., posterior paralysis) have been observed in response to methylmercury exposure at doses as low as 0.6 mg mercury/kg-day (ATSDR, 1999).

Cats and monkeys appear to be more sensitive than rodents to the neurotoxicity of organic mercury, neurological lesions and signs of neurotoxicity having been observed at lower doses. Neurotoxic signs in these animals include loss of coordination, visual and sensory impairment including blindness, abnormal reflexes, and/or abnormal behavior. Adverse visual and motor effects have been seen in monkeys at mercury doses as low as 0.05 mg/kg-day, when administered as methylmercuric chloride for up to seven years (ATSDR, 1999).

Ulceration of the gastrointestinal tract has been observed in oral toxicity studies in which mercury was administered as methymercuric chloride at a dose of 0.69 mg/kg-day for two years. Other toxic effects that have been reported occasionally for methylmercuric chloride include an increase in blood pressure (at gavage doses of 0.4 mg mercury/kg-day for 3-4 weeks) and decreases in body weight or body weight gain (at doses as low as 0.8 mg mercury/kg-day) (ATSDR, 1999).

In general, methylmercury appears to depress the immune response in animals. Decreased production of antibody-producing cells and decreased antibody titre have been reported in mice at doses as low as 0.076 mg mercury/kg-day administered for 3 weeks. IgG (i.e., immunoglobulin G) deposits in the kidney, suggestive of an autoimmune response, have been observed in rats at doses of 4.8 mg mercury/kg-day administered for a period of up to two months (EPA, 1996). One study conducted over 12 weeks reported a decrease in natural killer cell activity at 0.5 mg mercury/kg-day, although an increased lymphoproliferative response was concurrently observed in the spleen (ATSDR, 1999).

The main reproductive effect of oral exposure to organic mercury in animals is an increase in abortions and decreased litter size. Decreased conceptions and increased abortions have been seen in monkeys exposed to 0.06 mg mercury/kg-day for four months. Testicular effects have been seen in both rodents and monkeys. A limited 20-week study in monkeys indicated a decrease in sperm motility, accompanied by an increase in sperm tail defects at organic mercury doses as low as 0.025 mercury/kg-day. Testicular atrophy has been observed in mice following chronic exposure to mercury as methylmercuric chloride at a dose of 0.69 mg/kg-day (ATSDR, 1999).

Numerous animal studies have documented the developmental toxicity of organic mercury resulting from intrauterine exposure. Various morphological abnormalities have been observed including skeletal effects, cleft palate, decreased fetal weight, generalized edema, brain lesions, hydrocephaly, and kidney effects. Adverse effects have been seen at mercury doses (administered as methyl mercuric choride) as low as 2 mg/kg-day when administered throughout gestation. Effects on the immune system, including changes in lymphocyte activity have been reported at a dose of 0.5 mg mercury/kg-day. Functional disturbances due to neurotoxicological effects have been studied by postnatal behavioral testing. Changes have been noted in a number of behavioral parameters as evidenced by changes in reflexes, overall motor activity, motor coordination, and learning ability. In some studies the behavioral effects were correlated with histomorphological or histochemical changes in the brain. Subtle changes in behavior have been shown to be the most sensitive toxic endpoints caused by prenatal organic mercury exposure. Changes in operant behavior performance have been seen in rats that had been exposed to mercury as methylmercury on days 6-9 of gestation at a dose of 0.008 mg/kg-day (ATSDR, 1999).

Several animal studies suggest that methylmercury may be carcinogenic. Increases in kidney tumors (epithelial cell adenomas, adenocarcinomas, and carcinomas) were observed in male mice in three separate dietary studies (mercury doses ranged from 0.69-1.6 mg/kg-day). The interpretation of the results of these studies was complicated, however, by the fact that the tumors were observed only in cases where evidence of other severe kidney damage was apparent, suggesting that the tumors may have resulted from repair processes. Furthermore, in two of the studies the tumors were observed only at dose levels that exceeded the maximum tolerated dose, as indicated by increases in mortality. One additional dietary study in mice and four dietary studies in rats gave negative results (EPA, 2005). A dietary study in cats also produced negative results (EPA, 2001). Most of the negative studies were noted to be deficient in study design or failed to identify a maximum tolerated dose (EPA, 1996; 2001; EPA, 2005).

There are data that suggest that increased selenium intake may afford some protection against methylmercury poisoning. Selenium complexes with methylmercury to form a bismethymercury complex. Although it has been suggested that the presence of selenium in foods, particularly in fish where selenium tends to accumulate, could reduce the bioavailability of methylmercury, the postulate is not supported by the available experimental data (ATSDR, 1999). Animal data do indicate, however, that selenium may delay the onset of renal toxicity in adults and may reduce some negative effects (i.e., hypoactivity) resulting from prenatal methylmercury exposure (EPA, 1996).

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TABLES

Table 1-1

Chronology of Primary Evaluations and Investigations Conducted at the Nyanza Superfund Site
Ashland, Massachusetts

Investigation	Investigator and Date	Key Findings
Waste disposal violations	Massachusetts Departments of Public Health (DPH) and Massachusetts Department of Water Pollution Control, 1972-1977	Identified several waste disposal violations.
Investigation of Mercury Problems in Massachusetts	JBF Scientific Corp. 1972	Identified elevated levels of mercury in water, sediments and biota in the Sudbury River, and qualitatively linked mercury contamination in the Sudbury River to the Nyanza Site.
Environmental Site Investigation	Camp, Dresser and McKee, 1974	Determined on- and off-site contamination sources and developed a groundwater contamination control plan.
Sudbury River Fish Monitoring Study	U.S. Fish and Wildlife Service (USFWS) 1977-1987	Detected elevated mercury concentrations in several fish species and sediment collected in the Sudbury River.
Preliminary Site Assessment	Massachusetts Department of Environmental Quality and Engineering (DEQE) 1980	Performed a site assessment and review of previous studies that identified off-site migration of several metal (including mercury) and organic contaminants.
Environmental Investigations of Sudbury River	Massachusetts, DEQE Metropolitan District Commission (MDC), 1980-1987	Identified metal and organic contamination in surface water, sediment, and fish collected in the Sudbury River near the site.
Remedial Action Master Plan	Camp, Dresser and McKee 1982	Remedial action plan emphasizing on-site source control is developed.
Operable Unit I (on-site surficial soil, sediment, and sludge) RI/FS	NUS Corporation, 1984	Characterized the extent of on-site inorganic and organic contamination and recommended source removal and stabilization activities. ROD based on findings signed in 1985.

Table 1-1

Chronology of Primary Evaluations and Investigations Conducted at the Nyanza Superfund Site
Ashland, Massachusetts
(Continued)

Investigation	Investigator and Date	Key Findings
Off-site Groundwater Control, OU II	EPA, 1991	Activities involved in the groundwater study included installation of monitoring wells, topographic and geophysical studies, aquifer testing, and groundwater, surface water, sediment, and subsurface sampling. As a result, it was concluded that a contaminated groundwater plume containing VOCs and metals was traveling north, east, and northeast toward the Sudbury River. It was concluded that there were minimal human health risks due to groundwater in basements or drinking water. The minimal risk is attributed to the lack of known public or private drinking wells. It was concluded that if individuals began to utilize the groundwater for future household use or if groundwater was not properly addressed, potential human health and environmental risks exists.
Sudbury River Study, OU III	NUS Corporation, 1992	Following Phase I sampling, surface water had minimal contamination, mercury, chromium, and lead contamination found in sediments, and mercury, PCB, and pesticide contamination found in fish. Following Phase II activities, minimal surface water contamination confirmed Phase I findings, high levels of mercury contamination found in sediments downstream of site, high mercury levels in fish found in entire river stretch, and PCB and pesticide contamination found not related to Nyanza site.
Additional On-site Investigations	Camp, Dresser and McKee, 1996	Identified additional on-site source areas in support of remedial design.
Sludge Removal Action	EPA Region 1 Environmental Service Division (ESD), 1987	The “vault”, or major source of organic groundwater contamination is removed. E.C. Jordan begins RI/FS activities on Operable Unit II (groundwater). On-site sludges were excavated, solidified and buried on Mejunko Hill, then covered with a cap.

Table 1-1

Chronology of Primary Evaluations and Investigations Conducted at the Nyanza Superfund Site
Ashland, Massachusetts
(Continued)

Investigation	Investigator and Date	Key Findings
Final Extent of Contamination Report for Pre-Design Investigations, OU III	Ebasco Services, Inc., 1995	Determined the extent of mercury contamination in the Continuing Sources Area soils and excluded both TCL and TAL chemicals in surface water. Most soil mercury levels below 1-foot depth were less than 1.0 ppm. Mercury contamination in soils in the Eastern Wetlands was present to depths of at least 0.5 feet. Trolley Creek had mercury contamination as high as 126 ppm at depths of 2 to 3 feet. Study estimated that approximately 18,750 cubic yards of soil would require excavation. Surface water sampling was limited; however, no VOC, SVOC, pesticides or PCB's were present. Mercury in surface waters was detected at levels ranging from 0.22 to 16.9 ppb.
Ecological Task Force Findings	Task Force Members, 1997	Following initial site investigations of the Sudbury River, it was concluded that additional studies were necessary. Sediments and fish were contaminated with mercury and other heavy metals.
Baseline Human Health Risk Assessment	Roy F. Weston, Inc. 1999a	Evaluation showed human health effects from mercury due to fish consumption. Risks to recreational anglers and subsistence fishermen due to exposure from fish consumption were above a hazard quotient of 1. Routine monitoring of mercury in fish in the Sudbury River was recommended to evaluate the need for continued fish advisories due to mercury contamination.
Baseline Ecological Risk Assessment	Roy F. Weston, Inc., 1999b	Evaluation showed sediment contamination effects on benthic communities within Sudbury River and nearby wetlands and tributaries; methylation of inorganic mercury occurring in wetlands, bioaccumulation of methylmercury occurring within study area, and reproductive/developmental and neurotoxic/behavioral effects occurring on avian receptors. Recommended need for continued monitoring and data collection and potential remediation.
Supplemental Investigation (Sediment, fish, and crayfish concentrations)	EPA, 2003	Results pending.
Kingfisher Study	Biodiversity Research Institute (BRI), in review	Results pending.
Marsh Bird Study	BRI, in review	Results pending.

Table 1-1

Chronology of Primary Evaluations and Investigations Conducted at the Nyanza Superfund Site
Ashland, Massachusetts
(Continued)

Investigation	Investigator and Date	Key Findings
Hooded Merganser Study	BRI, in review	Results pending.
Tree Swallow Study	BRI, in review	Results pending.
Mink and Otter Study	BRI, in review	Results pending.
Supplemental Baseline Ecological Risk Assessment	Avatar Environmental, in progress	Results pending.

Table 1-2

OU IV Mercury Assessment Studies at the Nyanza Superfund Site Ashland, Massachusetts

Title	Researchers and Date	Affiliation	Objectives
Distribution and transport of total mercury and methylmercury in mercury-contaminated sediments in reservoirs and wetlands of the Sudbury River, east-central Massachusetts	Colman, J.A., M.C. Waldron, R.F Breault, and R.M. Lent, 1999	U.S. Geological Survey	Determine the effect of Hg contaminated-Sudbury River sediment on net MeHg generation as determined by the presence, distribution, and correlation of ∑ Hg and MeHg in the bed sediments.
Sampling for mercury at sub-nanogram per liter concentrations for load estimation in rivers.	Colman, J.A. and R.F Breault, 2000	U.S. Geological Survey	Collect and analyze Hg water concentrations at subnanogram/liter concentrations of stream cross-sections so that constituent load estimates could be calculated.
Artifact formation of methyl mercury during aqueous distribution and alternative for the extraction of methyl mercury environmental samples	Bloom, N.S., Colman, J.A. and L. Barber, 1997	Frontier Geo-Sciences, Inc., U.S. Geological Survey, Duke University	Determine the relative proportion of methyl mercury generated during standard pre-extraction distillation procedures and identify method modifications that may result in the elimination or reduction in pre-extraction methyl mercury production.
Sudbury River Sediment Transport Model	Nail, G.H. and D.D. Abraham, 1997	U.S. Army Corps of Engineers	Determine the extent of mercury contamination in existing river sediment, and the potential for resuspension and movement of these sediments.
Distribution, hydrologic transport, and cycling of total mercury and methyl mercury in a contaminated river-reservoir-wetland system (Sudbury River, eastern Massachusetts)	Waldron, M.C., Colman, J.A. and R.F. Breault, 2000	U.S. Geological Survey	What is the current occurrence and distribution of Hg in the water column? What are the current sources of Hg in the Sudbury River? How does Hg from the Superfund site move downstream through the system? How do the reservoirs affect Hg transport and sedimentation? Are contaminated sediment beds sites of elevated MeHg production? What is the contribution of the wetland associated reaches to the rivers MeHg load? Is transport of MeHg from ∑Hg contaminated sites upstream an important source of MeHg to food chains at downstream sites?

Table 1-2

OU IV Mercury Assessment Studies at the Nyanza Superfund Site Ashland, Massachusetts (Continued)

Title	Researchers and Date	Affiliation	Objectives
Estimating historical mercury concentrations and assessing fish exposure to mercury in a contaminated reservoir on the Sudbury River, East-Central Massachusetts, using a constant settling-velocity model and accumulation rates of mercury in sediment cores	J.A. Colman, 1997	U.S. Geological Survey	Estimate historical mercury concentrations in the first reservoir downstream from the Nyanza Superfund site for use in assessing exposure of fish to mercury.
Factors affecting food chain transfer of mercury in the vicinity of the Nyanza Site, Sudbury River, Massachusetts	Haines, T.A., May, T.W., Finlayson, R.T., Merzykowski, S.E. and M.W. Powell, 1997	U.S. Geological Survey-Biological Resources Division, University of Maine, U.S. Fish and Wildlife Service	Characterize total mercury content of the most important predator fish species in reference and contaminated sites in the Sudbury River, considering both impounded and free-flowing reaches and three seasons (spring, summer and fall). Characterize total and methyl mercury concentrations in invertebrates and forage fish in reference and contaminated sites in the Sudbury River, in order to assist in the determination of the importance of food chain pathways of mercury in the continuing contamination of fish and wildlife resources in the river. Construct a computer model that represents the major pathways of methyl mercury into the food chain leading to predatory fish and develop forecast models that predict biota mercury accumulation from environmental variables and can be used to evaluate remediation strategies.

Table 1-2

OU IV Mercury Assessment Studies at the Nyanza Superfund Site Ashland, Massachusetts (Continued)

Title	Researchers and Date	Affiliation	Objectives
Bioavailability of sediment associated mercury in *Hexagenia* mayflies in a contaminated floodplain river	Naimo, T.J. Wiener, J.G., Cope, W.G., and N.S. Bloom, 1997	U.S. Geological Survey, Biological Resources Division, Frontier Geosciences	Determine if *Hexagenia* mayfly nymphs exposed to mercury-contaminated surficial sediment from the Sudbury River accumulate MeHg. Determine if the accumulation of MeHg in mayflies is a function of the ∑Hg concentration in sediment. Assess which contaminated areas on the Sudbury River have the greatest potential for MeHg transfer into the benthic food chain.
An in-situ assessment of mercury contamination in the Sudbury River, Massachusetts, using bioaccumulation and growth in transplanted mussels	Salazar, S.M., Beckvar, N, Salazar, M.H. and K., Finkelstein, 1996	National Oceanic and Atmospheric Administration E.V.S. Consultants	Demonstrate the extent of bioavailable mercury within the downstream reaches of the Sudbury River resulting from operations at the Nyanza site. Identify areas that could act as sources of mercury for transport downstream. Determine the effect of mercury exposure on a resident species.
Stratigraphy and historic accumulation of mercury in recent depositional sediments in the Sudbury River	Frazier, B.E., Wiener, J.G., Rada, R.G., and D.E. Engstrom, 1997	University of Wisconsin-La Cross U.S. Geological Survey, Biological Resources Division Science Museum of Minnesota	Determine the vertical distribution of mercury in sediments from the Sudbury River. Estimate the recent inputs of mercury to depositional environments in the Sudbury River, as reflected by the temporal pattern in accumulation rates of mercury in the sediments.

Table 1-2

OU IV Mercury Assessment Studies at the Nyanza Superfund Site Ashland, Massachusetts (Continued)

Title	Researchers and Date	Affiliation	Objectives
Kingfisher Study	Biodiversity Research Institute (BRI), in review	Not Applicable	Determine the extent to which mercury has accumulated in the blood and feathers of adult kingfisher foraging the Sudbury River for comparison with existing data on effects levels (i.e., critical residue levels); Determine the extent to which mercury has accumulated in the eggs of kingfisher for comparison with existing data on effects levels; Obtain data on the ambient levels of mercury in eggs and in blood and feathers of adult kingfisher inhabiting reference surface waters including Sudbury Reservoir and the Charles River; Evaluate the bioaccumulation and trophic dynamics of mercury transfer from sediment to kingfisher and other piscivorous birds for use in establishing remedial measures if necessary.
Marsh Bird Study	BRI, in review	Not Applicable	Determine the extent to which mercury has accumulated in the blood and feathers of adult marsh birds inhabiting the floodplains of the Sudbury River for comparison with existing data on effects levels (i.e., critical residue levels); Determine the extent to which mercury has accumulated in the eggs of marsh birds for comparison with existing data on effects levels; Obtain data on the ambient levels of mercury in eggs and in blood and feathers of marsh birds inhabiting reference floodplains including Sudbury Reservoir and the Charles River; Evaluate the bioaccumulation and trophic dynamics of mercury transfer from sediment and floodplain soils to marsh birds for use in establishing remedial measures if necessary.

Table 1-2

OU IV Mercury Assessment Studies at the Nyanza Superfund Site Ashland, Massachusetts (Continued)

Title	Researchers and Date	Affiliation	Objectives
Hooded Merganser Study	BRI, in review	Not Applicable	Determine the extent to which mercury has accumulated in the blood and feathers of adult mergansers inhabiting the Sudbury River for comparison with existing data on effects levels (i.e., critical residue levels); Determine the extent to which mercury has accumulated in the eggs of mergansers for comparison with existing data on effects levels; Obtain data on the ambient levels of mercury in eggs and in blood and feathers of adult mergansers inhabiting reference surface waters including Sudbury Reservoir and the Charles River; Evaluate the bioaccumulation and trophic dynamics of mercury transfer from sediment to mergansers for use in establishing remedial measures if necessary.
Tree Swallow Study	BRI, in review	Not Applicable	Determine the extent to which mercury has accumulated in the blood and feathers of adult tree swallows for comparison with existing data on effects levels (i.e., critical residue levels); Determine the extent to which mercury has accumulated in the eggs of tree swallows for comparison with existing data on effects levels; Obtain data on the ambient levels of mercury in eggs and in blood and feathers of adult tree swallows inhabiting reference surface waters including Sudbury Reservoir and the Charles River; Evaluate the bioaccumulation and trophic dynamics of mercury transfer from sediment to tree swallows for use in establishing remedial measures if necessary.

Table 1-2

OU IV Mercury Assessment Studies at the Nyanza Superfund Site Ashland, Massachusetts (Continued)

Title	Researchers and Date	Affiliation	Objectives
Mink and Otter Study	BRI, in review	Not Applicable	Determine the extent to which mercury has accumulated in the blood and fur of mink and otter inhabiting the Sudbury River for comparison with existing data on effects levels (i.e., critical residue levels); Obtain data on the ambient levels of mercury in blood and fur in mink and otter inhabiting reference surface waters including Sudbury Reservoir and the Charles River; Evaluate the bioaccumulation and trophic dynamics of mercury transfer from sediment to mink and otter for use in establishing remedial measures if necessary.

Table 2-1
Nyanza OU IV Fish Summary
Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Reach	Subreach	Species	Size Class	# Samples Collected		
				Fillet	Offal	Whole Body
1	0	Largemouth Bass	-	11	3	-
		White Sucker	-	-	-	8
		Yellow Bullhead	-	2	2	2
		Yellow Perch	C	-	-	5
			D	14	3	-
2	0	Largemouth Bass	-	3	2	-
		White Sucker	-	-	-	2
		Yellow Perch	C	-	-	6
			D	7	3	-
	1	Brown Bullhead	-	-	-	3
		Largemouth Bass	-	3	2	-
		Yellow Perch	C	-	-	2
			D	1	1	-
	2	Largemouth Bass	-	4	2	-
		White Sucker	-	-	-	2
		Yellow Perch	C	-	-	5
			D	5	2	-
3	1	Brown Bullhead	-	3	1	-
		Largemouth Bass	-	3	1	-
		Yellow Perch	C	-	-	6
			D	6	1	-
	2	Brown Bullhead	-	1	1	-
		Largemouth Bass	-	3	1	-
		Yellow Bullhead	-	2	-	-
		Yellow Perch	D	5	1	-
	3	Brown Bullhead	-	3	1	-
		Largemouth Bass	-	4	2	-
		Yellow Bullhead	-	1	1	-
		Yellow Perch	C	-	-	7
			D	2	1	-
4	1	Largemouth Bass	-	5	2	-
		Yellow Bullhead	-	1	1	-
		Yellow Perch	C	-	-	5
			D	6	2	-
	2	Brown Bullhead	-	5	1	-
		Largemouth Bass	-	5	1	-
		Yellow Bullhead	-	4	2	-
		Yellow Perch	C	-	-	8
			D	9	2	-
5	1	Yellow Bullhead	-	-	-	3
	2	Largemouth Bass	-	6	2	-
		Yellow Bullhead	-	1	1	-
		Yellow Perch	C	-	-	2
			D	6	1	-
	3	Brown Bullhead	-	10	2	-
		Largemouth Bass	-	5	2	-
		Yellow Perch	C	-	-	1
			D	8	2	-
6	0	Brown Bullhead	-	1	1	-
		Largemouth Bass	-	11	3	-
		Yellow Bullhead	-	9	2	-
		Yellow Perch	C	-	-	13
			D	14	3	-
7	1	Brown Bullhead	-	2	1	-
		Largemouth Bass	-	6	2	-
		Yellow Bullhead	-	2	1	-
		Yellow Perch	C	-	-	6
			D	9	2	-
	2	Brown Bullhead	-	2	1	-
		Largemouth Bass	-	7	2	-
		Yellow Bullhead	-	4	-	-
		Yellow Perch	C	-	-	7
			D	5	2	-
	3	Largemouth Bass	-	10	3	-
		Yellow Bullhead	-	10	3	-
		Yellow Perch	C	-	-	13
			D	10	3	-
	X	Brown Bullhead	-	-	-	-
		Largemouth Bass	-	-	-	-
		Yellow Bullhead	-	-	-	-
		Yellow Perch	C	-	-	-
			D	-	-	-

Table 2-1
Nyanza OU IV Fish Summary
Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Reach	Subreach	Species	Size Class	# Samples Collected Fillet	Offal	Whole Body
8	1	Largemouth Bass	-	4	2	-
		Yellow Bullhead	-	3	2	-
		Yellow Perch	C	-	-	10
			D	6	3	-
	2	Bluegill	C	-	-	5
		Brown Bullhead	-	2	2	-
		Largemouth Bass	-	4	2	-
		Yellow Bullhead	-	4	-	-
		Yellow Perch	C	1	-	10
			D	10	4	-
	3	Brown Bullhead	-	5	2	-
		Largemouth Bass	-	3	2	-
		Yellow Perch	C	-	-	10
			D	6	3	-
	X	Brown Bullhead	-	-	-	-
		Largemouth Bass	-	-	-	-
		Yellow Bullhead	-	-	-	-
		Yellow Perch	C	-	-	-
			D	-	-	-
9	0	Brown Bullhead	-	10	3	-
		Largemouth Bass	-	11	3	-
		Yellow Perch	C	-	-	13
			D	14	3	-
10	0	Brown Bullhead	-	7	1	-
		Largemouth Bass	-	11	3	-
		Yellow Bullhead	-	4	2	-
		Yellow Perch	C	1	-	13
			D	13	3	-
Charles River	0	Brown Bullhead	-	2	2	-
		Largemouth Bass	-	10	3	-
		Yellow Bullhead	-	8	1	-
		Yellow Perch	C	-	-	13
			D	13	3	-
Sudbury Reservoir	0	Brown Bullhead	-	2	1	-
		Largemouth Bass	-	9	2	-
		Yellow Bullhead	-	7	2	-
		Yellow Perch	C	1	-	13
			D	13	3	-

Note - Fish from subreaches noted "X" are kingfisher prey.

