EXPLANATION OF SIGNIFICANT DIFFERENCES (ESD)

NYANZA CHEMICAL WASTE DUMP SITE
OPERABLE UNIT 4

ASHLAND, MASSACHUSETTS

Public Comment Draft
August 2016

Send written comments, postmarked no later than September 9th, 2016, to:

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5 Post Office Square
Boston, MA 02109
Or via email to: keefe.daniel@epa.gov

U.S. ENVIRONMENTAL PROTECTION AGENCY
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BOSTON, MA 02109-3912

SEMS Doc ID 591246

U.S. EPA Region 1
Explanation of Significant Differences (ESD)
Nyanza Chemical Waste Dump Superfund Site Operable Unit 4
Public Comment Draft
August 2016

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I. INTRODUCTION

A. SITE NAME & LOCATION

Nyanza Chemical Waste Dump Superfund Site, Operable Unit (OU) 4
Ashland, Massachusetts
CERCLIS No. MAD990685422

B. LEAD & SUPPORT AGENCIES

Lead Agency: United States Environmental Protection Agency (EPA)

- *Contact: Daniel Keefe, EPA Remedial Project Manager, (617) 918-1327*

Support Agency: Massachusetts Department of Environmental Protection (MassDEP)

- *Contact: David Buckley, MassDEP Project Manager, (617) 556-1184*

C. LEGAL AUTHORITY FOR ESD

Section 117(c) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. § 9617(c), and Section 300.435(c)(2)(i) of the National Contingency Plan (NCP, 40 CFR § 300.435(c)(2)(i) require that, if any remedial action is taken after adoption of a final remedial action plan, and such action differs in any significant respect from the final plan, EPA shall publish an ESD and the reason such changes were made. While not required by Section 300.435(c)(2)(i) of the NCP, EPA will hold a public comment period from August 10th, 2016 to September 9th, 2016 on this draft ESD to ensure that all interested parties have an opportunity to provide input to EPA before its final decision on this modification to the remedy.

D. SUMMARY OF ESD

1. The Record of Decision (ROD) for Nyanza OU4, signed in September 2010, is a combination remedy consisting of enhanced natural recovery (ENR) via thin-layer sand capping in Reach 3, monitored natural recovery (MNR), institutional controls (ICs), and long-term monitoring. Each of these components addresses human consumption of fish contaminated by mercury.
2. This ESD recommends a significant change to the selected remedy whereas the "Enhanced Natural Recovery" (via thin-layer sand capping) component in Reach 3 is replaced with the "Monitored Natural Recovery" component as described in the 2010 ROD.

3. The basis for this change is the reduction in fish tissue mercury concentration (and corresponding human health risk) posed by these fish from within the portion of the river were ENR was selected.
4. The updated risk for this portion of the river (i.e., Reach 3) is less than or equal to the risk posed by other river reaches where MNR was the selected remedy in 2010 ROD.
5. This ESD updates a number of federal and state Applicable or Relevant and Appropriate (ARARs) cited in the 2010 ROD that either have been eliminated, modified or otherwise changed from when was the ROD was issued (Attachment A). These changes to the ARARs are necessary to ensure that the remedy is protective of human health and the environment, in accordance with 40 CFR § 300.430(f)(1)(ii)(B)(1). None of these changes fundamentally alters the selected remedy.

E. PUBLIC COMMENT PERIOD

This draft ESD is being issued for public comment. A formal public comment period on this draft ESD will run from August 10th, 2016 to September 9th, 2016. During this period, EPA will accept written and emailed comments on this draft ESD. Comments should be sent:

via mail: Daniel Keefe, Remedial Project Manager
U.S. EPA, Region 1
Office of Site Remediation and Restoration, OSRR (07-01)
5 Post Office Square, Suite 100
Boston, MA 02109-3912

via email: keefe.daniel@epa.gov

The final ESD will include a copy of all comments received during the comment period, along with EPA's responses to those comments and a description of any changes to the ESD since the issuance of the draft ESD.