Table 2-2
Large Fish Fillet Methylmercury to Total Mercury Comparison Summary
Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Species	Total Samples	Range of Concentrations		Mean of Concentrations		Range of MeHg to Total Hg Ratios	Mean MeHg to Total Hg Ratios	Range of RPD	Mean of RPD
		Total Hg	MeHg	Total Hg	MeHg				
Bullhead	35	8.96E+01 - 8.47E+02	7.52E+01 - 6.96E+02	2.70E+02	2.51E+02	0.63 - 1.35	0.94	0 - 46	15
Largemouth Bass	39	1.42E+02 - 1.83E+03	1.23E+02 - 2.07E+03	7.30E+02	7.26E+02	0.63 - 1.35	0.99	1 - 45	17
Yellow Perch	45	5.44E+01 - 8.76E+02	4.53E+01 - 8.33E+02	3.61E+02	3.06E+02	0.12 - 1.32	0.89	1 - 156	22

* All concentrations are presented in ng/g, wet. Duplicates averaged.
RPD = Relative percent difference. Calculated as abs(a-b)÷average(a,b)*100; where a = tHg concentration and b = associated meHg concentration for that sample.

Table 2-3
Large Fish Offal Methylmercury to Total Mercury Comparison Summary
Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Species	Total Samples	Range of Concentrations		Mean of Concentrations		Range of MeHg to Total Hg Ratios	Mean MeHg to Total Hg Ratios	Range of RPD	Mean of RPD
		Total Hg	MeHg	Total Hg	MeHg				
Bullhead	35	4.94E+01 - 4.67E+02	3.94E+01 - 3.14E+02	1.55E+02	1.41E+02	0.46 - 1.60	0.94	1 - 74	22
Largemouth Bass	38	1.09E+02 - 1.09E+03	8.73E+01 - 9.82E+02	4.25E+02	3.76E+02	0.50 - 1.78	0.95	0 - 67	22
Yellow Perch	41	5.20E+01 - 5.30E+02	3.99E+01 - 7.50E+02	1.94E+02	1.93E+02	0.56 - 1.76	0.99	0 - 56	23

* All concentrations are presented in ng/g, wet. Duplicates averaged.
RPD = Relative percent difference. Calculated as abs(a-b)÷average(a,b)*100; where a = tHg concentration and b = associated meHg concentration for that sample.

Table 2-4
Large Fish Whole Body Methylmercury to Total Mercury Comparison Summary
Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Species	Total Samples	Range of Concentrations		Mean of Concentrations		Range of MeHg to Total Hg Ratios	Mean MeHg to Total Hg Ratios	Range of RPD	Mean of RPD
		Total Hg	MeHg	Total Hg	MeHg				
Bullhead	3	8.88E+01 - 1.63E+02	7.66E+01 - 1.63E+02	1.14E+02	1.11E+02	0.86 - 1.02	0.96	0 - 15	6

* All concentrations are presented in ng/g, wet.
RPD = Relative percent difference. Calculated as abs(a-b)÷average(a,b)*100; where a = tHg concentration and b = associated meHg concentration for that sample.

Table 2-5

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 1 - Bullhead	7487-94-7	Mercury	4.23E-01	8.47E-01	mg/kg	S1-0-FFYB0002-0-030729	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	3.31E-01	6.96E-01	mg/kg	S1-0-FFYB0002-0-030729	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 1 - Largemouth Bass	7487-94-7	Mercury	2.96E-01	4.18E-01	mg/kg	S1-0-FFLB0002-0-030729	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	2.14E-01	4.24E-01	mg/kg	S1-0-FFLB0002-0-030729	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 1 - Yellow Perch	7487-94-7	Mercury	3.38E-02	3.65E-01	mg/kg	S1-0-FFYPD008-0-030729	13/13	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.11E-01	1.86E-01	mg/kg	S1-0-FFYPD003-0-030729	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-6

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 1 - Largemouth Bass	7487-94-7	Mercury	1.96E-01	2.55E-01	mg/kg	S1-0-FRLB0002-0-030729	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.69E-01	2.62E-01	mg/kg	S1-0-FRLB0002-0-030729	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 1 - White Sucker	7487-94-7	Mercury	4.00E-02	2.40E-01	mg/kg	S1-0-FWWS0002-0-030730	8/8	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 1 - Yellow Bullhead	7487-94-7	Mercury	5.70E-02	5.55E-01	mg/kg	S1-0-FRYB0002-0-030729	4/4	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	2.05E-01	4.02E-01	mg/kg	S1-0-FRYB0002-0-030729	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 1 - Yellow Perch	7487-94-7	Mercury	3.38E-02	3.65E-01	mg/kg	S1-0-FFYPD008-0-030729	18/18	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	6.88E-02	1.44E-01	mg/kg	S1-0-FRYPD003-0-030729	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.

(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-7

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 2 - Largemouth Bass	7487-94-7	Mercury	4.05E-01	1.50E+00	mg/kg	S2-2-FFLB0009-0-030730	7/7	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	3.97E-01	6.56E-01	mg/kg	S2-0-FFLB0001-0-030730	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 2 - Yellow Perch	7487-94-7	Mercury	1.94E-01	8.76E-01	mg/kg	S2-2-FFYPD008-0-030730	13/13	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.01E-01	7.30E-01	mg/kg	S2-2-FFYPD008-0-030730	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.

(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-8

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 2 - Brown Bullhead	7487-94-7	Mercury	8.88E-02	1.63E-01	mg/kg	S2-1-FWBB0002-0-030730	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	7.66E-02	1.63E-01	mg/kg	S2-1-FWBB0002-0-030730	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 2 - Largemouth Bass	7487-94-7	Mercury	2.52E-01	1.50E+00	mg/kg	S2-2-FFLB0009-0-030730	7/7	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	2.74E-01	4.50E-01	mg/kg	S2-0-FRLB0001-0-030730	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 2 - White Sucker	7487-94-7	Mercury	8.84E-02	1.60E-01	mg/kg	S2-0-FWWS0003-0-030730	4/4	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 2 - Yellow Perch	7487-94-7	Mercury	7.43E-02	6.23E-01	mg/kg	S2-2-FFYPD010-0-030730	26/26	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.86E-01	7.45E-01	mg/kg	S2-2-FRYPD008-0-030730	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-9

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 3 - Bullhead	7487-94-7	Mercury	1.98E-01	1.48E+00	mg/kg	S3-1-FFBB0006-0-030808	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.65E-01	5.15E-01	mg/kg	S3-3-FFBB0012-0-030808	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 3 - Largemouth Bass	7487-94-7	Mercury	5.73E-01	1.76E+00	mg/kg	S3-2-FFLB0007-0-030730	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	8.94E-01	1.20E+00	mg/kg	S3-3-FFLB0011-0-030731	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 3 - Yellow Perch	7487-94-7	Mercury	2.99E-01	9.11E-01	mg/kg	S3-1-FFYPD002-0-030730	12/12	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	5.05E-01	8.33E-01	mg/kg	S3-3-FFYPD011-0-030731	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.

(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-10

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 3 - Bullhead	7487-94-7	Mercury	1.20E-01	1.48E+00	mg/kg	S3-1-FFBB0006-0-030808	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	9.02E-02	3.60E-01	mg/kg	S3-3-FRBB0012-0-030808	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 3 - Largemouth Bass	7487-94-7	Mercury	4.26E-01	1.76E+00	mg/kg	S3-2-FFLB0007-0-030730	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	5.22E-01	8.99E-01	mg/kg	S3-3-FRLB0011-0-030731	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 3 - Yellow Perch	7487-94-7	Mercury	1.12E-01	9.11E-01	mg/kg	S3-1-FFYPD002-0-030730	25/25	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	3.22E-01	5.17E-01	mg/kg	S3-3-FRYPD011-0-030731	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-11

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 4 - Bullhead	7487-94-7	Mercury	1.02E-01	4.13E-01	mg/kg	S4-2-FFYB0004-0-030807	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.15E-01	3.06E-01	mg/kg	S4-1-FFYB0001-0-030731	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 4 - Largemouth Bass	7487-94-7	Mercury	4.66E-01	9.13E-01	mg/kg	S4-1-FFLB0003-0-030731	9/9	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	7.46E-01	9.18E-01	mg/kg	S4-2-FFLB0006-0-030731	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 4 - Yellow Perch	7487-94-7	Mercury	1.68E-01	7.42E-01	mg/kg	S4-2-FFYPD007-0-030731	13/13	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	4.76E-01	7.29E-01	mg/kg	S4-1-FFYPD001-0-030731	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-12

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 4 - Bullhead	7487-94-7	Mercury	9.98E-02	3.50E-01	mg/kg	S4-2-FFYB0006-0-030807	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	9.96E-02	2.64E-01	mg/kg	S4-1-FRYB0001-0-030731	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 4 - Largemouth Bass	7487-94-7	Mercury	4.30E-01	9.13E-01	mg/kg	S4-1-FFLB0003-0-030731	9/9	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	4.73E-01	7.31E-01	mg/kg	S4-2-FRLB0006-0-030731	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 4 - Yellow Perch	7487-94-7	Mercury	7.38E-02	6.92E-01	mg/kg	S4-1-FFYPD004-0-030731	26/26	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	3.12E-01	4.92E-01	mg/kg	S4-1-FRYPD001-0-030731	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-13

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 5 - Bullhead	7487-94-7	Mercury	1.26E-01	3.42E-01	mg/kg	S5-3-FFBB0005-0-030801	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.99E-01	2.81E-01	mg/kg	S5-3-FFBB0002-0-030801	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 5 - Largemouth Bass	7487-94-7	Mercury	3.98E-01	8.24E-01	mg/kg	S5-2-FFLB0003-0-030731	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	4.77E-01	8.14E-01	mg/kg	S5-2-FFLB0002-0-030731	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 5 - Yellow Perch	7487-94-7	Mercury	1.22E-01	8.24E-01	mg/kg	S5-3-FFYPD007-0-030801	13/13	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.98E-01	7.82E-01	mg/kg	S5-3-FFYPD007-0-030801	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-14

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 5 - Bullhead	7487-94-7	Mercury	1.26E-01	3.42E-01	mg/kg	S5-3-FFBB0005-0-030801	13/13	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.23E-01	1.77E-01	mg/kg	S5-3-FRBB0002-0-030801	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 5 - Largemouth Bass	7487-94-7	Mercury	2.64E-01	8.24E-01	mg/kg	S5-2-FFLB0003-0-030731	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	3.17E-01	5.84E-01	mg/kg	S5-2-FRLB0002-0-030731	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 5 - Yellow Perch	7487-94-7	Mercury	1.11E-01	5.05E-01	mg/kg	S5-3-FFYPD011-0-030801	16/16	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.53E-01	6.36E-01	mg/kg	S5-3-FRYPD007-0-030801	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.

(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-15

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 6 - Bullhead	7487-94-7	Mercury	1.92E-01	6.10E-01	mg/kg	S6-0-FFYB0003-0-030807	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.53E-01	5.91E-01	mg/kg	S6-0-FFYB0003-0-030807	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 6 - Largemouth Bass	7487-94-7	Mercury	3.64E-01	1.09E+00	mg/kg	S6-0-FFLB0008-0-030807	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	6.96E-01	1.07E+00	mg/kg	S6-0-FFLB0001-0-030807	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 6 - Yellow Perch	7487-94-7	Mercury	1.24E-01	6.02E-01	mg/kg	S6-0-FFYPD006-0-030807	13/13	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	2.05E-01	2.93E-01	mg/kg	S6-0-FFYPD001-0-030807	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.

(2) To date, no background study has been completed.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-16

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 6 - Bullhead	7487-94-7	Mercury	1.03E-01	6.00E-01	mg/kg	S6-0-FFYB0004-0-030807	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	9.61E-02	2.92E-01	mg/kg	S6-0-FRYB0003-0-030807	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 6 - Largemouth Bass	7487-94-7	Mercury	3.64E-01	1.09E+00	mg/kg	S6-0-FFLB0008-0-030807	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	4.06E-01	6.39E-01	mg/kg	S6-0-FRLB0001-0-030807	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 6 - Yellow Perch	7487-94-7	Mercury	5.78E-02	6.02E-01	mg/kg	S6-0-FFYPD006-0-030807	26/26	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.40E-01	2.23E-01	mg/kg	S6-0-FRYPD001-0-030807	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-17

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 7 - Bullhead	7487-94-7	Mercury	1.47E-01	6.44E-01	mg/kg	S7-2-FFYB0011-0-030805	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.23E-01	3.44E-01	mg/kg	S7-1-FFYB0003-0-030804	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 7 - Largemouth Bass	7487-94-7	Mercury	3.87E-01	1.05E+00	mg/kg	S7-2-FFLB0009-0-030804	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	6.13E-01	9.17E-01	mg/kg	S7-2-FFLB0002-0-030804	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 7 - Yellow Perch	7487-94-7	Mercury	1.53E-01	3.36E-01	mg/kg	S7-2-FFYPD001-0-030804	13/13	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.74E-01	2.64E-01	mg/kg	S7-2-FFYPD001-0-030804	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 7 - Heard Pond - Bullhead	7487-94-7	Mercury	2.41E-02	1.51E-01	mg/kg	S7-3-FFYB0010-0-040811	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.27E-01	1.85E-01	mg/kg	S7-3-FFYB0010-0-040811	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 7 - Heard Pond - Largemouth Bass	7487-94-7	Mercury	8.89E-02	2.45E-01	mg/kg	S7-3-FFLB0010-1-040811	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.29E-01	2.79E-01	mg/kg	S7-3-FFLB0010-0-040811	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 7 - Heard Pond - Yellow Perch	7487-94-7	Mercury	2.17E-02	1.05E-01	mg/kg	S7-3-FFYPD008-0-040811	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	4.53E-02	1.05E-01	mg/kg	S7-3-FFYPD008-0-040811	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-18

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 7 - Bullhead	7487-94-7	Mercury	1.06E-01	6.44E-01	mg/kg	S7-2-FFYB0011-0-030805	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	7.59E-02	2.69E-01	mg/kg	S7-1-FRYB0003-0-030804	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 7 - Largemouth Bass	7487-94-7	Mercury	3.62E-01	1.05E+00	mg/kg	S7-2-FFLB0009-0-030804	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	4.33E-01	7.16E-01	mg/kg	S7-2-FRLB0002-0-030804	2/2	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 7 - Yellow Perch	7487-94-7	Mercury	8.08E-02	2.70E-01	mg/kg	S7-2-FFYPD009-0-030804	26/26	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.28E-01	2.03E-01	mg/kg	S7-2-FRYPD001-0-030804	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 7 - Heard Pond - Bullhead	7487-94-7	Mercury	2.41E-02	1.27E-01	mg/kg	S7-3-FRYB0007-0-040812	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.04E-01	1.26E-01	mg/kg	S7-3-FRYB0008-0-040811	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 7 - Heard Pond - Largemouth Bass	7487-94-7	Mercury	8.89E-02	1.93E-01	mg/kg	S7-3-FRLB0010-0-040811	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	9.99E-02	2.37E-01	mg/kg	S7-3-FRLB0010-0-040811	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 7 - Heard Pond - Yellow Perch	7487-94-7	Mercury	2.12E-02	7.62E-02	mg/kg	S7-3-FRYPD008-0-040811	23/23	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	4.52E-02	6.81E-02	mg/kg	S7-3-FRYPD008-0-040811	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.

(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-19

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 8 - Bullhead	7487-94-7	Mercury	8.96E-02	8.62E-01	mg/kg	S8-1-FFYB0001-0-030805	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	7.52E-02	1.72E-01	mg/kg	S8-2-FFBB0001-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 8 - Largemouth Bass	7487-94-7	Mercury	6.21E-01	1.66E+00	mg/kg	S8-1-FFLB0001-0-030805	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	7.18E-01	1.50E+00	mg/kg	S8-1-FFLB0001-0-030805	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 8 - Yellow Perch	7487-94-7	Mercury	1.97E-01	6.09E-01	mg/kg	S8-3-FFYPD003-0-030805	22/22	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.14E-01	3.91E-01	mg/kg	S8-3-FFYPD001-0-030805	5/5	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-20

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 8 - Bullhead	7487-94-7	Mercury	5.91E-02	4.97E-01	mg/kg	S8-2-FFYB0005-0-030806	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	4.80E-02	1.42E-01	mg/kg	S8-2-FRBB0001-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 8 - Bluegill	7487-94-7	Mercury	2.12E-01	3.49E-01	mg/kg	S8-2-FWBGC301-0-031014	5/5	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 8 - Largemouth Bass	7487-94-7	Mercury	3.88E-01	1.22E+00	mg/kg	S8-1-FFLB0004-0-030805	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	4.55E-01	9.45E-01	mg/kg	S8-1-FRLB0001-0-030805	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 8 - Yellow Perch	7487-94-7	Mercury	8.62E-02	6.09E-01	mg/kg	S8-3-FFYPD003-0-030805	52/52	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	8.42E-02	2.87E-01	mg/kg	S8-3-FRYPD001-0-030805	5/5	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-21

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 9 - Bullhead	7487-94-7	Mercury	1.75E-01	2.85E-01	mg/kg	S9-0-FFBB0008-0-030806	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.55E-01	2.14E-01	mg/kg	S9-0-FFBB0001-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 9 - Largemouth Bass	7487-94-7	Mercury	6.45E-01	1.83E+00	mg/kg	S9-0-FFLB0001-0-030806	9/9	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	7.83E-01	1.38E+00	mg/kg	S9-0-FFLB0001-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 9 - Yellow Perch	7487-94-7	Mercury	2.40E-01	6.10E-01	mg/kg	S9-0-FFYPD005-0-030806	13/13	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	3.15E-01	3.85E-01	mg/kg	S9-0-FFYPD002-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.

(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-22

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 9 - Brown Bullhead	7487-94-7	Mercury	1.52E-01	2.80E-01	mg/kg	S9-0-FFBB0008-0-030806	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	9.52E-02	1.35E-01	mg/kg	S9-0-FRBB0001-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 9 - Largemouth Bass	7487-94-7	Mercury	6.45E-01	1.43E+00	mg/kg	S9-0-FFLB0009-0-030807	9/9	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	4.98E-01	7.99E-01	mg/kg	S9-0-FRLB0001-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 9 - Yellow Perch	7487-94-7	Mercury	1.36E-01	6.10E-01	mg/kg	S9-0-FFYPD005-0-030806	26/26	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.78E-01	2.58E-01	mg/kg	S9-0-FRYPD001-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-23

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 10 - Bullhead	7487-94-7	Mercury	9.86E-02	8.71E-01	mg/kg	S0-0-FFBB0005-0-030807	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.88E-01	3.84E-01	mg/kg	S0-0-FFYB0002-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 10 - Largemouth Bass	7487-94-7	Mercury	3.96E-01	1.66E+00	mg/kg	S0-0-FFLB0002-0-030806	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.15E+00	2.07E+00	mg/kg	S0-0-FFLB0002-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 10 - Yellow Perch	7487-94-7	Mercury	2.16E-01	6.63E-01	mg/kg	S0-0-FFYPD007-0-030806	13/13	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	2.42E-01	6.71E-01	mg/kg	S0-0-FFYPD001-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-24

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Reach 10 - Bullhead	7487-94-7	Mercury	9.86E-02	8.71E-01	mg/kg	S0-0-FFBB0005-0-030807	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.28E-01	2.84E-01	mg/kg	S0-0-FRYB0002-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 10 - Largemouth Bass	7487-94-7	Mercury	3.96E-01	1.27E+00	mg/kg	S0-0-FRLB0003-0-030806	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	7.11E-01	1.31E+00	mg/kg	S0-0-FRLB0002-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Reach 10 - Yellow Perch	7487-94-7	Mercury	1.46E-01	6.52E-01	mg/kg	S0-0-FFYPD007-0-030806	26/26	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.61E-01	4.66E-01	mg/kg	S0-0-FRYPD001-0-030806	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.

(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-25

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Charles River - Bullhead	7487-94-7	Mercury	1.24E-01	5.48E-01	mg/kg	CR-0-FFYB0004-0-030729	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.08E-01	2.40E-01	mg/kg	CR-0-FFBB0002-0-030728	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Charles River - Largemouth Bass	7487-94-7	Mercury	2.66E-01	5.59E-01	mg/kg	CR-0-FFLB0008-0-030728	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	3.21E-01	6.39E-01	mg/kg	CR-0-FFLB0003-0-030728	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Charles River - Yellow Perch	7487-94-7	Mercury	1.20E-01	2.36E-01	mg/kg	CR-0-FFYPD011-0-030728	13/13	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.41E-01	3.03E-01	mg/kg	CR-0-FFYPD001-0-030728	5/5	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-26

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Charles River - Bullhead	7487-94-7	Mercury	7.95E-02	5.48E-01	mg/kg	CR-0-FFYB0004-0-030729	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	6.14E-02	1.66E-01	mg/kg	CR-0-FRBB0002-0-030728	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Charles River - Largemouth Bass	7487-94-7	Mercury	2.49E-01	5.59E-01	mg/kg	CR-0-FFLB0008-0-030728	10/10	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	2.64E-01	4.41E-01	mg/kg	CR-0-FRLB0003-0-030728	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Charles River - Yellow Perch	7487-94-7	Mercury	9.05E-02	2.36E-01	mg/kg	CR-0-FFYPD011-0-030728	26/26	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.27E-01	2.19E-01	mg/kg	CR-0-FRYPD001-0-030728	5/5	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-27

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Sudbury Reservoir - Bullhead	7487-94-7	Mercury	8.44E-02	3.07E-01	mg/kg	SR-0-FFBB0003-0-030729	9/9	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	9.82E-02	3.10E-01	mg/kg	SR-0-FFBB0003-0-030729	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Sudbury Reservoir - Largemouth Bass	7487-94-7	Mercury	1.94E-01	6.16E-01	mg/kg	SR-0-FFLB0006-0-030729	7/7	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.23E-01	2.62E-01	mg/kg	SR-0-FFLB0001-0-030729	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Sudbury Reservoir - Yellow Perch	7487-94-7	Mercury	6.68E-02	1.78E-01	mg/kg	SR-0-FFYPD002-0-030729	13/13	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	9.01E-02	1.64E-01	mg/kg	SR-0-FFYPD002-0-030729	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

Table 2-28

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Sample with Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (1) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Sudbury Reservoir - Bullhead	7487-94-7	Mercury	8.44E-02	2.73E-01	mg/kg	SR-0-FFBB0008-0-030730	9/9	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	8.78E-02	1.83E-01	mg/kg	SR-0-FRBB0003-0-030729	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Sudbury Reservoir - Largemouth Bass	7487-94-7	Mercury	1.55E-01	6.16E-01	mg/kg	SR-0-FFLB0006-0-030729	7/7	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	1.23E-01	2.12E-01	mg/kg	SR-0-FRLB0002-0-030729	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
Sudbury Reservoir - Yellow Perch	7487-94-7	Mercury	3.32E-02	1.38E-01	mg/kg	SR-0-FFYPD013-0-030729	26/26	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A
	22967-92-6	Methylmercury	7.61E-02	1.18E-01	mg/kg	SR-0-FRYPD002-0-030729	3/3	NA	N/A	N/A	N/A	N/A	N/A	Y	N/A

(1) All chemicals carried through as COPCs.
(2) To date, no background study has been completed.

Definitions: ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
COPC = Chemical of Potential Concern
N/A = Not Applicable

TABLE 3-1

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD: Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Mercury	Chronic	1.00E-04	mg/kg/day	1	1.00E-04	mg/kg/day	Nervous System (Developmental)	10	IRIS (MeHg value)	6/1/2005

(1) Source: Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. Section 4.2 and Exhibit 4-1.

Definitions: IRIS=Integrated Risk Information System

Table 4-1
SELECTION OF EXPOSURE PATHWAYS
Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Fish Tissue	Fillet (Skin On)	Reaches 1 through 10, Charles River, and Sudbury Reservoir	Recreational angler	Child	Ingestion	On-site	Quantitative	Sudbury River is stocked with trout by Massachusetts Fish and Wildlife for catch and release programs. Other edible fish present in the river. Cannot guarantee that individuals heed consumption advisories.
					Adult	Ingestion	On-site	Quantitative	Sudbury River is stocked with trout by Massachusetts Fish and Wildlife for catch and release programs. Other edible fish present in the river. Cannot guarantee that individuals heed consumption advisories.
				Subsistence Fisher	Child	Ingestion	On-site	None	Highly unlikely that the child of the subsistence angler would only consume fish fillets from the Sudbury River as a sole source of dietary protein.
					Adult	Ingestion	On-site	Quantitative	Sudbury River is stocked with trout by Massachusetts Fish and Wildlife for catch and release programs. Other edible fish present in the river. Both river and fish base large enough to provide sufficient fish to fulfill daily protein needs. Cannot guarantee that individuals heed consumption advisories.
				Ethnic Fisher	Child	Ingestion	On-site	None	Anecdotal evidence of ethnic group living within the Sudbury River area that subsists on locally caught whole body fish rather than fillet fish tissue.
					Adult	Ingestion	On-site	None	Anecdotal evidence of ethnic group living within the Sudbury River area that subsists on locally caught whole body fish rather than fillet fish tissue.
		Whole Body	Reaches 1 through 10, Charles River, and Sudbury Reservoir	Recreational angler	Child	Ingestion	On-site	None	Exposure to ethnic fisher expected to be greater than to a recreational angler. Insufficient data available upon which to base recreational angler child fish ingestion rate for whole body fish tissue.
					Adult	Ingestion	On-site	None	Exposure to ethnic fisher expected to be greater than to a recreational angler. Insufficient data available upon which to base recreational angler adult fish ingestion rate for whole body fish tissue.
				Subsistence Fisher	Child	Ingestion	On-site	None	Exposure to ethnic fisher expected to be greater than to a subsistence angler. Insufficient data available upon which to base subsistence angler child fish ingestion rate for whole body fish tissue.
					Adult	Ingestion	On-site	None	Exposure to ethnic fisher expected to be greater than to a subsistence angler. Insufficient data available upon which to base subsistence angler adult fish ingestion rate for whole body fish tissue.
				Ethnic Fisher	Child	Ingestion	On-site	Quantitative	Anecdotal evidence of ethnic group living within the Sudbury River area that subsists on locally caught whole body fish.
					Adult	Ingestion	On-site	Quantitative	Anecdotal evidence of ethnic group living within the Sudbury River area that subsists on locally caught whole body fish.

TABLE 4-2

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
						Value	Units	Statistic	Rationale
Reach 1 - Bullhead	Mercury	mg/kg	6.35E-01	---	8.47E-01	8.47E-01	mg/kg	Max	W-Test (2)
	Methylmercury	mg/kg	5.14E-01	---	6.96E-01	6.96E-01	mg/kg	Max	W-Test (2)
Reach 1 - Largemouth Bass	Mercury	mg/kg	3.57E-01	---	4.18E-01	4.18E-01	mg/kg	Max	W-Test (2)
	Methylmercury	mg/kg	3.19E-01	---	4.24E-01	4.24E-01	mg/kg	Max	W-Test (2)
Reach 1 - Yellow Perch	Mercury	mg/kg	2.39E-01	2.83E-01 (N)	3.65E-01	2.83E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.58E-01	---	1.86E-01	1.86E-01	mg/kg	Max	W-Test (2)
Reach 1 - Aggregate (7)	Mercury	mg/kg	N/A	N/A	N/A	5.16E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A	N/A	4.35E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-3

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 1 - Yellow Bullhead	Mercury	mg/kg	2.66E-01	5.12E-01	(N)	5.55E-01	5.12E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	3.04E-01	---		4.02E-01	4.02E-01	mg/kg	Max	W-Test (2)
Reach 1 - Largemouth Bass	Mercury	mg/kg	2.25E-01	---		2.55E-01	2.55E-01	mg/kg	Max	W-Test (2)
	Methylmercury	mg/kg	2.15E-01	---		2.62E-01	2.62E-01	mg/kg	Max	W-Test (2)
Reach 1 - White Sucker	Mercury	mg/kg	9.65E-02	1.48E-01	(G)	2.40E-01	1.48E-01	mg/kg	Approximate Gamma UCL	KS-Test (4)
Reach 1 - Yellow Perch	Mercury	mg/kg	1.97E-01	2.37E-01	(N)	3.65E-01	2.37E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.12E-01	---		1.44E-01	1.44E-01	mg/kg	Max	W-Test (2)
Reach 1 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	2.88E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	2.69E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(2) 95% UCL exceeds maximum detected concentration. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(6) Shapiro-Wilk W Test indicates data are neither normally nor lognormally distributed. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: G = Gamma
Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-4

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 2 - Largemouth Bass	Mercury	mg/kg	8.53E-01	1.14E+00	(N)	1.50E+00	1.14E+00	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	5.27E-01	---		6.56E-01	6.56E-01	mg/kg	Max	W-Test (2)
Reach 2 - Yellow Perch	Mercury	mg/kg	4.34E-01	5.27E-01	(N)	8.76E-01	5.27E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	4.21E-01	---		7.30E-01	7.30E-01	mg/kg	Max	W-Test (2)
Reach 2 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	8.31E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	6.93E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL exceeds maximum detected concentration. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Shapiro-Wilk W Test indicates data are neither normally nor lognormally distributed. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-5

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Reach 2 Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 2 - Brown Bullhead	Mercury	mg/kg	1.26E-01	---		1.63E-01	1.63E-01	mg/kg	Max	W-Test (2)
	Methylmercury	mg/kg	1.20E-01	---		1.63E-01	1.63E-01	mg/kg	Max	W-Test (2)
Reach 2 - Largemouth Bass	Mercury	mg/kg	6.89E-01	1.01E+00	(N)	1.50E+00	1.01E+00	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	3.62E-01	---		4.50E-01	4.50E-01	mg/kg	Max	W-Test (2)
Reach 2 - White Sucker	Mercury	mg/kg	1.18E-01	1.55E-01	(N)	1.60E-01	1.55E-01	mg/kg	Student's-t UCL	W-Test (3)
Reach 2 - Yellow Perch	Mercury	mg/kg	2.73E-01	3.21E-01	(N)	6.23E-01	3.21E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	3.88E-01	---		7.45E-01	7.45E-01	mg/kg	Max	W-Test (2)
Reach 2 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	4.12E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	4.53E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(2) 95% UCL exceeds maximum detected concentration. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(6) Shapiro-Wilk W Test indicates data are neither normally nor lognormally distributed. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-6

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 3 - Bullhead	Mercury	mg/kg	7.31E-01	9.37E-01	(N)	1.48E+00	9.37E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	3.81E-01	---		5.15E-01	5.15E-01	mg/kg	Max	W-Test (2)
Reach 3 - Largemouth Bass	Mercury	mg/kg	9.91E-01	1.21E+00	(N)	1.76E+00	1.21E+00	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.03E+00	---		1.20E+00	1.20E+00	mg/kg	Max	W-Test (2)
Reach 3 - Yellow Perch	Mercury	mg/kg	5.60E-01	6.65E-01	(N)	9.11E-01	6.65E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	6.20E-01	---		8.33E-01	8.33E-01	mg/kg	Max	W-Test (2)
Reach 3 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	9.36E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	8.49E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size ≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-7

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 3 - Bullhead	Mercury	mg/kg	6.62E-01	8.91E-01	(N)	1.48E+00	8.91E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	2.65E-01	---		3.60E-01	3.60E-01	mg/kg	Max	W-Test (2)
Reach 3 - Largemouth Bass	Mercury	mg/kg	8.62E-01	1.13E+00	(G)	1.76E+00	1.13E+00	mg/kg	Approximate Gamma UCL	KS-Test (4)
	Methylmercury	mg/kg	6.95E-01	---		8.99E-01	8.99E-01	mg/kg	Max	W-Test (2)
Reach 3 - Yellow Perch	Mercury	mg/kg	3.81E-01	4.51E-01	(G)	9.11E-01	4.51E-01	mg/kg	Approximate Gamma UCL	KS-Test (4)
	Methylmercury	mg/kg	4.19E-01	---		5.17E-01	5.17E-01	mg/kg	Max	W-Test (2)
Reach 3 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	8.23E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	5.92E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size ≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: G = Gamma
Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-8

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 4 - Bullhead	Mercury	mg/kg	2.52E-01	3.12E-01	(N)	4.13E-01	3.12E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	2.15E-01	---		3.06E-01	3.06E-01	mg/kg	Max	W-Test (2)
Reach 4 - Largemouth Bass	Mercury	mg/kg	7.28E-01	8.15E-01	(N)	9.13E-01	8.15E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	8.35E-01	---		9.18E-01	9.18E-01	mg/kg	Max	W-Test (2)
Reach 4 - Yellow Perch	Mercury	mg/kg	5.19E-01	6.09E-01	(N)	7.42E-01	6.09E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	6.37E-01	---		7.29E-01	7.29E-01	mg/kg	Max	W-Test (2)
Reach 4 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	5.78E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	6.51E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size ≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-9

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 4 - Bullhead	Mercury	mg/kg	2.31E-01	2.86E-01	(N)	3.50E-01	2.86E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.78E-01	---		2.64E-01	2.64E-01	mg/kg	Max	W-Test (2)
Reach 4 - Largemouth Bass	Mercury	mg/kg	6.68E-01	7.85E-01	(N)	9.13E-01	7.85E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	5.73E-01	---		7.31E-01	7.31E-01	mg/kg	Max	W-Test (2)
Reach 4 - Yellow Perch	Mercury	mg/kg	3.05E-01	4.01E-01	(T)	6.92E-01	4.01E-01	mg/kg	95% H-UCL	W-Test (5)
	Methylmercury	mg/kg	4.04E-01	---		4.92E-01	4.92E-01	mg/kg	Max	W-Test (2)
Reach 4 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	4.91E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	4.95E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable
T = Transformed

TABLE 4-10

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 5 - Bullhead	Mercury	mg/kg	1.98E-01	2.39E-01	(N)	3.42E-01	2.39E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	2.43E-01	---		2.81E-01	2.81E-01	mg/kg	Max	W-Test (2)
Reach 5 - Largemouth Bass	Mercury	mg/kg	6.45E-01	7.22E-01	(N)	8.24E-01	7.22E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	6.44E-01	---		8.14E-01	8.14E-01	mg/kg	Max	W-Test (2)
Reach 5 - Yellow Perch	Mercury	mg/kg	3.27E-01	4.30E-01	(G)	8.24E-01	4.30E-01	mg/kg	Approximate Gamma UCL	KS-Test (4)
	Methylmercury	mg/kg	4.42E-01	---		7.82E-01	7.82E-01	mg/kg	Max	W-Test (2)
Reach 5 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	4.63E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	6.26E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: G = Gamma
Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-11

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 5 - Bullhead	Mercury	mg/kg	1.78E-01	2.04E-01	(G)	3.42E-01	2.04E-01	mg/kg	Approximate Gamma UCL	KS-Test (4)
	Methylmercury	mg/kg	1.58E-01	---		1.77E-01	1.77E-01	mg/kg	Max	W-Test (2)
Reach 5 - Largemouth Bass	Mercury	mg/kg	5.61E-01	6.67E-01	(N)	8.24E-01	6.67E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	4.35E-01	---		5.84E-01	5.84E-01	mg/kg	Max	W-Test (2)
Reach 5 - Yellow Perch	Mercury	mg/kg	2.59E-01	3.15E-01	(N)	5.05E-01	3.15E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	3.78E-01	---		6.36E-01	6.36E-01	mg/kg	Max	W-Test (2)
Reach 5 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	3.96E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	4.66E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size ≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: G = Gamma
Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-12

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 6 - Bullhead	Mercury	mg/kg	4.01E-01	4.90E-01	(N)	6.10E-01	4.90E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	4.03E-01	---		5.91E-01	5.91E-01	mg/kg	Max	W-Test (2)
Reach 6 - Largemouth Bass	Mercury	mg/kg	7.55E-01	9.10E-01	(N)	1.09E+00	9.10E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	8.86E-01	---		1.07E+00	1.07E+00	mg/kg	Max	W-Test (2)
Reach 6 - Yellow Perch	Mercury	mg/kg	3.27E-01	4.01E-01	(N)	6.02E-01	4.01E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	2.60E-01	---		2.93E-01	2.93E-01	mg/kg	Max	W-Test (2)
Reach 6 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	6.00E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	6.51E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size ≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-13

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 6 - Bullhead	Mercury	mg/kg	3.44E-01	4.29E-01	(N)	6.00E-01	4.29E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	2.22E-01	---		2.92E-01	2.92E-01	mg/kg	Max	W-Test (2)
Reach 6 - Largemouth Bass	Mercury	mg/kg	6.83E-01	8.44E-01	(N)	1.09E+00	8.44E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	5.04E-01	---		6.39E-01	6.39E-01	mg/kg	Max	W-Test (2)
Reach 6 - Yellow Perch	Mercury	mg/kg	1.97E-01	2.51E-01	(G)	6.02E-01	2.51E-01	mg/kg	Approximate Gamma UCL	KS-Test (4)
	Methylmercury	mg/kg	1.87E-01	---		2.23E-01	2.23E-01	mg/kg	Max	W-Test (2)
Reach 6 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	5.08E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	3.85E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable
T = Transformed

TABLE 4-14

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 7 - Bullhead	Mercury	mg/kg	3.26E-01	4.11E-01	(N)	6.44E-01	4.11E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	2.10E-01	---		3.44E-01	3.44E-01	mg/kg	Max	W-Test (2)
Reach 7 - Largemouth Bass	Mercury	mg/kg	7.29E-01	8.67E-01	(N)	1.05E+00	8.67E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	7.65E-01	---		9.17E-01	9.17E-01	mg/kg	Max	W-Test (2)
Reach 7 - Yellow Perch	Mercury	mg/kg	2.10E-01	2.36E-01	(N)	3.36E-01	2.36E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	2.19E-01	---		2.64E-01	2.64E-01	mg/kg	Max	W-Test (2)
Reach 7 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	5.05E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	5.08E-01	mg/kg	N/A	N/A
Reach 7 - Heard Pond - Bullhead	Mercury	mg/kg	9.81E-02	1.20E-01	(N)	1.51E-01	1.20E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.60E-01	---		1.85E-01	1.85E-01	mg/kg	Max	W-Test (2)
Reach 7 - Heard Pond - Largemouth Bass	Mercury	mg/kg	1.39E-01	1.68E-01	(N)	2.45E-01	1.68E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	2.03E-01	---		2.79E-01	2.79E-01	mg/kg	Max	W-Test (2)
Reach 7 - Heard Pond - Yellow Perch	Mercury	mg/kg	5.56E-02	6.66E-02	(N)	1.05E-01	6.66E-02	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	6.22E-02	---		1.05E-01	1.05E-01	mg/kg	Max	W-Test (2)
Reach 7 - Heard Pond - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	1.18E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	1.90E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-15

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 7 - Bullhead	Mercury	mg/kg	3.07E-01	3.99E-01	(N)	6.44E-01	3.99E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.45E-01	---		2.69E-01	2.69E-01	mg/kg	Max	W-Test (2)
Reach 7 - Largemouth Bass	Mercury	mg/kg	6.63E-01	8.02E-01	(N)	1.05E+00	8.02E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	5.74E-01	---		7.16E-01	7.16E-01	mg/kg	Max	W-Test (2)
Reach 7 - Yellow Perch	Mercury	mg/kg	1.52E-01	1.69E-01	(N)	2.70E-01	1.69E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.64E-01	---		2.03E-01	2.03E-01	mg/kg	Max	W-Test (2)
Reach 7 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	4.57E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	3.96E-01	mg/kg	N/A	N/A
Reach 7 - Heard Pond - Bullhead	Mercury	mg/kg	8.75E-02	1.05E-01	(N)	1.27E-01	1.05E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.18E-01	---		1.26E-01	1.26E-01	mg/kg	Max	W-Test (2)
Reach 7 - Heard Pond - Largemouth Bass	Mercury	mg/kg	1.28E-01	1.49E-01	(N)	1.93E-01	1.49E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.64E-01	---		2.37E-01	2.37E-01	mg/kg	Max	W-Test (2)
Reach 7 - Heard Pond - Yellow Perch	Mercury	mg/kg	4.27E-02	4.83E-02	(N)	7.62E-02	4.83E-02	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	5.39E-02	---		6.81E-02	6.81E-02	mg/kg	Max	W-Test (2)
Reach 7 - Heard Pond - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	1.01E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	1.44E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-16

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 8 - Bullhead	Mercury	mg/kg	3.45E-01	4.79E-01	(N)	8.62E-01	4.79E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.35E-01	---		1.72E-01	1.72E-01	mg/kg	Max	W-Test (2)
Reach 8 - Largemouth Bass	Mercury	mg/kg	1.02E+00	1.21E+00	(N)	1.66E+00	1.21E+00	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	9.99E-01	---		1.50E+00	1.50E+00	mg/kg	Max	W-Test (2)
Reach 8 - Yellow Perch	Mercury	mg/kg	3.47E-01	3.88E-01	(N)	6.09E-01	3.88E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	2.68E-01	3.66E-01	(N)	3.91E-01	3.66E-01	mg/kg	Student's-t UCL	W-Test (3)
Reach 8 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	6.91E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	6.79E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-17

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 8 - Bullhead	Mercury	mg/kg	2.73E-01	3.72E-01	(N)	4.97E-01	3.72E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	9.78E-02	---		1.42E-01	1.42E-01	mg/kg	Max	W-Test (2)
Reach 8 - Bluegill	Mercury	mg/kg	2.71E-01	3.26E-01	(N)	3.49E-01	3.26E-01	mg/kg	Student's-t UCL	W-Test (3)
Reach 8 - Largemouth Bass	Mercury	mg/kg	8.15E-01	9.63E-01	(N)	1.22E+00	9.63E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	6.57E-01	---		9.45E-01	9.45E-01	mg/kg	Max	W-Test (2)
Reach 8 - Yellow Perch	Mercury	mg/kg	2.10E-01	2.32E-01	(G)	6.09E-01	2.32E-01	mg/kg	Approximate Gamma UCL	KS-Test (4)
	Methylmercury	mg/kg	1.94E-01	2.68E-01	(N)	2.87E-01	2.68E-01	mg/kg	Student's-t UCL	W-Test (3)
Reach 8 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	4.73E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	4.51E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size ≤ 3.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(2) 95% UCL exceeds maximum detected concentration. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(6) Shapiro-Wilk W Test indicates data are neither normally nor lognormally distributed. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: G = Gamma
Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-18

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 9 - Bullhead	Mercury	mg/kg	2.18E-01	2.40E-01	(N)	2.85E-01	2.40E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.93E-01	---		2.14E-01	2.14E-01	mg/kg	Max	W-Test (2)
Reach 9 - Largemouth Bass	Mercury	mg/kg	1.07E+00	1.31E+00	(N)	1.83E+00	1.31E+00	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.11E+00	---		1.38E+00	1.38E+00	mg/kg	Max	W-Test (2)
Reach 9 - Yellow Perch	Mercury	mg/kg	4.40E-01	5.07E-01	(N)	6.10E-01	5.07E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	3.53E-01	---		3.85E-01	3.85E-01	mg/kg	Max	W-Test (2)
Reach 9 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	6.85E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	6.60E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-19

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 9 - Brown Bullhead	Mercury	mg/kg	1.98E-01	2.18E-01	(N)	2.80E-01	2.18E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.14E-01	---		1.35E-01	1.35E-01	mg/kg	Max	W-Test (2)
Reach 9 - Largemouth Bass	Mercury	mg/kg	9.26E-01	1.11E+00	(N)	1.43E+00	1.11E+00	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	6.59E-01	---		7.99E-01	7.99E-01	mg/kg	Max	W-Test (2)
Reach 9 - Yellow Perch	Mercury	mg/kg	2.84E-01	3.37E-01	(G)	6.10E-01	3.37E-01	mg/kg	Approximate Gamma UCL	KS-Test (4)
	Methylmercury	mg/kg	2.31E-01	---		2.58E-01	2.58E-01	mg/kg	Max	W-Test (2)
Reach 9 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	5.53E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	3.98E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: G = Gamma
Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-20

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 10 - Bullhead	Mercury	mg/kg	3.45E-01	4.86E-01	(N)	8.71E-01	4.86E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	2.73E-01	---		3.84E-01	3.84E-01	mg/kg	Max	W-Test (2)
Reach 10 - Largemouth Bass	Mercury	mg/kg	9.55E-01	1.21E+00	(N)	1.66E+00	1.21E+00	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.69E+00	---		2.07E+00	2.07E+00	mg/kg	Max	W-Test (2)
Reach 10 - Yellow Perch	Mercury	mg/kg	3.85E-01	4.58E-01	(N)	6.63E-01	4.58E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	3.82E-01	---		6.71E-01	6.71E-01	mg/kg	Max	W-Test (2)
Reach 10 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	7.19E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	1.04E+00	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-21

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Reach 10 - Bullhead	Mercury	mg/kg	3.23E-01	5.12E-01	(G)	8.71E-01	5.12E-01	mg/kg	Approximate Gamma UCL	KS-Test (4)
	Methylmercury	mg/kg	2.03E-01	---		2.84E-01	2.84E-01	mg/kg	Max	W-Test (2)
Reach 10 - Largemouth Bass	Mercury	mg/kg	8.51E-01	1.03E+00	(N)	1.27E+00	1.03E+00	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.07E+00	---		1.31E+00	1.31E+00	mg/kg	Max	W-Test (2)
Reach 10 - Yellow Perch	Mercury	mg/kg	2.83E-01	3.28E-01	(NP)	6.52E-01	3.28E-01	mg/kg	Mod-t UCL (Adjusted for skewness)	W-Test (6)
	Methylmercury	mg/kg	2.68E-01	---		4.66E-01	4.66E-01	mg/kg	Max	W-Test (2)
Reach 10 - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	6.25E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	6.87E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: G = Gamma
Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable
NP = Non-parametric

TABLE 4-22

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Charles River - Bullhead	Mercury	mg/kg	2.83E-01	3.56E-01	(N)	5.48E-01	3.56E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.96E-01	---		2.40E-01	2.40E-01	mg/kg	Max	W-Test (2)
Charles River - Largemouth Bass	Mercury	mg/kg	4.23E-01	4.80E-01	(N)	5.59E-01	4.80E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	5.31E-01	---		6.39E-01	6.39E-01	mg/kg	Max	W-Test (2)
Charles River - Yellow Perch	Mercury	mg/kg	1.82E-01	2.02E-01	(N)	2.36E-01	2.02E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	2.09E-01	2.71E-01	(N)	3.03E-01	2.71E-01	mg/kg	Student's-t UCL	W-Test (3)
Charles River - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	3.46E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	3.83E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size ≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-23

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Charles River - Bullhead	Mercury	mg/kg	2.64E-01	3.47E-01	(N)	5.48E-01	3.47E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.18E-01	---		1.66E-01	1.66E-01	mg/kg	Max	W-Test (2)
Charles River - Largemouth Bass	Mercury	mg/kg	3.87E-01	4.45E-01	(N)	5.59E-01	4.45E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	3.55E-01	5.57E-01	(N)	4.41E-01	4.41E-01	mg/kg	Max	W-Test (2)
Charles River - Yellow Perch	Mercury	mg/kg	1.37E-01	1.51E-01	(G)	2.36E-01	1.51E-01	mg/kg	Approximate Gamma UCL	KS-Test (4)
	Methylmercury	mg/kg	1.63E-01	1.97E-01	(N)	2.19E-01	1.97E-01	mg/kg	Student's-t UCL	W-Test (3)
Charles River - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	3.14E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	2.68E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size ≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: G = Gamma
Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-24

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Sudbury Reservoir - Bullhead	Mercury	mg/kg	1.65E-01	2.13E-01	(N)	3.07E-01	2.13E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.83E-01	---		3.10E-01	3.10E-01	mg/kg	Max	W-Test (2)
Sudbury Reservoir - Largemouth Bass	Mercury	mg/kg	2.95E-01	4.21E-01	(G)	6.16E-01	4.21E-01	mg/kg	Approximate Gamma UCL	KS-Test (4)
	Methylmercury	mg/kg	1.98E-01	---		2.62E-01	2.62E-01	mg/kg	Max	W-Test (2)
Sudbury Reservoir - Yellow Perch	Mercury	mg/kg	1.09E-01	1.25E-01	(N)	1.78E-01	1.25E-01	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	1.24E-01	---		1.64E-01	1.64E-01	mg/kg	Max	W-Test (2)
Sudbury Reservoir - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	2.53E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	2.45E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: G = Gamma
Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable

TABLE 4-25

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)	Exposure Point Concentration (1)			
							Value	Units	Statistic	Rationale
Sudbury Reservoir - Bullhead	Mercury	mg/kg	1.35E-01	1.77E-01	(G)	2.73E-01	1.77E-01	mg/kg	Approximate Gamma UCL	KS-Test (4)
	Methylmercury	mg/kg	1.32E-01	---		1.83E-01	1.83E-01	mg/kg	Max	W-Test (2)
Sudbury Reservoir - Largemouth Bass	Mercury	mg/kg	2.60E-01	3.86E-01	(NP)	6.16E-01	3.86E-01	mg/kg	Mod-t UCL (Adjusted for skewness)	W-Test (6)
	Methylmercury	mg/kg	1.78E-01	---		2.12E-01	2.12E-01	mg/kg	Max	W-Test (2)
Sudbury Reservoir - Yellow Perch	Mercury	mg/kg	7.96E-02	8.88E-02	(N)	1.38E-01	8.88E-02	mg/kg	Student's-t UCL	W-Test (3)
	Methylmercury	mg/kg	9.38E-02	---		1.18E-01	1.18E-01	mg/kg	Max	W-Test (2)
Sudbury Reservoir - Aggregate (7)	Mercury	mg/kg	N/A	N/A		N/A	2.17E-01	mg/kg	N/A	N/A
	Methylmercury	mg/kg	N/A	N/A		N/A	1.71E-01	mg/kg	N/A	N/A

--- = 95% UCL not calculated; sample size ≤ 3.