F. PUBLIC RECORD

EPA will consider and respond to all comments received during the comment period before issuing the final ESD. EPA's responses to these comments will be included in the final ESD. The public comments and EPA's responses to them will be made part of the administrative record for the Site that is available for public review at the locations listed below:

U.S. Environmental Protection Agency
Records Center
5 Post Office Square, Suite 100
Boston, MA 02109
617-918-1440
Monday-Friday: 9:00 am - 5:00 pm

Ashland Public Library
66 Front Street
Ashland, MA 01721
508-881-0134
Tuesday -Thursday: 10:00 am – 8:00 pm
Friday: 10:00 am – 6:00 pm
Saturday: 10:00am – 5:00 pm

Framingham Public Library
49 Lexington Street
Framingham, MA 01801
508-532-5570
Monday-Thursday: 9:00 am – 9:00 pm
Friday - Saturday: 9:00 am – 5:00 pm
Sunday: 1:00 pm – 5:00 pm

II. SUMMARY OF SITE HISTORY, CONTAMINATION AND SELECTED REMEDY

A. SITE HISTORY, CONTAMINATION AND SITE RISKS

The 35-acre former Nyanza Chemical facility ("facility") is located in Ashland, Middlesex County, Massachusetts, approximately 22 miles west of Boston (Figure 1). The facility is situated in an industrial area 400 feet south of the Sudbury River (Figure 2). Mercury was used as a catalyst 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; a total of approximately 45 to 57 metric tons of mercury were released to the Sudbury River during this period. From 1970 until the facility closed in 1978, wastes were treated on site and wastewater was discharged to Ashland's town sewer system. During the period of operation, large volumes of chemical wastes (volatile organic compounds, semi-volatile organic compounds, and heavy metals) were disposed in burial pits, below ground containment structures and various lagoons. Process chemicals that could not be reused or recycled, such as phenol, nitrobenzene, and mercuric sulfate, were disposed of at an on-site landfill or discharged into the Sudbury River mainly through a collection of streams and culverts referred to as Chemical Brook, Trolley Brook, Outfall Creek and the Lower Raceway.

The Site was listed on the National Priority List (NPL) on September 8, 1983. Due to the size and complexity of environmental impacts at the Site, multiple Operable Units ("OUs") were created to allow independent evaluation of distinct portions of the Site and/or contaminated media. OU1 is the landfill at the Site; OU2 is the contaminated groundwater; OU3 addressed contamination in the Eastern Wetland, Chemical Brook, Trolley Brook and Outfall Creek. OU4 is that portion of the Sudbury River which became contaminated due to the historic discharge (and subsequent migration of) mercury to and within the Sudbury River. Figure 3 depicts the relationship of OU4 to the other Nyanza Operable Units.

With regard to OU4, to facilitate assessment and evaluation, the Sudbury River has been routinely been divided into ten "reaches", with each "reach" having unique hydrologic properties (e.g., fast-flowing areas, impounded areas, wetlands). These reaches are depicted on Figure 4. The River is a flowing stream (Reach 1) upstream of the Nyanza facility. Reach 2 consists of Mill Pond and a small flowing steam which is the location of historic surface water discharges from the Nyanza site. The River flows into Reach 3 (a.k.a. Framingham Reservoir No. 2), the subject reach of this ESD, and then into Reach 4 (a.k.a., Framingham Reservoir No. 1). Each of the reservoirs effectively acts as a settling basin, as velocity decreases and depth and width increase within these impoundment areas. After Reach 4, the River increases in velocity and returns to a narrow channel (Reach 5) until it reaches the Saxonville impoundment (Reach 6), where the channel widens and the velocity decreases allowing sediments to deposit again in the River's third impoundment area. As the River outlets from Saxonville impoundment, the River channel narrows again and has adjacent areas of wetlands along its banks (Reach 7) until it reaches the Great Meadows National Wildlife Refuge ("GMNWR") (Reach 8), where the Sudbury River follows a narrow channel surrounded by an expansive 4,000-acre floodplain. Downstream of GMNWR, the River enters Fairhaven Bay (Reach 9), where it widens and velocity decreases again. The last portion of the River is Reach 10, where the River returns to a flowing stream in a narrow channel with isolated areas of wetlands along the banks until its confluence with the Assabet River in Concord, MA.