(1) The EPC is based on the lower of the 95% UCL and the maximum detected concentration.

(2) 95% UCL either exceeds maximum detected concentration or was not calculated. Therefore, maximum concentration used for EPC.

(3) Shapiro-Wilk W Test indicates data are normally distributed.

(4) Kolmogorov-Smirnov Test indicates data fit a gamma distribution.

(5) Shapiro-Wilk W Test indicates data are lognormally distributed.

(6) Data do not fit a normal, lognormal, or gamma distribution. Nonparametric ProUCL recommendation assumed.

(7) Aggregate EPC = average of species-specific EPCs.

Definitions: G = Gamma
Max = Maximum Detected Value.
N = Normal
N/A = Not Applicable
NP = Non-parametric

TABLE 4-26

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational Angler	Child	Reaches 1 through 10 (including Heard Pond), Charles River, and Sudbury Reservoir	C_{Fish}	Chemical Concentration in Fish	See Tables 4-2 through 4-25	mg/kg	(1)	CDI (mg/kg-day) =
				IR-F	Fish Ingestion Rate (All Waters)	13	g/day	Ebert et al., 1993 (2)	C_{Fish} x IR-F x FI x CF x EF x ED x 1/BW x 1/AT
					Fish Ingestion Rate (Flowing)	6.1	g/day	Ebert et al., 1993 (2)	
					Fish Ingestion Rate (Standing)	6.9	g/day	Ebert et al., 1993 (2)	
				FI	Fraction of fish ingested from contaminated source	0.5	unitless	Ebert et al., 1993	
				CF	Conversion Factor	1E-03	kg/g	---	
				EF	Exposure Frequency	350	days/year	EPA, 1991	
				ED	Exposure Duration	6	years	EPA Region 1, 1994	
				BW	Body Weight	15	kg	EPA, 1997a	
				AT-NC	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Adult	Reaches 1 through 10 (including Heard Pond), Charles River, and Sudbury Reservoir	C_{Fish}	Chemical Concentration in Fish	See Tables 4-2 through 4-25	mg/kg	(1)	CDI (mg/kg-day) =
				IR-F	Fish Ingestion Rate (All Waters)	32	g/day	Ebert et al., 1993 (2)	C_{Fish} x IR-F x FI x CF x EF x ED x 1/BW x 1/AT
					Fish Ingestion Rate (Flowing)	14	g/day	Ebert et al., 1993 (2)	
					Fish Ingestion Rate (Standing)	18	g/day	Ebert et al., 1993 (2)	
				FI	Fraction of fish ingested from contaminated source	0.5	unitless	Ebert et al., 1993	
				CF	Conversion Factor	1E-03	kg/g	---	
				EF	Exposure Frequency	350	days/year	EPA, 1991	
				ED	Exposure Duration	30	years	EPA Region 1, 1994	
				BW	Body Weight	70	kg	EPA, 1997a	
				AT-NC	Averaging Time (Non-Cancer)	10,950	days	EPA, 1989	

(1) The C_{Fish} is based on the lower of the 95% UCL and the maximum detected concentration.

(2) All waters include Reaches 2 and 9; flowing waters include Reaches 1, 5, 7, 8, 10, and Charles River; standing waters include Reaches 3, 4, 6, Heard Pond, and Sudbury Reservoir.

Ebert et al., 1993: *Estimating Consumption of Freshwater Fish Among Maine Anglers.* North Amer. J. Fisheries Management. 13: 737-745.

EPA, 1991: *Risk Assessment Guidance for Superfund.* Volume 1: *Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors* Interim Final. OSWER 9285.6-03.

EPA Region 1, 1994: *Risk Update #2*. Waste Management Division.

EPA, 1997: Exposure Factors Handbook, Volume 1: General Factors. EPA/600/P-95/002Fa.

EPA 1989: *Risk Assessment Guidance for Superfund.* Volume 1: *Human Health Evaluation Manual, Part A*. OERR EPA/540/1-89/002.

TABLE 4-27

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational Angler	Child	Reaches 1 through 10 (including Heard Pond), Charles River, and Sudbury Reservoir	C_{Fish}	Chemical Concentration in Fish	See Tables 4-2 through 4-25	mg/kg	(1)	CDI (mg/kg-day) =
				IR-F	Fish Ingestion Rate (All Waters)	6.4	g/day	Ebert et al., 1993 (2)	C_{Fish} x IR-F x FI x CF x EF x ED x 1/BW x 1/AT
					Fish Ingestion Rate (Flowing)	3.7	g/day	Ebert et al., 1993 (2)	
					Fish Ingestion Rate (Standing)	2.7	g/day	Ebert et al., 1993 (2)	
				FI	Fraction of fish ingested from contaminated source	0.5	unitless	Ebert et al., 1993	
				CF	Conversion Factor	1E-03	kg/g	---	
				EF	Exposure Frequency	350	days/year	EPA, 1991	
				ED	Exposure Duration	2	years	EPA Region 1, 1994	
				BW	Body Weight	15	kg	EPA, 1997a	
				AT-NC	Averaging Time (Non-Cancer)	730	days	EPA, 1989	
		Adult	Reaches 1 through 10 (including Heard Pond), Charles River, and Sudbury Reservoir	C_{Fish}	Chemical Concentration in Fish	See Tables 4-2 through 4-25	mg/kg	(1)	CDI (mg/kg-day) =
				IR-F	Fish Ingestion Rate (All Waters)	15	g/day	Ebert et al., 1993 (2)	C_{Fish} x IR-F x FI x CF x EF x ED x 1/BW x 1/AT
					Fish Ingestion Rate (Flowing)	8.9	g/day	Ebert et al., 1993 (2)	
					Fish Ingestion Rate (Standing)	6.1	g/day	Ebert et al., 1993 (2)	
				FI	Fraction of fish ingested from contaminated source	0.5	unitless	Ebert et al., 1993	
				CF	Conversion Factor	1E-03	kg/g	---	
				EF	Exposure Frequency	350	days/year	EPA, 1991	
				ED	Exposure Duration	9	years	EPA Region 1, 1994	
				BW	Body Weight	70	kg	EPA, 1997a	
				AT-NC	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	

(1) The C_{Fish} is based on the lower of the 95% UCL and the maximum detected concentration.

(2) All waters include Reaches 2 and 9; flowing waters include Reaches 1, 5, 7, 8, 10, and Charles River; standing waters include Reaches 3, 4, 6, Heard Pond, and Sudbury Reservoir.

Ebert et al., 1993: *Estimating Consumption of Freshwater Fish Among Maine Anglers.* North Amer. J. Fisheries Management. 13: 737-745.

EPA, 1991: *Risk Assessment Guidance for Superfund.* Volume 1: *Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors* Interim Final. OSWER 9285.6-03.

EPA Region 1, 1994: *Risk Update #2*. Waste Management Division.

EPA, 1997: Exposure Factors Handbook, Volume 1: General Factors. EPA/600/P-95/002Fa.

EPA 1989: *Risk Assessment Guidance for Superfund.* Volume 1: *Human Health Evaluation Manual, Part A*. OERR EPA/540/1-89/002.

TABLE 4-28

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Subsistence Angler	Adult	Reaches 1 through 10 (including Heard Pond), Charles River, and Sudbury Reservoir	C_{Fish}	Chemical Concentration in Fish	See Tables 4-2 through 4-25	mg/kg	(1)	CDI (mg/kg-day) = C_{Fish} x IR-F x FI x CF x EF x ED x 1/BW x 1/AT
				IR-F	Fish Ingestion Rate	142.4	g/day	CSFII, 1994-1996	
				FI	Fraction of fish ingested from contaminated source	0.5	unitless	Ebert et al., 1993	
				CF	Conversion Factor	1E-03	kg/g	---	
				EF	Exposure Frequency	350	days/year	EPA, 1991	
				ED	Exposure Duration	30	years	EPA Region 1, 1994	
				BW	Body Weight	70	kg	EPA, 1997a	
				AT-NC	Averaging Time (Non-Cancer)	10,950	days	EPA, 1989	

(1) The C_{Fish} is based on the lower of the 95% UCL and the maximum detected concentration.

Ebert et al., 1993: *Estimating Consumption of Freshwater Fish Among Maine Anglers.* North Amer. J. Fisheries Management. 13: 737-745.

EPA, 1991: *Risk Assessment Guidance for Superfund.* Volume 1: *Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors* Interim Final. OSWER 9285.6-03.

EPA Region 1, 1994: *Risk Update #2*. Waste Management Division.

EPA, 1997: Exposure Factors Handbook, Volume 1: General Factors. EPA/600/P-95/002Fa.

EPA 1989: *Risk Assessment Guidance for Superfund.* Volume 1: *Human Health Evaluation Manual, Part A*. OERR EPA/540/1-89/002.

EPA, 2000: Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health. Office of Water. EPA-822-B-00-004.

TABLE 4-29

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Fillet Fish Tissue (Skin On)

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Subsistence Angler	Adult	Reaches 1 through 10 (including Heard Pond), Charles River, and Sudbury Reservoir	C_{Fish}	Chemical Concentration in Fish	See Tables 4-2 through 4-25	mg/kg	(1)	CDI (mg/kg-day) = C_{Fish} x IR-F x FI x CF x EF x ED x 1/BW x 1/AT
				IR-F	Fish Ingestion Rate	70	g/day	EPA, 1997a	
				FI	Fraction of fish ingested from contaminated source	0.5	unitless	Ebert et al., 1993	
				CF	Conversion Factor	1E-03	kg/g	---	
				EF	Exposure Frequency	350	days/year	EPA, 1991	
				ED	Exposure Duration	9	years	EPA Region 1, 1994	
				BW	Body Weight	70	kg	EPA, 1997a	
				AT-NC	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	

(1) The C_{Fish} is based on the lower of the 95% UCL and the maximum detected concentration.

Ebert et al., 1993: *Estimating Consumption of Freshwater Fish Among Maine Anglers.* North Amer. J. Fisheries Management. 13: 737-745.

EPA, 1991: *Risk Assessment Guidance for Superfund.* Volume 1: *Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors* Interim Final. OSWER 9285.6-03.

EPA Region 1, 1994: *Risk Update #2*. Waste Management Division.

EPA, 1997: Exposure Factors Handbook, Volume 1: General Factors. EPA/600/P-95/002Fa.

EPA 1989: *Risk Assessment Guidance for Superfund.* Volume 1: *Human Health Evaluation Manual, Part A*. OERR EPA/540/1-89/002.

TABLE 4-30

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Ethnic Angler	Child	Reaches 1 through 10 (including Heard Pond), Charles River, and Sudbury Reservoir	C_{Fish}	Chemical Concentration in Fish	See Tables 4-2 through 4-25	mg/kg	(1)	CDI (mg/kg-day) =
				IR-F	Fish Ingestion Rate	56.96	g/day	40 % of adult value (see text for detailed explanation)	C_{Fish} x IR-F x FI x CF x EF x ED x 1/BW x 1/AT
				FI	Fraction of fish ingested from contaminated source	0.5	unitless	Ebert et al., 1993	
				CF	Conversion Factor	1E-03	kg/g	---	
				EF	Exposure Frequency	350	days/year	EPA, 1991	
				ED	Exposure Duration	6	years	EPA Region 1, 1994	
				BW	Body Weight	15	kg	EPA, 1997a	
				AT-NC	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Adult	Reaches 1 through 10 (including Heard Pond), Charles River, and Sudbury Reservoir	C_{Fish}	Chemical Concentration in Fish	See Tables 4-2 through 4-25	mg/kg	(1)	CDI (mg/kg-day) =
				IR-F	Fish Ingestion Rate	142.4	g/day	CSFII, 1994-1996	C_{Fish} x IR-F x FI x CF x EF x ED x 1/BW x 1/AT
				FI	Fraction of fish ingested from contaminated source	0.5	unitless	Ebert et al., 1993	
				CF	Conversion Factor	1E-03	kg/g	---	
				EF	Exposure Frequency	350	days/year	EPA, 1991	
				ED	Exposure Duration	30	years	EPA Region 1, 1994	
				BW	Body Weight	70	kg	EPA, 1997a	
				AT-NC	Averaging Time (Non-Cancer)	10,950	days	EPA, 1989	

(1) The C_{Fish} is based on the lower of the 95% UCL and the maximum detected concentration.

Ebert et al., 1993: *Estimating Consumption of Freshwater Fish Among Maine Anglers.* North Amer. J. Fisheries Management. 13: 737-745.

EPA, 1991: *Risk Assessment Guidance for Superfund.* Volume 1: *Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors* Interim Final. OSWER 9285.6-03.

EPA Region 1, 1994: *Risk Update #2*. Waste Management Division.

EPA, 1997: Exposure Factors Handbook, Volume 1: General Factors. EPA/600/P-95/002Fa.

EPA 1989: *Risk Assessment Guidance for Superfund.* Volume 1: *Human Health Evaluation Manual, Part A*. OERR EPA/540/1-89/002.

EPA, 2000: Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health. Office of Water. EPA-822-B-00-004.

TABLE 4-31

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Medium: Fish Tissue
Exposure Medium: Whole Body Fish Tissue

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Ethnic Angler	Child	Reaches 1 through 10 (including Heard Pond), Charles River, and Sudbury Reservoir	C_{Fish}	Chemical Concentration in Fish	See Tables 4-2 through 4-25	mg/kg	(1)	CDI (mg/kg-day) =
				IR-F	Fish Ingestion Rate	28	g/day	40 % of adult value (see text for detailed explanation)	C_{Fish} x IR-F x FI x CF x EF x ED x 1/BW x 1/AT
				FI	Fraction of fish ingested from contaminated source	0.5	unitless	Ebert et al., 1993	
				CF	Conversion Factor	1E-03	kg/g	---	
				EF	Exposure Frequency	350	days/year	EPA, 1991	
				ED	Exposure Duration	2	years	EPA Region 1, 1994	
				BW	Body Weight	15	kg	EPA, 1997a	
				AT-NC	Averaging Time (Non-Cancer)	730	days	EPA, 1989	
		Adult	Reaches 1 through 10 (including Heard Pond), Charles River, and Sudbury Reservoir	C_{Fish}	Chemical Concentration in Fish	See Tables 4-2 through 4-25	mg/kg	(1)	CDI (mg/kg-day) =
				IR-F	Fish Ingestion Rate	70	g/day	EPA, 1997a	C_{Fish} x IR-F x FI x CF x EF x ED x 1/BW x 1/AT
				FI	Fraction of fish ingested from contaminated source	0.5	unitless	Ebert et al., 1993	
				CF	Conversion Factor	1E-03	kg/g	---	
				EF	Exposure Frequency	350	days/year	EPA, 1991	
				ED	Exposure Duration	9	years	EPA Region 1, 1994	
				BW	Body Weight	70	kg	EPA, 1997a	
				AT-NC	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	

(1) The C_{Fish} is based on the lower of the 95% UCL and the maximum detected concentration.

Ebert et al., 1993: *Estimating Consumption of Freshwater Fish Among Maine Anglers.* North Amer. J. Fisheries Management. 13: 737-745.

EPA, 1991: *Risk Assessment Guidance for Superfund.* Volume 1: *Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors* Interim Final. OSWER 9285.6-03.

EPA Region 1, 1994: *Risk Update #2*. Waste Management Division.

EPA, 1997: Exposure Factors Handbook, Volume 1: General Factors. EPA/600/P-95/002Fa.

EPA 1989: *Risk Assessment Guidance for Superfund.* Volume 1: *Human Health Evaluation Manual, Part A*. OERR EPA/540/1-89/002.

Table 4-32

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Recreational Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 1	Ingestion	Mercury	0.52	mg/kg	---	---	---	---	---	1.01E-04	mg/kg/day	1.0E-04	mg/kg/day	1.0
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 2	Ingestion	Mercury	0.83	mg/kg	---	---	---	---	---	3.45E-04	mg/kg/day	1.0E-04	mg/kg/day	3.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 3	Ingestion	Mercury	0.94	mg/kg	---	---	---	---	---	2.06E-04	mg/kg/day	1.0E-04	mg/kg/day	2.1
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 4	Ingestion	Mercury	0.58	mg/kg	---	---	---	---	---	1.28E-04	mg/kg/day	1.0E-04	mg/kg/day	1.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 5	Ingestion	Mercury	0.46	mg/kg	---	---	---	---	---	9.04E-05	mg/kg/day	1.0E-04	mg/kg/day	0.9
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 6	Ingestion	Mercury	0.60	mg/kg	---	---	---	---	---	1.32E-04	mg/kg/day	1.0E-04	mg/kg/day	1.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7	Ingestion	Mercury	0.50	mg/kg	---	---	---	---	---	9.84E-05	mg/kg/day	1.0E-04	mg/kg/day	1.0
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7 - Heard Pond	Ingestion	Mercury	0.12	mg/kg	---	---	---	---	---	2.61E-05	mg/kg/day	1.0E-04	mg/kg/day	0.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 8	Ingestion	Mercury	0.69	mg/kg	---	---	---	---	---	1.35E-04	mg/kg/day	1.0E-04	mg/kg/day	1.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 9	Ingestion	Mercury	0.69	mg/kg	---	---	---	---	---	2.85E-04	mg/kg/day	1.0E-04	mg/kg/day	2.8
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 10	Ingestion	Mercury	0.72	mg/kg	---	---	---	---	---	1.40E-04	mg/kg/day	1.0E-04	mg/kg/day	1.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Charles River	Ingestion	Mercury	0.35	mg/kg	---	---	---	---	---	6.74E-05	mg/kg/day	1.0E-04	mg/kg/day	0.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Sudbury Reservoir	Ingestion	Mercury	0.25	mg/kg	---	---	---	---	---	5.58E-05	mg/kg/day	1.0E-04	mg/kg/day	0.6

--- = Pathway not evalutated.

* Value represents aggregate EPC.

Table 4-33

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Recreational Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 1	Ingestion	Mercury	0.52	mg/kg	---	---	---	---	---	4.95E-05	mg/kg/day	1.0E-04	mg/kg/day	0.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 2	Ingestion	Mercury	0.83	mg/kg	---	---	---	---	---	1.82E-04	mg/kg/day	1.0E-04	mg/kg/day	1.8
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 3	Ingestion	Mercury	0.94	mg/kg	---	---	---	---	---	1.15E-04	mg/kg/day	1.0E-04	mg/kg/day	1.2
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 4	Ingestion	Mercury	0.58	mg/kg	---	---	---	---	---	7.13E-05	mg/kg/day	1.0E-04	mg/kg/day	0.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 5	Ingestion	Mercury	0.46	mg/kg	---	---	---	---	---	4.44E-05	mg/kg/day	1.0E-04	mg/kg/day	0.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 6	Ingestion	Mercury	0.60	mg/kg	---	---	---	---	---	7.40E-05	mg/kg/day	1.0E-04	mg/kg/day	0.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7	Ingestion	Mercury	0.50	mg/kg	---	---	---	---	---	4.84E-05	mg/kg/day	1.0E-04	mg/kg/day	0.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7 - Heard Pond	Ingestion	Mercury	0.12	mg/kg	---	---	---	---	---	1.46E-05	mg/kg/day	1.0E-04	mg/kg/day	0.1
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 8	Ingestion	Mercury	0.69	mg/kg	---	---	---	---	---	6.63E-05	mg/kg/day	1.0E-04	mg/kg/day	0.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 9	Ingestion	Mercury	0.69	mg/kg	---	---	---	---	---	1.50E-04	mg/kg/day	1.0E-04	mg/kg/day	1.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 10	Ingestion	Mercury	0.72	mg/kg	---	---	---	---	---	6.90E-05	mg/kg/day	1.0E-04	mg/kg/day	0.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Charles River	Ingestion	Mercury	0.35	mg/kg	---	---	---	---	---	3.32E-05	mg/kg/day	1.0E-04	mg/kg/day	0.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Sudbury Reservoir	Ingestion	Mercury	0.25	mg/kg	---	---	---	---	---	3.12E-05	mg/kg/day	1.0E-04	mg/kg/day	0.3

--- = Pathway not evalutated.

* Value represents aggregate EPC.

Table 4-34

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Recreational Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 1	Ingestion	Mercury	0.52	mg/kg	---	---	---	---	---	6.10E-05	mg/kg/day	1.0E-04	mg/kg/day	0.6
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 2	Ingestion	Mercury	0.83	mg/kg	---	---	---	---	---	1.70E-04	mg/kg/day	1.0E-04	mg/kg/day	1.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 3	Ingestion	Mercury	0.94	mg/kg	---	---	---	---	---	8.08E-05	mg/kg/day	1.0E-04	mg/kg/day	0.8
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 4	Ingestion	Mercury	0.58	mg/kg	---	---	---	---	---	4.99E-05	mg/kg/day	1.0E-04	mg/kg/day	0.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 5	Ingestion	Mercury	0.46	mg/kg	---	---	---	---	---	5.48E-05	mg/kg/day	1.0E-04	mg/kg/day	0.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 6	Ingestion	Mercury	0.60	mg/kg	---	---	---	---	---	5.18E-05	mg/kg/day	1.0E-04	mg/kg/day	0.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7	Ingestion	Mercury	0.50	mg/kg	---	---	---	---	---	5.97E-05	mg/kg/day	1.0E-04	mg/kg/day	0.6
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7 - Heard Pond	Ingestion	Mercury	0.12	mg/kg	---	---	---	---	---	1.02E-05	mg/kg/day	1.0E-04	mg/kg/day	0.1
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 8	Ingestion	Mercury	0.69	mg/kg	---	---	---	---	---	8.17E-05	mg/kg/day	1.0E-04	mg/kg/day	0.8
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 9	Ingestion	Mercury	0.69	mg/kg	---	---	---	---	---	1.40E-04	mg/kg/day	1.0E-04	mg/kg/day	1.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 10	Ingestion	Mercury	0.72	mg/kg	---	---	---	---	---	8.51E-05	mg/kg/day	1.0E-04	mg/kg/day	0.9
Fish Tissue	Fillet Fish Tissue (Skin On)	Charles River	Ingestion	Mercury	0.35	mg/kg	---	---	---	---	---	4.09E-05	mg/kg/day	1.0E-04	mg/kg/day	0.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Sudbury Reservoir	Ingestion	Mercury	0.25	mg/kg	---	---	---	---	---	2.18E-05	mg/kg/day	1.0E-04	mg/kg/day	0.2

--- = Pathway not evalutated.

* Value represents aggregate EPC.

Table 4-35

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Recreational Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 1	Ingestion	Mercury	0.52	mg/kg	---	---	---	---	---	3.15E-05	mg/kg/day	1.0E-04	mg/kg/day	0.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 2	Ingestion	Mercury	0.83	mg/kg	---	---	---	---	---	8.54E-05	mg/kg/day	1.0E-04	mg/kg/day	0.9
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 3	Ingestion	Mercury	0.94	mg/kg	---	---	---	---	---	3.91E-05	mg/kg/day	1.0E-04	mg/kg/day	0.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 4	Ingestion	Mercury	0.58	mg/kg	---	---	---	---	---	2.42E-05	mg/kg/day	1.0E-04	mg/kg/day	0.2
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 5	Ingestion	Mercury	0.46	mg/kg	---	---	---	---	---	2.83E-05	mg/kg/day	1.0E-04	mg/kg/day	0.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 6	Ingestion	Mercury	0.60	mg/kg	---	---	---	---	---	2.51E-05	mg/kg/day	1.0E-04	mg/kg/day	0.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7	Ingestion	Mercury	0.50	mg/kg	---	---	---	---	---	3.08E-05	mg/kg/day	1.0E-04	mg/kg/day	0.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7 - Heard Pond	Ingestion	Mercury	0.12	mg/kg	---	---	---	---	---	4.94E-06	mg/kg/day	1.0E-04	mg/kg/day	0.05
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 8	Ingestion	Mercury	0.69	mg/kg	---	---	---	---	---	4.21E-05	mg/kg/day	1.0E-04	mg/kg/day	0.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 9	Ingestion	Mercury	0.69	mg/kg	---	---	---	---	---	7.04E-05	mg/kg/day	1.0E-04	mg/kg/day	0.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 10	Ingestion	Mercury	0.72	mg/kg	---	---	---	---	---	4.38E-05	mg/kg/day	1.0E-04	mg/kg/day	0.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Charles River	Ingestion	Mercury	0.35	mg/kg	---	---	---	---	---	2.11E-05	mg/kg/day	1.0E-04	mg/kg/day	0.2
Fish Tissue	Fillet Fish Tissue (Skin On)	Sudbury Reservoir	Ingestion	Mercury	0.25	mg/kg	---	---	---	---	---	1.06E-05	mg/kg/day	1.0E-04	mg/kg/day	0.1

--- = Pathway not evalutated.

* Value represents aggregate EPC.

Table 4-36

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 1	Ingestion	Mercury	0.52	mg/kg	---	---	---	---	---	5.03E-04	mg/kg/day	1.0E-04	mg/kg/day	5.0
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 2	Ingestion	Mercury	0.83	mg/kg	---	---	---	---	---	8.11E-04	mg/kg/day	1.0E-04	mg/kg/day	8.1
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 3	Ingestion	Mercury	0.94	mg/kg	---	---	---	---	---	9.13E-04	mg/kg/day	1.0E-04	mg/kg/day	9.1
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 4	Ingestion	Mercury	0.58	mg/kg	---	---	---	---	---	5.64E-04	mg/kg/day	1.0E-04	mg/kg/day	5.6
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 5	Ingestion	Mercury	0.46	mg/kg	---	---	---	---	---	4.52E-04	mg/kg/day	1.0E-04	mg/kg/day	4.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 6	Ingestion	Mercury	0.60	mg/kg	---	---	---	---	---	5.86E-04	mg/kg/day	1.0E-04	mg/kg/day	5.9
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7	Ingestion	Mercury	0.50	mg/kg	---	---	---	---	---	4.92E-04	mg/kg/day	1.0E-04	mg/kg/day	4.9
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7 - Heard Pond	Ingestion	Mercury	0.12	mg/kg	---	---	---	---	---	1.15E-04	mg/kg/day	1.0E-04	mg/kg/day	1.2
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 8	Ingestion	Mercury	0.69	mg/kg	---	---	---	---	---	6.74E-04	mg/kg/day	1.0E-04	mg/kg/day	6.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 9	Ingestion	Mercury	0.69	mg/kg	---	---	---	---	---	6.68E-04	mg/kg/day	1.0E-04	mg/kg/day	6.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 10	Ingestion	Mercury	0.72	mg/kg	---	---	---	---	---	7.02E-04	mg/kg/day	1.0E-04	mg/kg/day	7.0
Fish Tissue	Fillet Fish Tissue (Skin On)	Charles River	Ingestion	Mercury	0.35	mg/kg	---	---	---	---	---	3.37E-04	mg/kg/day	1.0E-04	mg/kg/day	3.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Sudbury Reservoir	Ingestion	Mercury	0.25	mg/kg	---	---	---	---	---	2.47E-04	mg/kg/day	1.0E-04	mg/kg/day	2.5

--- = Pathway not evalutated.

* Value represents aggregate EPC.

Table 4-37

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 1	Ingestion	Mercury	0.52	mg/kg	---	---	---	---	---	2.47E-04	mg/kg/day	1.0E-04	mg/kg/day	2.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 2	Ingestion	Mercury	0.83	mg/kg	---	---	---	---	---	3.98E-04	mg/kg/day	1.0E-04	mg/kg/day	4.0
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 3	Ingestion	Mercury	0.94	mg/kg	---	---	---	---	---	4.49E-04	mg/kg/day	1.0E-04	mg/kg/day	4.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 4	Ingestion	Mercury	0.58	mg/kg	---	---	---	---	---	2.77E-04	mg/kg/day	1.0E-04	mg/kg/day	2.8
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 5	Ingestion	Mercury	0.46	mg/kg	---	---	---	---	---	2.22E-04	mg/kg/day	1.0E-04	mg/kg/day	2.2
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 6	Ingestion	Mercury	0.60	mg/kg	---	---	---	---	---	2.88E-04	mg/kg/day	1.0E-04	mg/kg/day	2.9
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7	Ingestion	Mercury	0.50	mg/kg	---	---	---	---	---	2.42E-04	mg/kg/day	1.0E-04	mg/kg/day	2.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7 - Heard Pond	Ingestion	Mercury	0.12	mg/kg	---	---	---	---	---	5.66E-05	mg/kg/day	1.0E-04	mg/kg/day	0.6
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 8	Ingestion	Mercury	0.69	mg/kg	---	---	---	---	---	3.31E-04	mg/kg/day	1.0E-04	mg/kg/day	3.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 9	Ingestion	Mercury	0.69	mg/kg	---	---	---	---	---	3.28E-04	mg/kg/day	1.0E-04	mg/kg/day	3.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 10	Ingestion	Mercury	0.72	mg/kg	---	---	---	---	---	3.45E-04	mg/kg/day	1.0E-04	mg/kg/day	3.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Charles River	Ingestion	Mercury	0.35	mg/kg	---	---	---	---	---	1.66E-04	mg/kg/day	1.0E-04	mg/kg/day	1.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Sudbury Reservoir	Ingestion	Mercury	0.25	mg/kg	---	---	---	---	---	1.21E-04	mg/kg/day	1.0E-04	mg/kg/day	1.2

--- = Pathway not evalutated.

* Value represents aggregate EPC.

Table 4-38

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Ethnic Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish Tissue	Whole Body Fish Tissue	Reach 1	Ingestion	Mercury	0.29	mg/kg	---	---	---	---	---	5.24E-04	mg/kg/day	1.0E-04	mg/kg/day	5.2
Fish Tissue	Whole Body Fish Tissue	Reach 2	Ingestion	Mercury	0.41	mg/kg	---	---	---	---	---	7.50E-04	mg/kg/day	1.0E-04	mg/kg/day	7.5
Fish Tissue	Whole Body Fish Tissue	Reach 3	Ingestion	Mercury	0.82	mg/kg	---	---	---	---	---	1.50E-03	mg/kg/day	1.0E-04	mg/kg/day	15.0
Fish Tissue	Whole Body Fish Tissue	Reach 4	Ingestion	Mercury	0.49	mg/kg	---	---	---	---	---	8.93E-04	mg/kg/day	1.0E-04	mg/kg/day	8.9
Fish Tissue	Whole Body Fish Tissue	Reach 5	Ingestion	Mercury	0.40	mg/kg	---	---	---	---	---	7.20E-04	mg/kg/day	1.0E-04	mg/kg/day	7.2
Fish Tissue	Whole Body Fish Tissue	Reach 6	Ingestion	Mercury	0.51	mg/kg	---	---	---	---	---	9.25E-04	mg/kg/day	1.0E-04	mg/kg/day	9.3
Fish Tissue	Whole Body Fish Tissue	Reach 7	Ingestion	Mercury	0.46	mg/kg	---	---	---	---	---	8.31E-04	mg/kg/day	1.0E-04	mg/kg/day	8.3
Fish Tissue	Whole Body Fish Tissue	Reach 7 - Heard Pond	Ingestion	Mercury	0.10	mg/kg	---	---	---	---	---	1.84E-04	mg/kg/day	1.0E-04	mg/kg/day	1.8
Fish Tissue	Whole Body Fish Tissue	Reach 8	Ingestion	Mercury	0.47	mg/kg	---	---	---	---	---	8.62E-04	mg/kg/day	1.0E-04	mg/kg/day	8.6
Fish Tissue	Whole Body Fish Tissue	Reach 9	Ingestion	Mercury	0.55	mg/kg	---	---	---	---	---	1.01E-03	mg/kg/day	1.0E-04	mg/kg/day	10.1
Fish Tissue	Whole Body Fish Tissue	Reach 10	Ingestion	Mercury	0.62	mg/kg	---	---	---	---	---	1.14E-03	mg/kg/day	1.0E-04	mg/kg/day	11.4
Fish Tissue	Whole Body Fish Tissue	Charles River	Ingestion	Mercury	0.31	mg/kg	---	---	---	---	---	5.73E-04	mg/kg/day	1.0E-04	mg/kg/day	5.7
Fish Tissue	Whole Body Fish Tissue	Sudbury Reservoir	Ingestion	Mercury	0.22	mg/kg	---	---	---	---	---	3.96E-04	mg/kg/day	1.0E-04	mg/kg/day	4.0

--- = Pathway not evalutated.

* Value represents aggregate EPC.

Table 4-39

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Ethnic Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish Tissue	Whole Body Fish Tissue	Reach 1	Ingestion	Mercury	0.29	mg/kg	---	---	---	---	---	2.81E-04	mg/kg/day	1.0E-04	mg/kg/day	2.8
Fish Tissue	Whole Body Fish Tissue	Reach 2	Ingestion	Mercury	0.41	mg/kg	---	---	---	---	---	4.02E-04	mg/kg/day	1.0E-04	mg/kg/day	4.0
Fish Tissue	Whole Body Fish Tissue	Reach 3	Ingestion	Mercury	0.82	mg/kg	---	---	---	---	---	8.03E-04	mg/kg/day	1.0E-04	mg/kg/day	8.0
Fish Tissue	Whole Body Fish Tissue	Reach 4	Ingestion	Mercury	0.49	mg/kg	---	---	---	---	---	4.78E-04	mg/kg/day	1.0E-04	mg/kg/day	4.8
Fish Tissue	Whole Body Fish Tissue	Reach 5	Ingestion	Mercury	0.40	mg/kg	---	---	---	---	---	3.86E-04	mg/kg/day	1.0E-04	mg/kg/day	3.9
Fish Tissue	Whole Body Fish Tissue	Reach 6	Ingestion	Mercury	0.51	mg/kg	---	---	---	---	---	4.96E-04	mg/kg/day	1.0E-04	mg/kg/day	5.0
Fish Tissue	Whole Body Fish Tissue	Reach 7	Ingestion	Mercury	0.46	mg/kg	---	---	---	---	---	4.45E-04	mg/kg/day	1.0E-04	mg/kg/day	4.5
Fish Tissue	Whole Body Fish Tissue	Reach 7 - Heard Pond	Ingestion	Mercury	0.10	mg/kg	---	---	---	---	---	9.84E-05	mg/kg/day	1.0E-04	mg/kg/day	1.0
Fish Tissue	Whole Body Fish Tissue	Reach 8	Ingestion	Mercury	0.47	mg/kg	---	---	---	---	---	4.62E-04	mg/kg/day	1.0E-04	mg/kg/day	4.6
Fish Tissue	Whole Body Fish Tissue	Reach 9	Ingestion	Mercury	0.55	mg/kg	---	---	---	---	---	5.40E-04	mg/kg/day	1.0E-04	mg/kg/day	5.4
Fish Tissue	Whole Body Fish Tissue	Reach 10	Ingestion	Mercury	0.62	mg/kg	---	---	---	---	---	6.09E-04	mg/kg/day	1.0E-04	mg/kg/day	6.1
Fish Tissue	Whole Body Fish Tissue	Charles River	Ingestion	Mercury	0.31	mg/kg	---	---	---	---	---	3.07E-04	mg/kg/day	1.0E-04	mg/kg/day	3.1
Fish Tissue	Whole Body Fish Tissue	Sudbury Reservoir	Ingestion	Mercury	0.22	mg/kg	---	---	---	---	---	2.12E-04	mg/kg/day	1.0E-04	mg/kg/day	2.1

--- = Pathway not evalutated.

* Value represents aggregate EPC.

Table 4-40

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Ethnic Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish Tissue	Whole Body Fish Tissue	Reach 1	Ingestion	Mercury	0.29	mg/kg	---	---	---	---	---	2.58E-04	mg/kg/day	1.0E-04	mg/kg/day	2.6
Fish Tissue	Whole Body Fish Tissue	Reach 2	Ingestion	Mercury	0.41	mg/kg	---	---	---	---	---	3.68E-04	mg/kg/day	1.0E-04	mg/kg/day	3.7
Fish Tissue	Whole Body Fish Tissue	Reach 3	Ingestion	Mercury	0.82	mg/kg	---	---	---	---	---	7.37E-04	mg/kg/day	1.0E-04	mg/kg/day	7.4
Fish Tissue	Whole Body Fish Tissue	Reach 4	Ingestion	Mercury	0.49	mg/kg	---	---	---	---	---	4.39E-04	mg/kg/day	1.0E-04	mg/kg/day	4.4
Fish Tissue	Whole Body Fish Tissue	Reach 5	Ingestion	Mercury	0.40	mg/kg	---	---	---	---	---	3.54E-04	mg/kg/day	1.0E-04	mg/kg/day	3.5
Fish Tissue	Whole Body Fish Tissue	Reach 6	Ingestion	Mercury	0.51	mg/kg	---	---	---	---	---	4.55E-04	mg/kg/day	1.0E-04	mg/kg/day	4.5
Fish Tissue	Whole Body Fish Tissue	Reach 7	Ingestion	Mercury	0.46	mg/kg	---	---	---	---	---	4.09E-04	mg/kg/day	1.0E-04	mg/kg/day	4.1
Fish Tissue	Whole Body Fish Tissue	Reach 7 - Heard Pond	Ingestion	Mercury	0.10	mg/kg	---	---	---	---	---	9.03E-05	mg/kg/day	1.0E-04	mg/kg/day	0.9
Fish Tissue	Whole Body Fish Tissue	Reach 8	Ingestion	Mercury	0.47	mg/kg	---	---	---	---	---	4.24E-04	mg/kg/day	1.0E-04	mg/kg/day	4.2
Fish Tissue	Whole Body Fish Tissue	Reach 9	Ingestion	Mercury	0.55	mg/kg	---	---	---	---	---	4.95E-04	mg/kg/day	1.0E-04	mg/kg/day	5.0
Fish Tissue	Whole Body Fish Tissue	Reach 10	Ingestion	Mercury	0.62	mg/kg	---	---	---	---	---	5.59E-04	mg/kg/day	1.0E-04	mg/kg/day	5.6
Fish Tissue	Whole Body Fish Tissue	Charles River	Ingestion	Mercury	0.31	mg/kg	---	---	---	---	---	2.81E-04	mg/kg/day	1.0E-04	mg/kg/day	2.8
Fish Tissue	Whole Body Fish Tissue	Sudbury Reservoir	Ingestion	Mercury	0.22	mg/kg	---	---	---	---	---	1.94E-04	mg/kg/day	1.0E-04	mg/kg/day	1.9

--- = Pathway not evalutated.

* Value represents aggregate EPC.

Table 4-41

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Ethnic Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish Tissue	Whole Body Fish Tissue	Reach 1	Ingestion	Mercury	0.29	mg/kg	---	---	---	---	---	1.38E-04	mg/kg/day	1.0E-04	mg/kg/day	1.4
Fish Tissue	Whole Body Fish Tissue	Reach 2	Ingestion	Mercury	0.41	mg/kg	---	---	---	---	---	1.97E-04	mg/kg/day	1.0E-04	mg/kg/day	2.0
Fish Tissue	Whole Body Fish Tissue	Reach 3	Ingestion	Mercury	0.82	mg/kg	---	---	---	---	---	3.95E-04	mg/kg/day	1.0E-04	mg/kg/day	3.9
Fish Tissue	Whole Body Fish Tissue	Reach 4	Ingestion	Mercury	0.49	mg/kg	---	---	---	---	---	2.35E-04	mg/kg/day	1.0E-04	mg/kg/day	2.4
Fish Tissue	Whole Body Fish Tissue	Reach 5	Ingestion	Mercury	0.40	mg/kg	---	---	---	---	---	1.90E-04	mg/kg/day	1.0E-04	mg/kg/day	1.9
Fish Tissue	Whole Body Fish Tissue	Reach 6	Ingestion	Mercury	0.51	mg/kg	---	---	---	---	---	2.44E-04	mg/kg/day	1.0E-04	mg/kg/day	2.4
Fish Tissue	Whole Body Fish Tissue	Reach 7	Ingestion	Mercury	0.46	mg/kg	---	---	---	---	---	2.19E-04	mg/kg/day	1.0E-04	mg/kg/day	2.2
Fish Tissue	Whole Body Fish Tissue	Reach 7 - Heard Pond	Ingestion	Mercury	0.10	mg/kg	---	---	---	---	---	4.84E-05	mg/kg/day	1.0E-04	mg/kg/day	0.5
Fish Tissue	Whole Body Fish Tissue	Reach 8	Ingestion	Mercury	0.47	mg/kg	---	---	---	---	---	2.27E-04	mg/kg/day	1.0E-04	mg/kg/day	2.3
Fish Tissue	Whole Body Fish Tissue	Reach 9	Ingestion	Mercury	0.55	mg/kg	---	---	---	---	---	2.65E-04	mg/kg/day	1.0E-04	mg/kg/day	2.7
Fish Tissue	Whole Body Fish Tissue	Reach 10	Ingestion	Mercury	0.62	mg/kg	---	---	---	---	---	2.99E-04	mg/kg/day	1.0E-04	mg/kg/day	3.0
Fish Tissue	Whole Body Fish Tissue	Charles River	Ingestion	Mercury	0.31	mg/kg	---	---	---	---	---	1.51E-04	mg/kg/day	1.0E-04	mg/kg/day	1.5
Fish Tissue	Whole Body Fish Tissue	Sudbury Reservoir	Ingestion	Mercury	0.22	mg/kg	---	---	---	---	---	1.04E-04	mg/kg/day	1.0E-04	mg/kg/day	1.0

--- = Pathway not evalutated.

* Value represents aggregate EPC.

Table 5-1

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Recreational Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 1	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.0	---	---	1.0
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 2	Mercury	---	---	---	---	---	Nervous System (Developmental)	3.5	---	---	3.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 3	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.1	---	---	2.1
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 4	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.3	---	---	1.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 5	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.9	---	---	0.9
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 6	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.3	---	---	1.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.0	---	---	1.0
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7 - Heard Pond	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.3	---	---	0.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 8	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.3	---	---	1.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 9	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.8	---	---	2.8
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 10	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.4	---	---	1.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Charles River	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.7	---	---	0.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Sudbury Reservoir	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.6	---	---	0.6

--- = Pathway not evalutated.

Table 5-2

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Recreational Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 1	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.5	---	---	0.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 2	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.8	---	---	1.8
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 3	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.2	---	---	1.2
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 4	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.7	---	---	0.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 5	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.4	---	---	0.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 6	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.7	---	---	0.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.5	---	---	0.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7 - Heard Pond	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.1	---	---	0.1
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 8	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.7	---	---	0.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 9	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.5	---	---	1.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 10	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.7	---	---	0.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Charles River	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.3	---	---	0.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Sudbury Reservoir	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.3	---	---	0.3

--- = Pathway not evalutated.

Table 5-3

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Recreational Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 1	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.6	---	---	0.6
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 2	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.7	---	---	1.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 3	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.8	---	---	0.8
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 4	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.5	---	---	0.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 5	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.5	---	---	0.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 6	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.5	---	---	0.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.6	---	---	0.6
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7 - Heard Pond	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.1	---	---	0.1
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 8	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.8	---	---	0.8
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 9	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.4	---	---	1.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 10	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.9	---	---	0.9
Fish Tissue	Fillet Fish Tissue (Skin On)	Charles River	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.4	---	---	0.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Sudbury Reservoir	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.2	---	---	0.2

--- = Pathway not evalutated.

Table 5-4

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Recreational Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 1	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.3	---	---	0.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 2	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.9	---	---	0.9
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 3	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.4	---	---	0.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 4	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.2	---	---	0.2
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 5	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.3	---	---	0.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 6	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.3	---	---	0.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.3	---	---	0.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7 - Heard Pond	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.05	---	---	0.05
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 8	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.4	---	---	0.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 9	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.7	---	---	0.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 10	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.4	---	---	0.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Charles River	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.2	---	---	0.2
Fish Tissue	Fillet Fish Tissue (Skin On)	Sudbury Reservoir	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.1	---	---	0.1

--- = Pathway not evalutated.

Table 5-5

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 1	Mercury	---	---	---	---	---	Nervous System (Developmental)	5.0	---	---	5.0
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 2	Mercury	---	---	---	---	---	Nervous System (Developmental)	8.1	---	---	8.1
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 3	Mercury	---	---	---	---	---	Nervous System (Developmental)	9.1	---	---	9.1
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 4	Mercury	---	---	---	---	---	Nervous System (Developmental)	5.6	---	---	5.6
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 5	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.5	---	---	4.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 6	Mercury	---	---	---	---	---	Nervous System (Developmental)	5.9	---	---	5.9
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.9	---	---	4.9
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7 - Heard Pond	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.2	---	---	1.2
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 8	Mercury	---	---	---	---	---	Nervous System (Developmental)	6.7	---	---	6.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 9	Mercury	---	---	---	---	---	Nervous System (Developmental)	6.7	---	---	6.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 10	Mercury	---	---	---	---	---	Nervous System (Developmental)	7.0	---	---	7.0
Fish Tissue	Fillet Fish Tissue (Skin On)	Charles River	Mercury	---	---	---	---	---	Nervous System (Developmental)	3.4	---	---	3.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Sudbury Reservoir	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.5	---	---	2.5

--- = Pathway not evalutated.

Table 5-6

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 1	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.5	---	---	2.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 2	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.0	---	---	4.0
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 3	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.5	---	---	4.5
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 4	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.8	---	---	2.8
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 5	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.2	---	---	2.2
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 6	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.9	---	---	2.9
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.4	---	---	2.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 7 - Heard Pond	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.6	---	---	0.6
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 8	Mercury	---	---	---	---	---	Nervous System (Developmental)	3.3	---	---	3.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 9	Mercury	---	---	---	---	---	Nervous System (Developmental)	3.3	---	---	3.3
Fish Tissue	Fillet Fish Tissue (Skin On)	Reach 10	Mercury	---	---	---	---	---	Nervous System (Developmental)	3.4	---	---	3.4
Fish Tissue	Fillet Fish Tissue (Skin On)	Charles River	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.7	---	---	1.7
Fish Tissue	Fillet Fish Tissue (Skin On)	Sudbury Reservoir	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.2	---	---	1.2

--- = Pathway not evalutated.

Table 5-7

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Ethnic Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish Tissue	Whole Body Fish Tissue	Reach 1	Mercury	---	---	---	---	---	Nervous System (Developmental)	5.2	---	---	5.2
Fish Tissue	Whole Body Fish Tissue	Reach 2	Mercury	---	---	---	---	---	Nervous System (Developmental)	7.5	---	---	7.5
Fish Tissue	Whole Body Fish Tissue	Reach 3	Mercury	---	---	---	---	---	Nervous System (Developmental)	15.0	---	---	15.0
Fish Tissue	Whole Body Fish Tissue	Reach 4	Mercury	---	---	---	---	---	Nervous System (Developmental)	8.9	---	---	8.9
Fish Tissue	Whole Body Fish Tissue	Reach 5	Mercury	---	---	---	---	---	Nervous System (Developmental)	7.2	---	---	7.2
Fish Tissue	Whole Body Fish Tissue	Reach 6	Mercury	---	---	---	---	---	Nervous System (Developmental)	9.3	---	---	9.3
Fish Tissue	Whole Body Fish Tissue	Reach 7	Mercury	---	---	---	---	---	Nervous System (Developmental)	8.3	---	---	8.3
Fish Tissue	Whole Body Fish Tissue	Reach 7 - Heard Pond	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.8	---	---	1.8
Fish Tissue	Whole Body Fish Tissue	Reach 8	Mercury	---	---	---	---	---	Nervous System (Developmental)	8.6	---	---	8.6
Fish Tissue	Whole Body Fish Tissue	Reach 9	Mercury	---	---	---	---	---	Nervous System (Developmental)	10.1	---	---	10.1
Fish Tissue	Whole Body Fish Tissue	Reach 10	Mercury	---	---	---	---	---	Nervous System (Developmental)	11.4	---	---	11.4
Fish Tissue	Whole Body Fish Tissue	Charles River	Mercury	---	---	---	---	---	Nervous System (Developmental)	5.7	---	---	5.7
Fish Tissue	Whole Body Fish Tissue	Sudbury Reservoir	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.0	---	---	4.0

--- = Pathway not evalutated.

Table 5-8

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Ethnic Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish Tissue	Whole Body Fish Tissue	Reach 1	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.8	---	---	2.8
Fish Tissue	Whole Body Fish Tissue	Reach 2	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.0	---	---	4.0
Fish Tissue	Whole Body Fish Tissue	Reach 3	Mercury	---	---	---	---	---	Nervous System (Developmental)	8.0	---	---	8.0
Fish Tissue	Whole Body Fish Tissue	Reach 4	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.8	---	---	4.8
Fish Tissue	Whole Body Fish Tissue	Reach 5	Mercury	---	---	---	---	---	Nervous System (Developmental)	3.9	---	---	3.9
Fish Tissue	Whole Body Fish Tissue	Reach 6	Mercury	---	---	---	---	---	Nervous System (Developmental)	5.0	---	---	5.0
Fish Tissue	Whole Body Fish Tissue	Reach 7	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.5	---	---	4.5
Fish Tissue	Whole Body Fish Tissue	Reach 7 - Heard Pond	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.0	---	---	1.0
Fish Tissue	Whole Body Fish Tissue	Reach 8	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.6	---	---	4.6
Fish Tissue	Whole Body Fish Tissue	Reach 9	Mercury	---	---	---	---	---	Nervous System (Developmental)	5.4	---	---	5.4
Fish Tissue	Whole Body Fish Tissue	Reach 10	Mercury	---	---	---	---	---	Nervous System (Developmental)	6.1	---	---	6.1
Fish Tissue	Whole Body Fish Tissue	Charles River	Mercury	---	---	---	---	---	Nervous System (Developmental)	3.1	---	---	3.1
Fish Tissue	Whole Body Fish Tissue	Sudbury Reservoir	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.1	---	---	2.1

--- = Pathway not evalutated.

Table 5-9

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Ethnic Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish Tissue	Whole Body Fish Tissue	Reach 1	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.6	---	---	2.6
Fish Tissue	Whole Body Fish Tissue	Reach 2	Mercury	---	---	---	---	---	Nervous System (Developmental)	3.7	---	---	3.7
Fish Tissue	Whole Body Fish Tissue	Reach 3	Mercury	---	---	---	---	---	Nervous System (Developmental)	7.4	---	---	7.4
Fish Tissue	Whole Body Fish Tissue	Reach 4	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.4	---	---	4.4
Fish Tissue	Whole Body Fish Tissue	Reach 5	Mercury	---	---	---	---	---	Nervous System (Developmental)	3.5	---	---	3.5
Fish Tissue	Whole Body Fish Tissue	Reach 6	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.5	---	---	4.5
Fish Tissue	Whole Body Fish Tissue	Reach 7	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.1	---	---	4.1
Fish Tissue	Whole Body Fish Tissue	Reach 7 - Heard Pond	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.9	---	---	0.9
Fish Tissue	Whole Body Fish Tissue	Reach 8	Mercury	---	---	---	---	---	Nervous System (Developmental)	4.2	---	---	4.2
Fish Tissue	Whole Body Fish Tissue	Reach 9	Mercury	---	---	---	---	---	Nervous System (Developmental)	5.0	---	---	5.0
Fish Tissue	Whole Body Fish Tissue	Reach 10	Mercury	---	---	---	---	---	Nervous System (Developmental)	5.6	---	---	5.6
Fish Tissue	Whole Body Fish Tissue	Charles River	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.8	---	---	2.8
Fish Tissue	Whole Body Fish Tissue	Sudbury Reservoir	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.9	---	---	1.9

--- = Pathway not evalutated.

Table 5-10

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURE

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Scenario Timeframe: Current/Future
Receptor Population: Ethnic Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish Tissue	Whole Body Fish Tissue	Reach 1	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.4	---	---	1.4
Fish Tissue	Whole Body Fish Tissue	Reach 2	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.0	---	---	2.0
Fish Tissue	Whole Body Fish Tissue	Reach 3	Mercury	---	---	---	---	---	Nervous System (Developmental)	3.9	---	---	3.9
Fish Tissue	Whole Body Fish Tissue	Reach 4	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.4	---	---	2.4
Fish Tissue	Whole Body Fish Tissue	Reach 5	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.9	---	---	1.9
Fish Tissue	Whole Body Fish Tissue	Reach 6	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.4	---	---	2.4
Fish Tissue	Whole Body Fish Tissue	Reach 7	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.2	---	---	2.2
Fish Tissue	Whole Body Fish Tissue	Reach 7 - Heard Pond	Mercury	---	---	---	---	---	Nervous System (Developmental)	0.5	---	---	0.5
Fish Tissue	Whole Body Fish Tissue	Reach 8	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.3	---	---	2.3
Fish Tissue	Whole Body Fish Tissue	Reach 9	Mercury	---	---	---	---	---	Nervous System (Developmental)	2.7	---	---	2.7
Fish Tissue	Whole Body Fish Tissue	Reach 10	Mercury	---	---	---	---	---	Nervous System (Developmental)	3.0	---	---	3.0
Fish Tissue	Whole Body Fish Tissue	Charles River	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.5	---	---	1.5
Fish Tissue	Whole Body Fish Tissue	Sudbury Reservoir	Mercury	---	---	---	---	---	Nervous System (Developmental)	1.0	---	---	1.0

--- = Pathway not evalutated.

Table 5-11
Summary of Hazard Quotients
Reasonable Maximum Exposure
Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Reach	RME - Hazard Quotient				
	Recreational Angler		Subsistence Angler	Ethnic Angler	
	Child	Adult	Adult	Child	Adult
Reach 1	1.0	0.5	5.0	5.2	2.8
Reach 2	3.5	1.8	8.1	7.5	4.0
Reach 3	2.1	1.2	9.1	15.0	8.0
Reach 4	1.3	0.7	5.6	8.9	4.8
Reach 5	0.9	0.4	4.5	7.2	3.9
Reach 6	1.3	0.7	5.9	9.3	5.0
Reach 7	1.0	0.5	4.9	8.3	4.5
Reach 7 - Heard Pond	0.3	0.1	1.2	1.8	1.0
Reach 8	1.3	0.7	6.7	8.6	4.6
Reach 9	2.8	1.5	6.7	10.1	5.4
Reach 10	1.4	0.7	7.0	11.4	6.1
Charles River	0.7	0.3	3.4	5.7	3.1
Sudbury Reservoir	0.6	0.3	2.5	4.0	2.1

Note: Shading indicates value exceeds the target hazard quotient of 1.0.

Table 5-12

Summary of Hazard Quotients

Central Tendency Exposure

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

	CTE - Hazard Quotient				
	Recreational Angler		Subsistence Angler	Ethnic Angler	
Reach	Child	Adult	Adult	Child	Adult
Reach 1	0.6	0.3	2.5	2.6	1.4
Reach 2	1.7	0.9	4.0	3.7	2.0
Reach 3	0.8	0.4	4.5	7.4	3.9
Reach 4	0.5	0.2	2.8	4.4	2.4
Reach 5	0.5	0.3	2.2	3.5	1.9
Reach 6	0.5	0.3	2.9	4.5	2.4
Reach 7	0.6	0.3	2.4	4.1	2.2
Reach 7 - Heard Pond	0.1	0.05	0.6	0.9	0.5
Reach 8	0.8	0.4	3.3	4.2	2.3
Reach 9	1.4	0.7	3.3	5.0	2.7
Reach 10	0.9	0.4	3.4	5.6	3.0
Charles River	0.4	0.2	1.7	2.8	1.5
Sudbury Reservoir	0.2	0.1	1.2	1.9	1.0

Note: Shading indicates value exceeds the target hazard quotient of 1.0.

Table 5-13

% of Individual Fillet Samples Exceeding Target EPC for the Adult Recreational Angler

Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Reach	Target EPC (mg/kg)	% Exceeding		
		Bullhead	Largemouth Bass	Yellow Perch
Reach 1	1.0	0%	0%	0%
Reach 2	0.5	---	71%	38%
Reach 3	0.8	50%	50%	17%
Reach 4	0.8	0%	33%	0%
Reach 5	1.0	0%	0%	0%
Reach 6	0.8	0%	40%	0%
Reach 7	1.0	0%	0%	0%
Reach 7 - Heard Pond	0.8	0%	0%	0%
Reach 8	1.0	0%	40%	0%
Reach 9	0.5	0%	100%	46%
Reach 10	1.0	0%	30%	0%
Charles River	1.0	0%	0%	0%
Sudbury Reservoir	0.8	0%	0%	0%

Notes:

Target EPC based on RME case and a target hazard quotient of 1.

Applicable only to Sudbury River fish. See text for assumptions and discussion on why values differ from MADPH fish advisory limits.

--- = Species not evaluated within reach.

TABLE 5-14

SITE VERSUS REFERENCE CONCENTRATION STATISTICAL COMPARISONS

Reach	Site Compared with Reference Concentrations					
	Bullhead		Largemouth Bass		Yellow Perch	
	Fillet	WB	Fillet	WB	Fillet	WB
Reach 1 Reference Area						
2	NA	NA	NA	NA	S (A)	NS (E)
5	NA	NS (K)	NA	NA	NS (K)	NS (E)
7	NA	NS (E)	NA	NA	NS (E)	NS(A)
10	NA	NS (K)	NA	NA	S (E)	S (K)
Charles River Reference Area						
8	NS (E)	NS (E)	S (A)	S (A)	S (A)	S (A)
9	NS (A)	NS (A)	S (A)	S (A)	S (A)	S (A)
Sudbury Reservoir Reference Area						
3	S (A)	S (K)	S (K)	S (K)	S (A)	S (K)
4	NS (E)	NS (K)	S (K)	S (K)	S (A)	S (K)
6	S (A)	S (K)	S (K)	S (K)	S (A)	S (K)
Reach 7 – Heard Pond	S (E)	NS (K)	S (K)	S (K)	S (A)	S (A)

Notes:

Variances tested using Variance-Ratio Equal-Variance Test and Modified-Levene Equal Variance Test.
All tests run at ($\alpha = 0.05$).

A = Aspin-Welch Unequal Variance Test
E = Equal Variance t-Test
K = Kolmogorov-Smirnov Test for Different Distributions.
NA = Not available. Insufficient sample count to complete comparison.
NS = Not statistically significantly different from reference.
S = Statistically significantly different from reference.

Table 5-15

Site Versus Background Hazard Quotient Comparison
Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

Reach	Ratio of Site-Impacted to Reference HQ	
	Recreational and Subsistence Angler*	**Ethnic Angler**
Reach 1 Reference Area		
2	3.4/3.7/1.6	1.4
5	0.9	1.4
7	1.0	1.6
10	1.4	2.2
Charles River Reference Area		
8	2.0	1.5
9	4.2/4.5/2.0	1.8
Sudbury Reservoir Reference Area		
3	3.7	3.8
4	2.3	2.3
6	2.4	2.3
7 - Heard Pond	0.5	0.5

*Recreational angler - child/Recreational angler - adult/Subsistence angler

Note: Because the only difference between the calculation of site and background HQs is the EPC, the ratios of site-impacted to background HQs within a reach are the same among receptors subjected to the same EPC (e.g., adult and child ethnic angler). The exception being for reaches 2 and 9, where for the recreational anglers, the ingestion rates were based on flow regimes and those regimes were assumed to be different from those of the background locations.

Table 6-1
Individual Species to Aggregate Species EPC Ratios
Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

	EPC (mg/kg)		Species EPC:Aggregate EPC	
Reach/Species	**Fillet**	**Whole Body**	**Fillet**	**Whole Body**
Reach 1				
Bullhead	8.47E-01	5.12E-01	1.64	1.78
Largemouth Bass	4.18E-01	2.55E-01	0.81	0.88
White Sucker	NA	1.48E-01	---	0.51
Yellow Perch	2.83E-01	2.37E-01	0.55	0.82
Aggregate	5.16E-01	2.88E-01	---	---
Reach 2				
Bullhead	NA	1.63E-01	---	0.40
Largemouth Bass	1.14E+00	1.01E+00	1.37	2.45
White Sucker	NA	1.55E-01	---	0.38
Yellow Perch	5.27E-01	3.21E-01	0.63	0.78
Aggregate	8.31E-01	4.12E-01	---	---
Reach 3				
Bullhead	9.37E-01	8.91E-01	1.00	1.08
Largemouth Bass	1.21E+00	1.13E+00	1.29	1.37
Yellow Perch	6.65E-01	4.51E-01	0.71	0.55
Aggregate	9.36E-01	8.23E-01	---	---
Reach 4				
Bullhead	3.12E-01	2.86E-01	0.54	0.58
Largemouth Bass	8.15E-01	7.85E-01	1.41	1.60
Yellow Perch	6.09E-01	4.01E-01	1.05	0.82
Aggregate	5.78E-01	4.91E-01	---	---
Reach 5				
Bullhead	2.39E-01	2.04E-01	0.52	0.52
Largemouth Bass	7.22E-01	6.67E-01	1.56	1.69
Yellow Perch	4.30E-01	3.15E-01	0.93	0.80
Aggregate	4.63E-01	3.96E-01	---	---
Reach 6				
Bullhead	4.90E-01	4.29E-01	0.82	0.84
Largemouth Bass	9.10E-01	8.44E-01	1.52	1.66
Yellow Perch	4.01E-01	2.51E-01	0.67	0.49
Aggregate	6.00E-01	5.08E-01	---	---
Reach 7				
Bullhead	4.11E-01	3.99E-01	0.81	0.87
Largemouth Bass	8.67E-01	8.02E-01	1.72	1.76
Yellow Perch	2.36E-01	1.69E-01	0.47	0.37
Aggregate	5.05E-01	4.57E-01	---	---
Reach 7 - Heard Pond				
Bullhead	1.20E-01	1.05E-01	1.02	1.04
Largemouth Bass	1.68E-01	1.49E-01	1.42	1.48
Yellow Perch	6.66E-02	4.83E-02	0.56	0.48
Aggregate	1.18E-01	1.01E-01	---	---
Reach 8				
Bullhead	4.79E-01	3.72E-01	0.69	0.79
Bluegill	NA	3.26E-01	---	0.69
Largemouth Bass	1.21E+00	9.63E-01	1.75	2.03
Yellow Perch	3.88E-01	2.32E-01	0.56	0.49
Aggregate	6.91E-01	4.73E-01	---	---
Reach 9				
Bullhead	2.40E-01	2.18E-01	0.35	0.39
Largemouth Bass	1.31E+00	1.11E+00	1.91	2.00
Yellow Perch	5.07E-01	3.37E-01	0.74	0.61
Aggregate	6.85E-01	5.53E-01	---	---
Reach 10				
Bullhead	4.86E-01	5.12E-01	0.68	0.82
Largemouth Bass	1.21E+00	1.03E+00	1.69	1.65
White Sucker			---	---
Yellow Perch	4.58E-01	3.28E-01	0.64	0.53
Aggregate	7.19E-01	6.25E-01	---	---
Charles River				
Bullhead	3.56E-01	3.47E-01	1.03	1.10
Largemouth Bass	4.80E-01	4.45E-01	1.39	1.41
Yellow Perch	2.02E-01	1.51E-01	0.58	0.48
Aggregate	3.46E-01	3.14E-01	---	---
Sudbury Reservoir				
Bullhead	2.13E-01	1.77E-01	0.84	0.81
Largemouth Bass	4.21E-01	3.86E-01	1.66	1.78
Yellow Perch	1.25E-01	8.88E-02	0.50	0.41
Aggregate	2.53E-01	2.17E-01	---	---

TABLE 6-2

SUMMARY OF EXPOSURE PARAMETER UNCERTAINTIES

Exposure Parameter	Potential Direction of Uncertainty Per Receptor				
	Recreational Angler		Subsistence Angler	Ethnic Angler	
	Child	**Adult**		**Child**	**Adult**
Fish Ingestion Rate	+ 2 – 3 times	Either	Either	+ 2 – 3 times	Either
Fraction Ingested	± 100%	± 100%	± 100%	± 100%	± 100%
Exposure Frequency	May underestimate	May underestimate	May underestimate	May underestimate	May underestimate
Body Weight	Either (quantifiable depending upon age)	Likely overestimates for males, may underestimate for females	Likely overestimates for males, may underestimate for females	Either (quantifiable depending upon age)	Likely overestimates for males, may underestimate for females
Overall Direction of Uncertainty	***Likely Overestimate***	***Likely Overestimate***	***Likely Overestimate***	***Likely Overestimate***	***Likely Overestimate***

Notes:

Either = Value used in risk assessment may lead to an under- or an overestimate of exposure and, subsequently in the prediction of the potential for adverse health effects.
Likely overestimates = Value used in risk assessment is more likely to overestimate exposure and, subsequently the potential for adverse health effects.
May underestimate = Depending upon the individual, value used in risk assessment may underestimate exposure and, subsequently the potential for adverse health effects.

TABLE 7-1

SUMMARY OF POTENTIALLY SIGNIFICANT RISKS

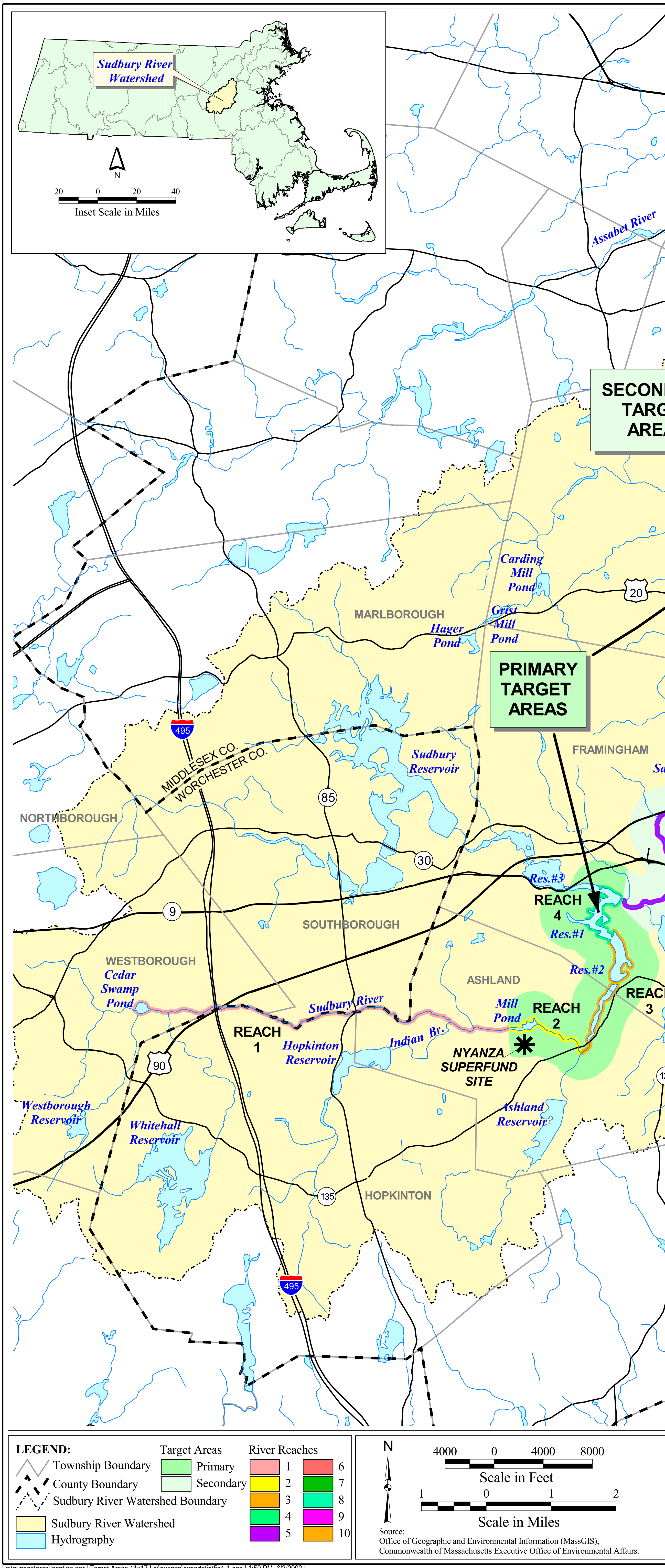
	Recreational Angler				Subsistence Angler		Ethnic Angler			
	RME		CTE		RME	CTE	RME		CTE	
Reach	**Child**	**Adult**	**Child**	**Adult**	**Adult**		**Child**	**Adult**	**Child**	**Adult**
Reach 1					√	√	√	√	√	√
Reach 2	√	√	√		√	√	√	√	√	√
Reach 3	√	√			√	√	√	√	√	√
Reach 4	√				√	√	√	√	√	√
Reach 5					√	√	√	√	√	√
Reach 6	√				√	√	√	√	√	√
Reach 7					√	√	√	√	√	√
Reach 7 – Heard Pond					√		√			
Reach 8	√				√	√	√	√	√	√
Reach 9	√	√	√		√	√	√	√	√	√
Reach 10	√				√	√	√	√	√	√
Charles River					√	√	√	√	√	√
Sudbury Reservoir					√	√	√	√	√	

√ - represents a potentially significant risk (HQ >1) from mercury exposure

Table 7-2
HHRA Risk Summary
Operable Unit IV - Nyanza Chemical Dump Superfund Site - Middlesex County, Massachusetts

	Site Impacted RME Hazard Quotient					Ratio of Site Impacted to Background Hazard Quotients	
	Recreational Angler		Subsistence Angler	Ethnic Angler		Recreational and Subsistence Angler	Ethnic Angler
Reach	Child	Adult	Adult	Child	Adult	(Recreational Child/Recreational Adult /Subsistence Adult)	Child/Adult
Reach 2	3.5	1.8	8.1	7.5	4.0	3.4/3.7/1.6	1.4
Reach 3	2.1	1.2	9.1	15	8.0	3.7	3.8
Reach 4	1.3	0.7	5.6	8.9	4.8	2.3	2.3
Reach 5	0.9	0.4	4.5	7.2	3.9	0.9	1.4
Reach 6	1.3	0.7	5.9	9.3	5.0	2.4	2.3
Reach 7	1.0	0.5	4.9	8.3	4.5	1.0	1.6
Reach 7 - Heard Pond	0.3	0.1	1.2	1.8	1.0	0.5	0.5
Reach 8	1.3	0.7	6.7	8.6	4.6	2.0	1.5
Reach 9	2.8	1.5	6.7	10	5.4	4.2/4.5/2.0	1.8
Reach 10	1.4	0.7	7.0	11	6.1	1.4	2.2

FIGURES



Nyanza Superfund Site OU IV
Sudbury River Mercury Contamination

FIGURE 1-1
LOCATION OF SUDBURY RIVER TARGET AREAS

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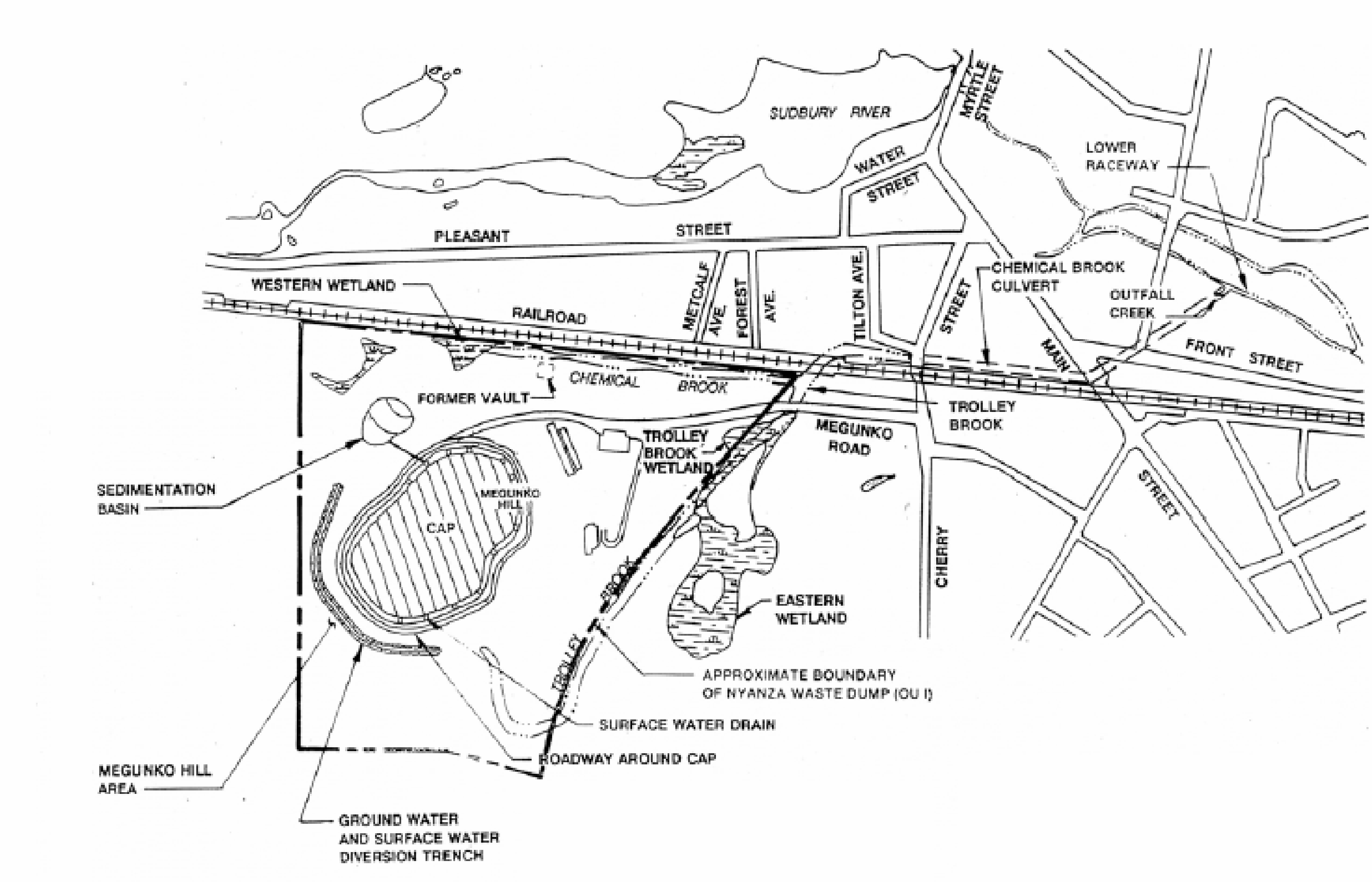
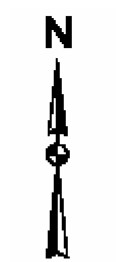


Legend:

Wetlands

Brooks/Streams



Scale: 1” ≅ 700’

Nyanza Chemical Dump Superfund Site
Middlesex County, Massachusetts

FIGURE 1-2
NYANZA FACILITY MAP

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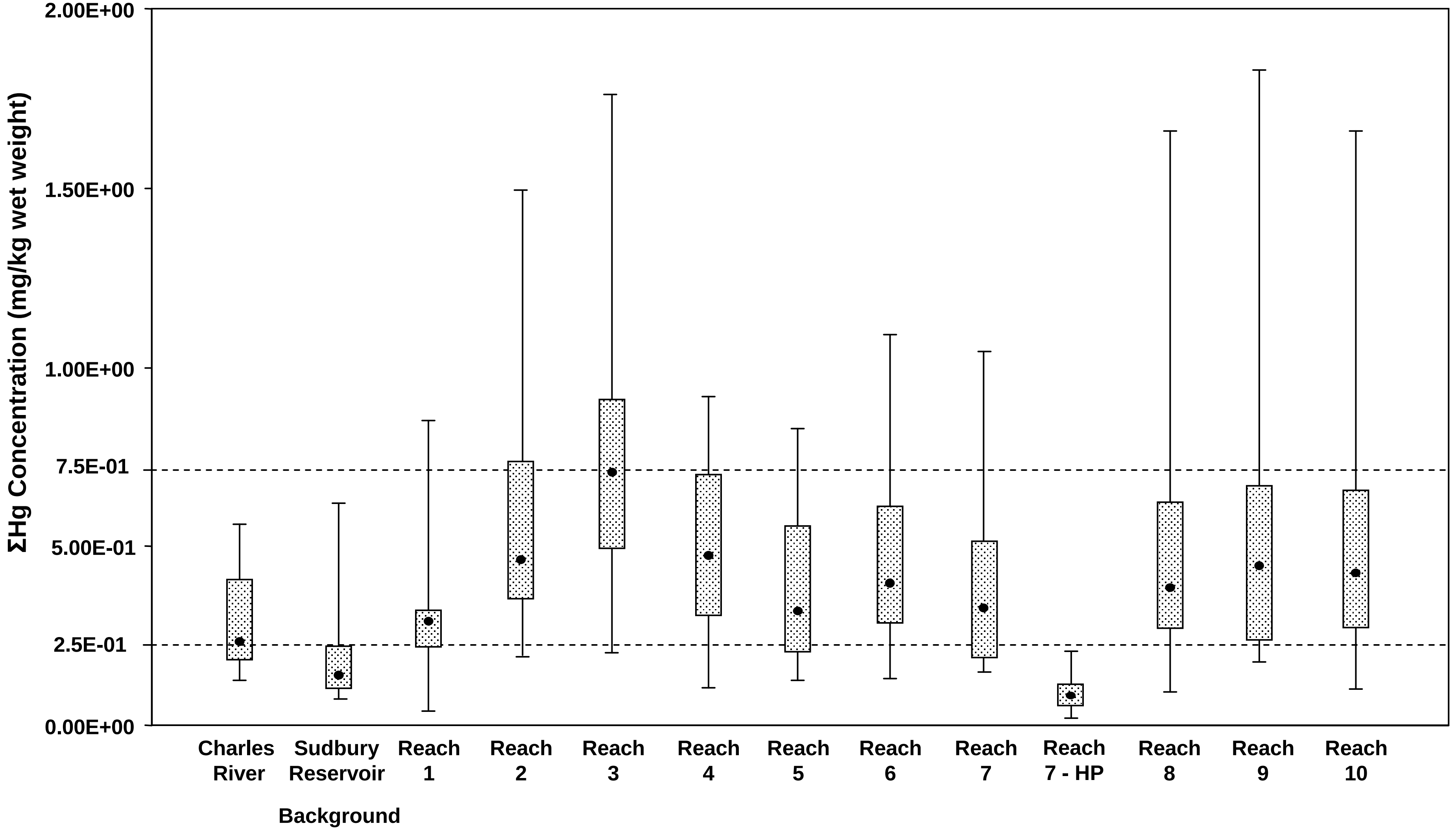
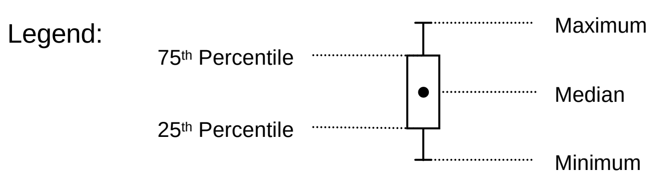
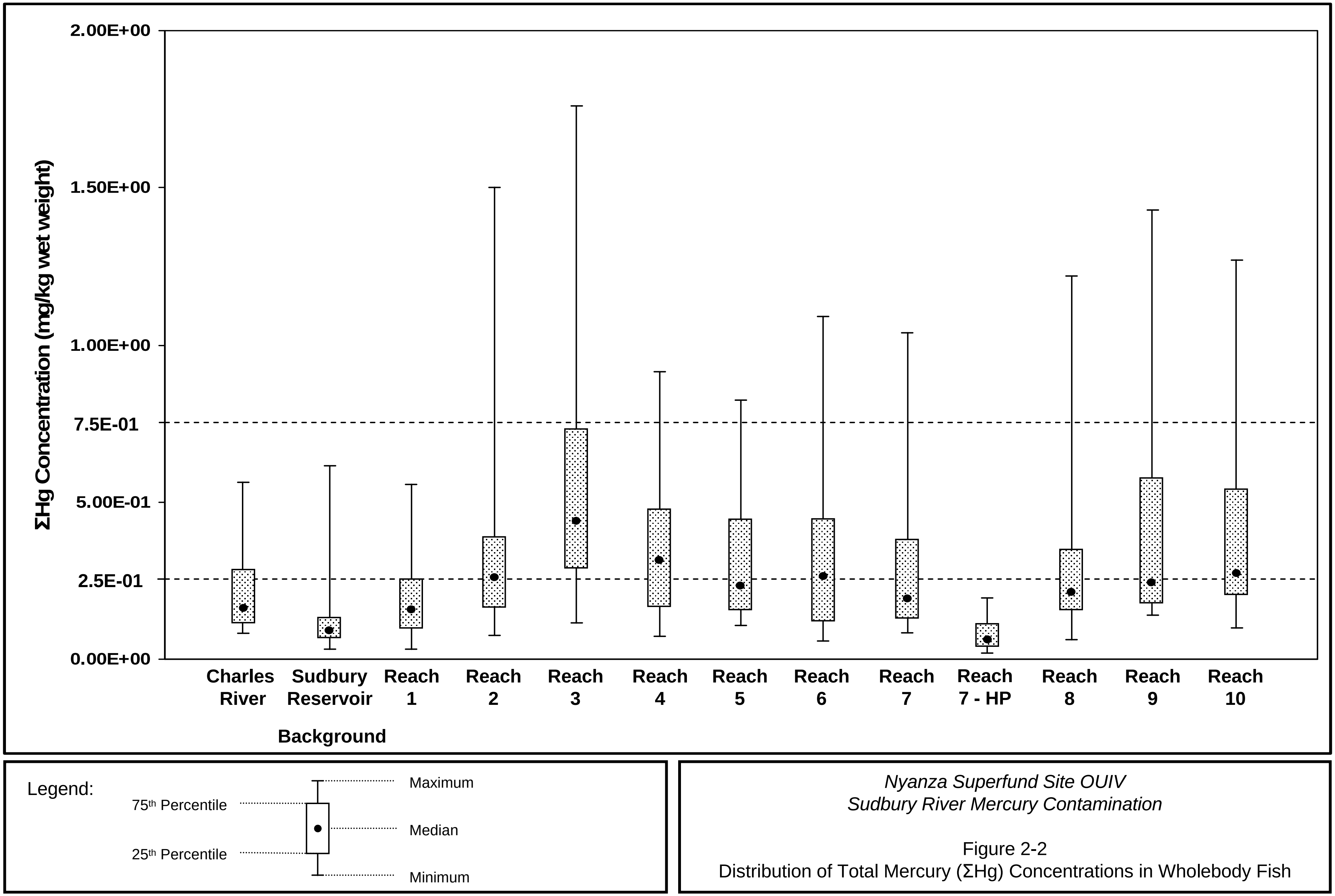




Nyanza Superfund Site OUIV
Sudbury River Mercury Contamination

Figure 2-1
Distribution of Total Mercury (ΣHg) Concentrations in Fish Fillets

Notes: Reach 1 – Headwaters to Pleasant Street Impoundment; Reach 2 - Pleasant Street Impoundment to Union Street Bridge; Reach 3 -Reservoir No. 2; Reach 4 - Reservoir No. 1; Reach 5 - Reservoir No. 1 dam to Massachusetts Turnpike overpass; Reach 6 - Turnpike overpass to the Saxonville Dam; Reach 7 - Saxonville Dam to Route 20 overpass; Reach 7 – HP = Heard Pond; Reach 8 - Route 20 overpass to the Route 117 overpass (includes Great Meadows National Wildlife Refuge); Reach 9 - Fairhaven Bay; Reach 10 - Fairhaven Bay outlet to the Sudbury/Assabet River confluence.

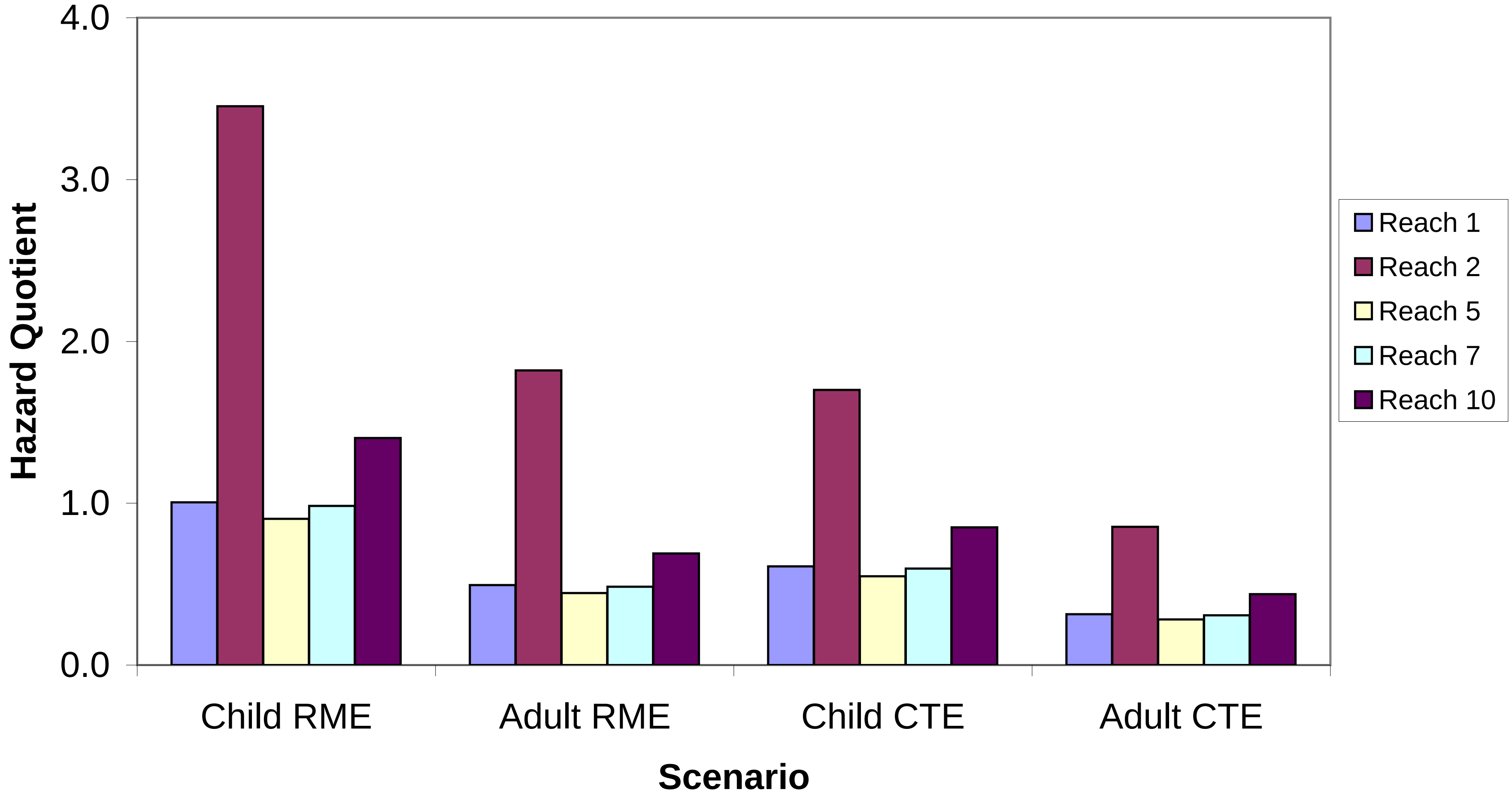


Nyanza Superfund Site OUIV
Sudbury River Mercury Contamination

Figure 2-2
Distribution of Total Mercury (ΣHg) Concentrations in Wholebody Fish

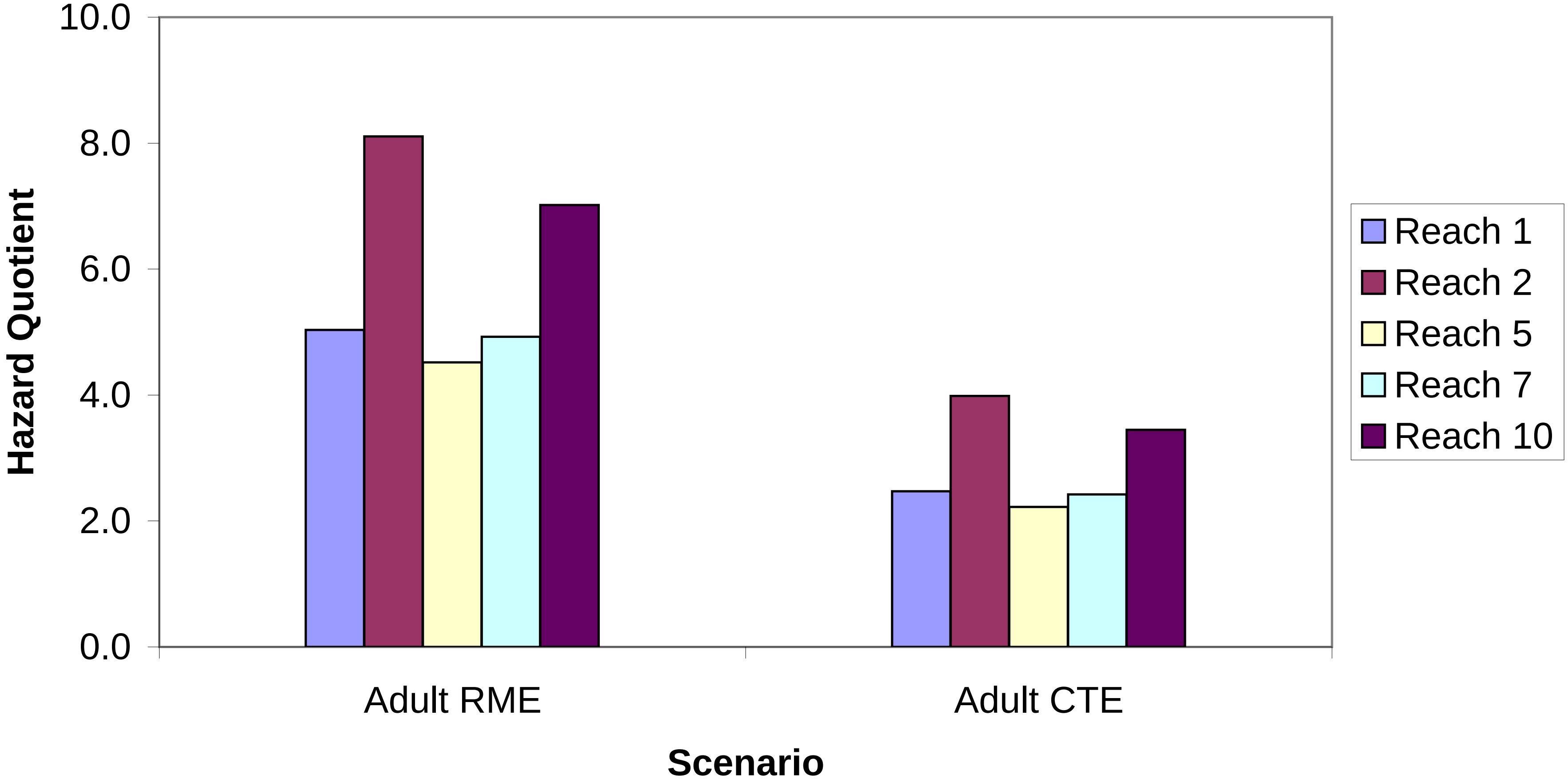
Notes: Reach 1 – Headwaters to Pleasant Street Impoundment; Reach 2 - Pleasant Street Impoundment to Union Street Bridge; Reach 3 -Reservoir No. 2; Reach 4 - Reservoir No. 1; Reach 5 - Reservoir No. 1 dam to Massachusetts Turnpike overpass; Reach 6 - Turnpike overpass to the Saxonville Dam; Reach 7 - Saxonville Dam to Route 20 overpass; Reach 7 – HP = Heard Pond; Reach 8 - Route 20 overpass to the Route 117 overpass (includes Great Meadows National Wildlife Refuge); Reach 9 - Fairhaven Bay; Reach 10 - Fairhaven Bay outlet to the Sudbury/Assabet River confluence.

Figure 5-1
Reach 1 Versus Associated Site Hazard Quotients - Recreational Angler
Operable Unit IV - Nyanza Chemical Dump Superfund Site
Middlesex County, Massachusetts



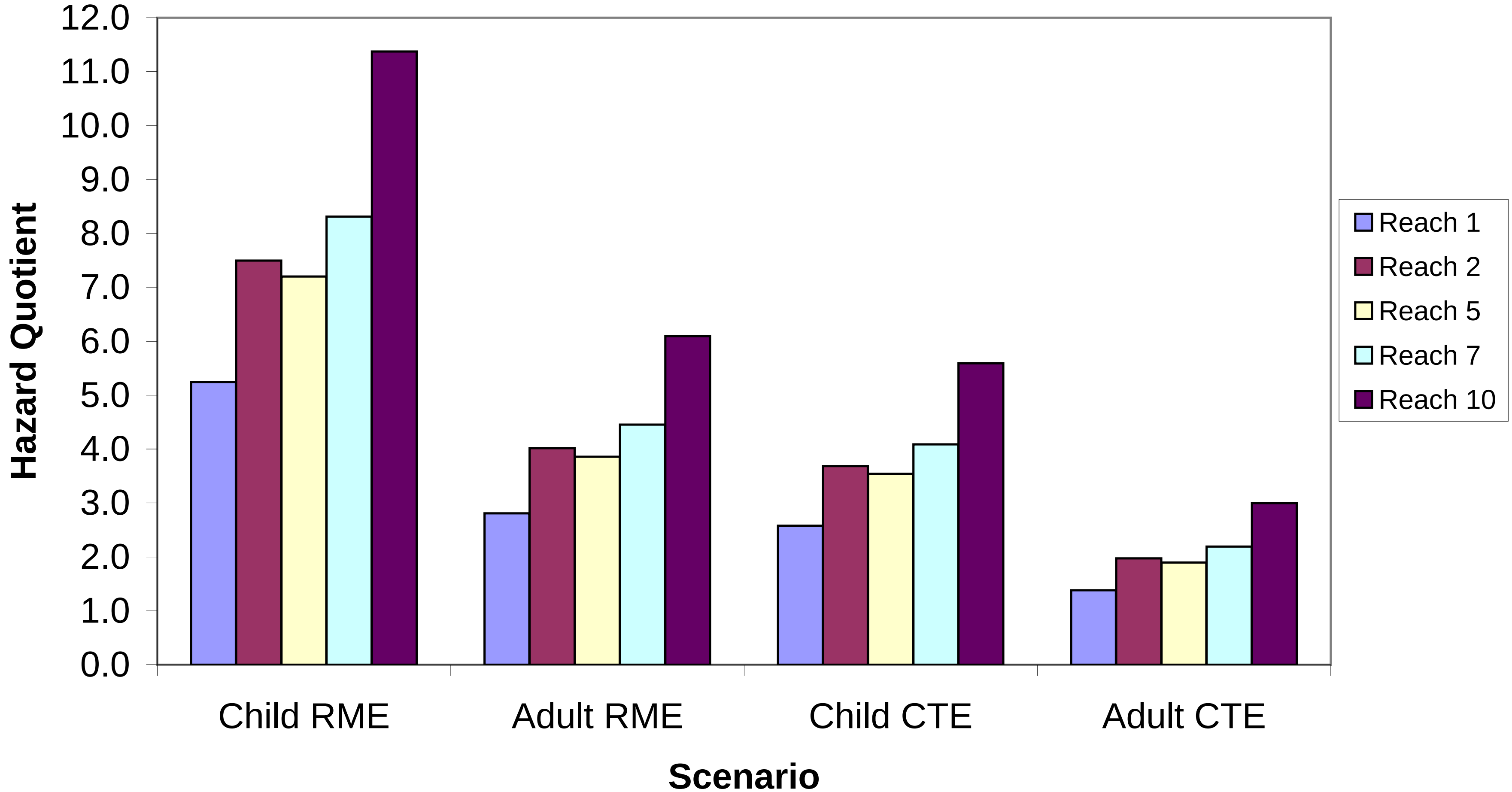
Note: Reach 1 is reference area

Figure 5-2
Reach 1 Versus Associated Site Hazard Quotients - Subsistence Fisher
Operable Unit IV - Nyanza Chemical Dump Superfund Site
Middlesex County, Massachusetts



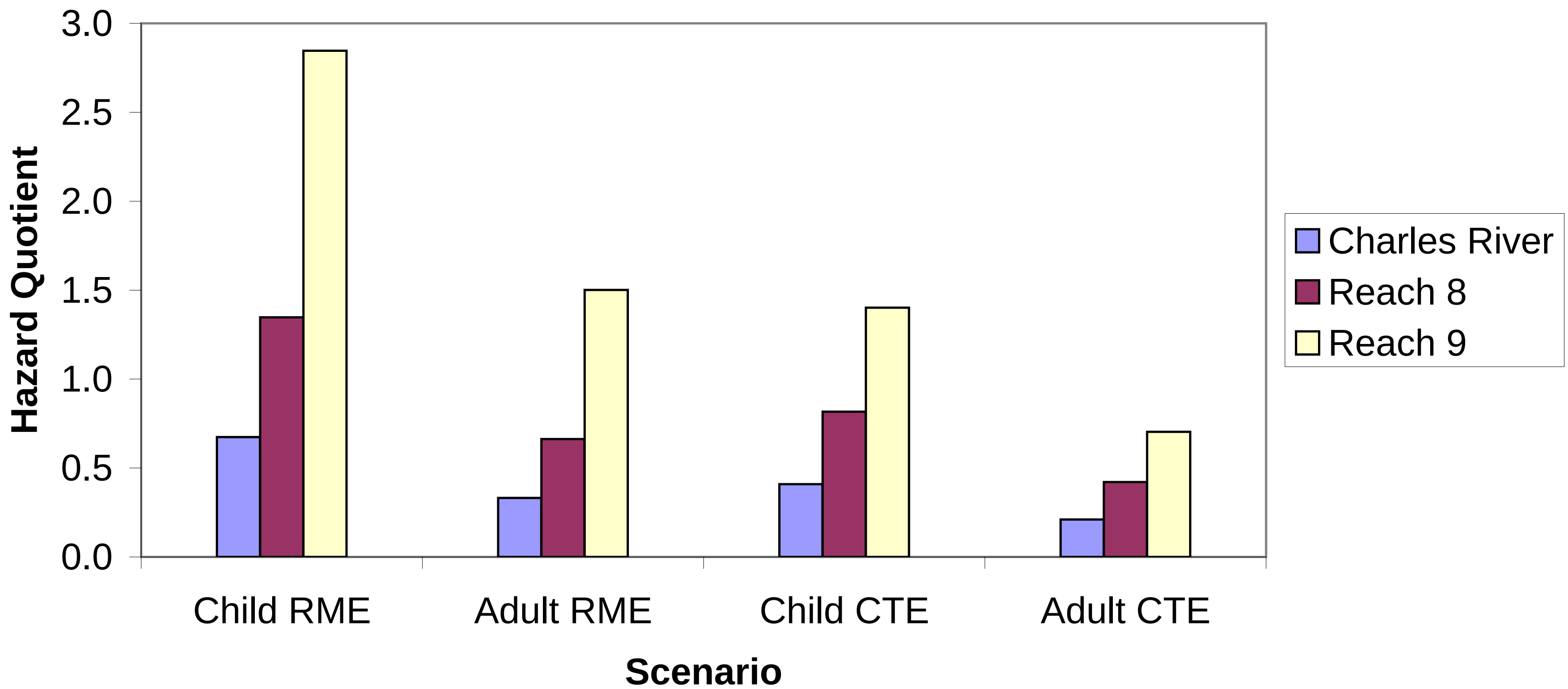
Note: Reach 1 is reference area

Figure 5-3
Reach 1 Versus Associated Site Hazard Quotients - Ethnic Angler
Operable Unit IV - Nyanza Chemical Dump Superfund Site
Middlesex County, Massachusetts



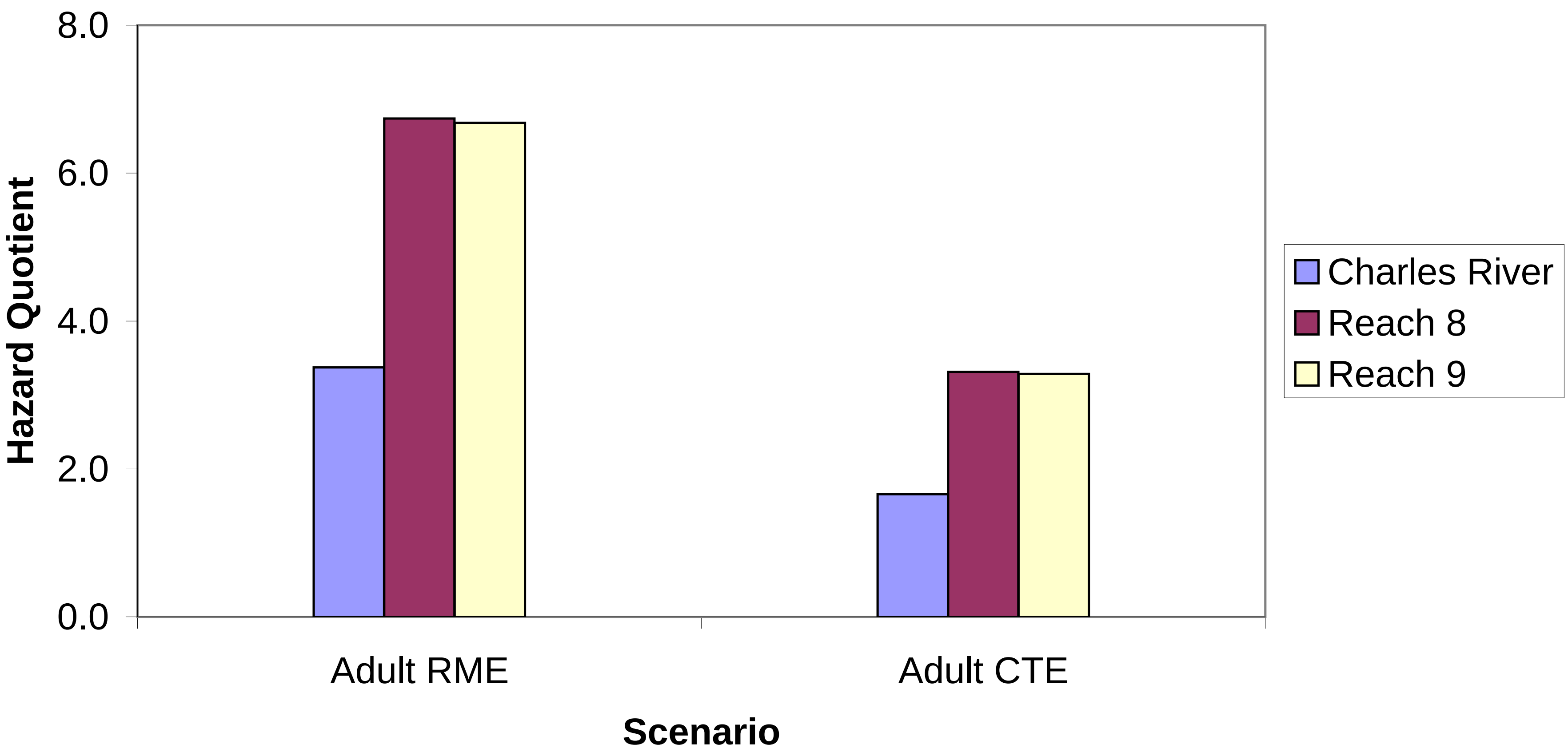
Note: Reach 1 is reference area

Figure 5-4
Charles River Versus Associated Site Hazard Quotients - Recreational Angler
Operable Unit IV - Nyanza Chemical Dump Superfund Site
Middlesex County, Massachusetts



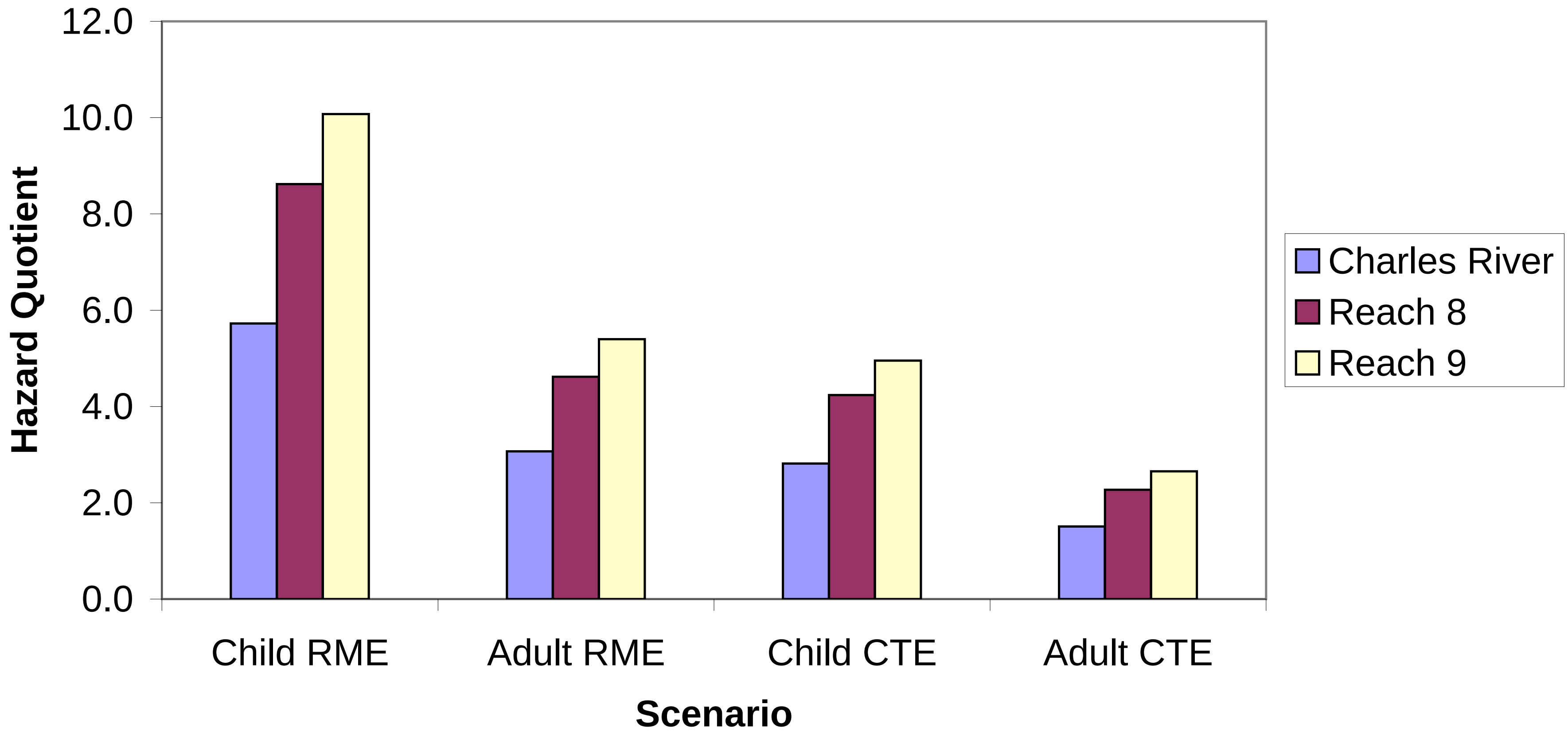
Note: Charles River is reference area

Figure 5-5
Charles River Versus Associated Site Hazard Quotients - Subsistence Fisher
Operable Unit IV - Nyanza Chemical Dump Superfund Site
Middlesex County, Massachusetts



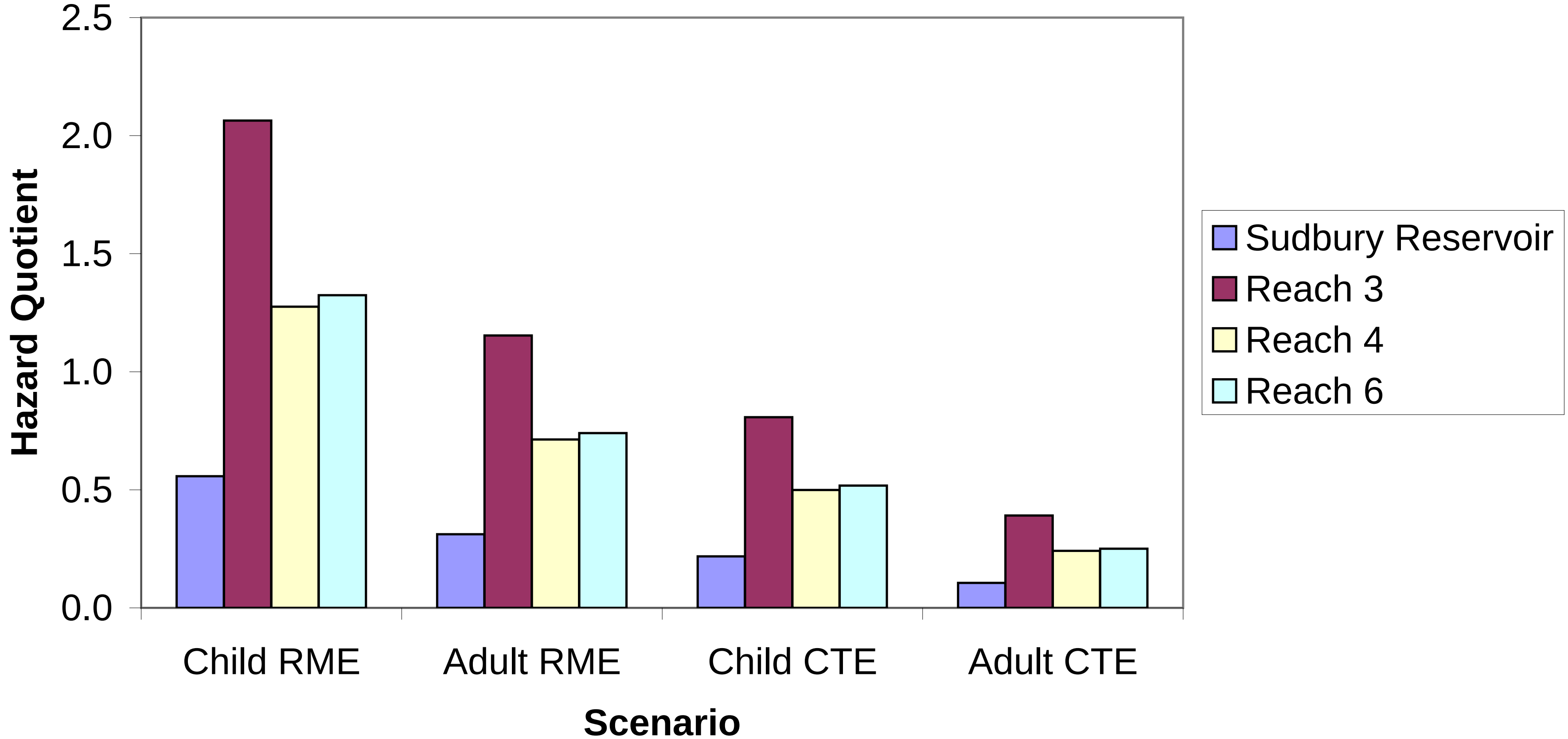
Note: Charles River is reference area

Figure 5-6
Charles River Versus Associated Site Hazard Quotients - Ethnic Angler
Operable Unit IV - Nyanza Chemical Dump Superfund Site
Middlesex County, Massachusetts



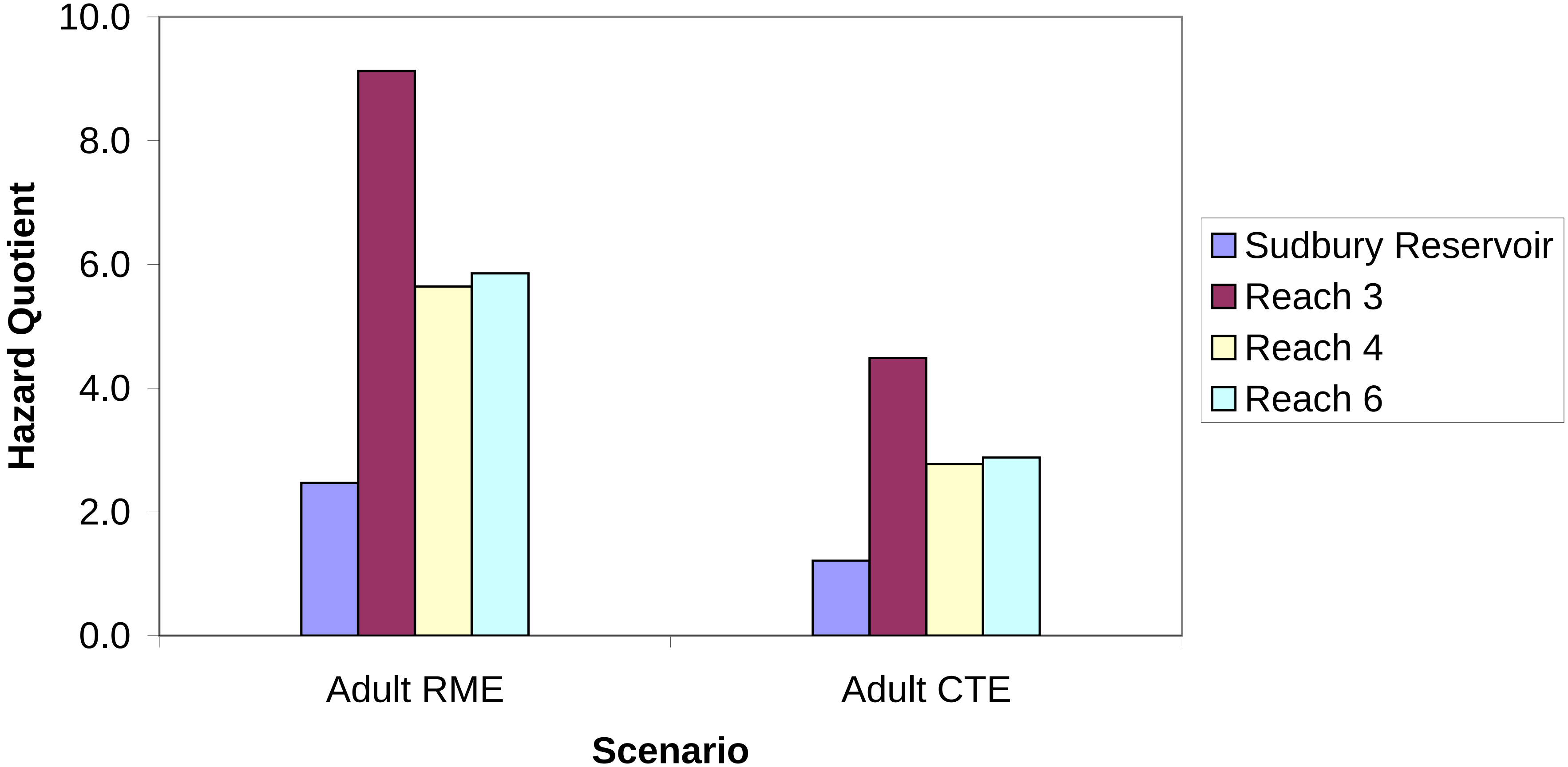
Note: Charles River is reference area

Figure 5-7
Sudbury Reservoir Versus Associated Site Hazard Quotients - Recreational Angler
Operable Unit IV - Nyanza Chemical Dump Superfund Site
Middlesex County, Massachusetts



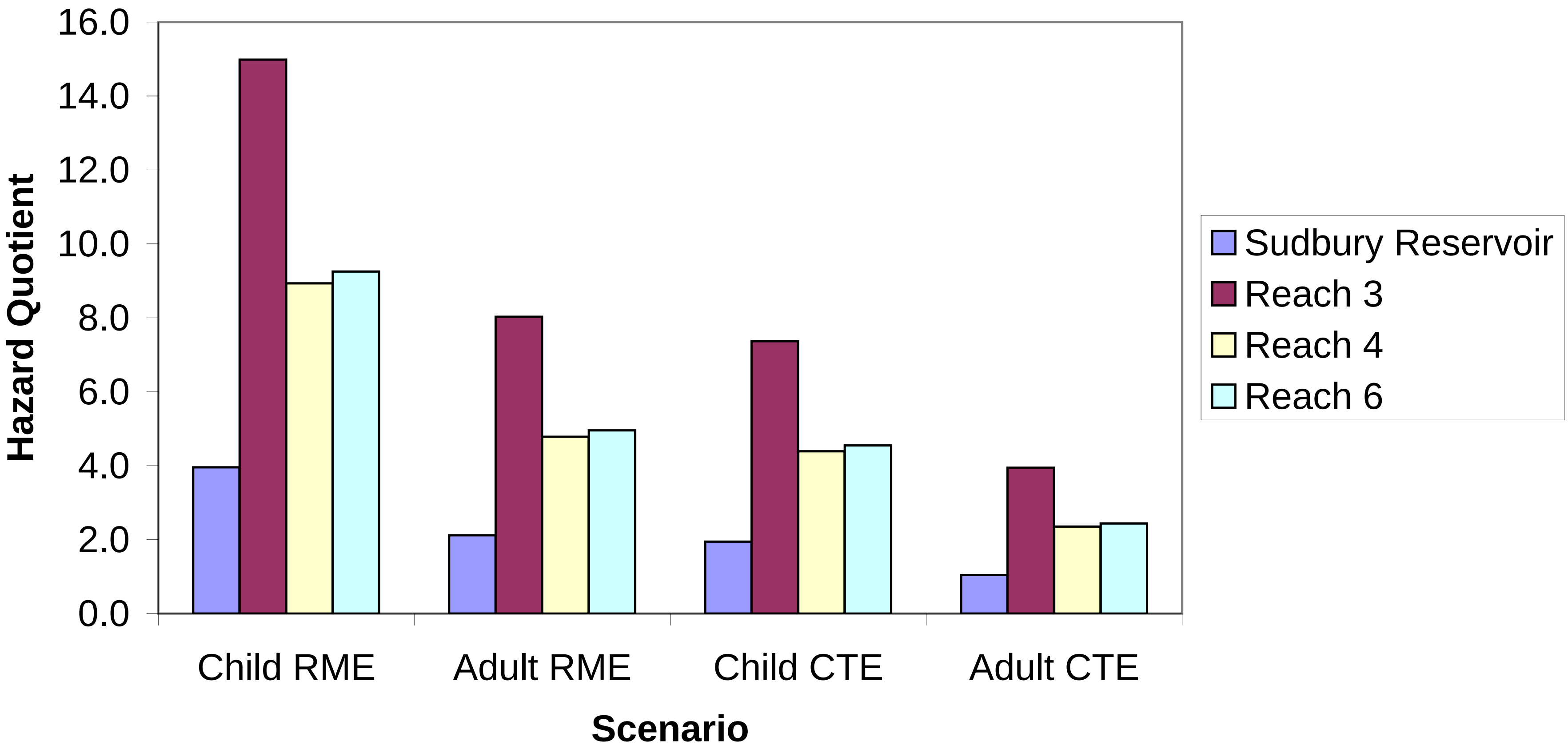
Note: Sudbury Reservoir is reference area

Figure 5-8
Sudbury Reservoir Versus Associated Site Hazard Quotients - Subsistence Fisher
Operable Unit IV - Nyanza Chemical Dump Superfund Site
Middlesex County, Massachusetts



Note: Sudbury Reservoir is reference area

Figure 5-9
Sudbury Reservoir Versus Associated Site Hazard Quotients - Ethnic Angler
Operable Unit IV - Nyanza Chemical Dump Superfund Site
Middlesex County, Massachusetts



Note: Sudbury Reservoir is reference area