Protected resources such as wetlands and floodplains exist in and around Reach 3. No endangered or species of concern have been identified in the area.

EPA has completed a number of studies and assessments of the Sudbury River. Notably, a Human Health Risk Assessment ("HHRA") was completed in 1999; it concluded that the only unacceptable risk to human health within the River was from the consumption of mercury-contaminated fish. Incidental ingestion and direct contact of surface water and sediment were also evaluated and were determined not to pose an unacceptable risk to human health. Following the collection of fish during 2003 from all 10 river reaches, a 2006 Supplemental HHRA concluded that the only exposure scenario resulting in an unacceptable risk to human health was the consumption of mercury-contaminated fish by a "recreational angler" (note a recreational angler is someone assumed to eat approximately 10 to 15 servings per year of fish fillets caught in the Sudbury River).

A Baseline Ecological Risk Assessment ("BERA") was completed in 1999. The 1999 BERA relied significantly on food chain modeling and, based on this modeling, the 1999 BERA projected the existence of certain ecological risks. Between 2002 and 2005, numerous field studies were completed and numerous samples collected to directly measure the degree of risk to ecological receptors, the results of which were reported in a 2008 Supplemental Baseline Ecological Risk Assessment ("SBERA"). The SBERA found no population-level effects on plants or animals from contamination in the Sudbury River.

B. SUMMARY OF THE OU4 ROD SELECTED REMEDY

The 2010 ROD for OU4 of the Nyanza Site has several components: institutional controls ("ICs"), monitored natural recovery ("MNR"), enhanced natural recovery ("ENR"), long-term monitoring, and five-year reviews. Each of these components addresses human consumption of fish contaminated by mercury or methylmercury. Human consumption of mercury-contaminated fish caught from the River represents the sole actionable threat to human health; there is no actionable threat or risk to the environment. This remedy allows OU4 to be used for fishing and fish consumption assuming "recreational" quantities of fish are consumed (not accounting for other sources of mercury), except in Reach 8 (refer to discussion in the ROD, page 21, regarding natural-occurring areas of increased methylmercury production). Certain river reaches (namely Reaches 1, 5 and 7) did not trigger an unacceptable health risk to recreational anglers; accordingly in the 2010 ROD, no remedy was selected for these river reaches.

The major components of the selected remedy, as described in the 2010 ROD, are:

1. Enhanced Natural Recovery for Reach 3. ENR entails placing a six-inch layer of sand over sediments containing a concentration of mercury in excess of 10 parts per million ("ppm") in surface sediment, so as to accelerate natural recovery processes by which mercury is diluted in river sediments. This, in turn, would contribute to a reduction of mercury concentrations in fish tissue over time. ENR was specified for an 80-acre portion of Reach 3 (refer to Figure 5), which is the reach with the highest level of mercury contamination in both fish and sediment.
2. Monitored Natural Recovery. MNR will involve taking samples of fish tissue, sediment, and/or surface water to monitor natural recovery processes. This was selected for the following river reaches: Reach 2, Reach 4, Reach 6, Reach 9 and Reach 10.
3. Long-term Monitoring. Reach 8 will be monitored to ensure that mercury concentrations in fish are stable or decreasing over time, although without any expectation that concentrations will reach levels allowing for safe consumption of fish on a recreational scale.
4. Institutional Controls. The ICs for OU4 shall include posting of fish advisory signs, coordination with State agencies responsible for maintaining dam structures along the River, and public outreach to discourage consumption of contaminated fish.
5. Five Year Reviews. There will be five-year reviews of the remedy's protectiveness and performance.

III. DESCRIPTION OF SIGNIFICANT DIFFERENCES AND THE BASIS FOR THESE DIFFERENCES

A. UPDATING HUMAN HEALTH RISK ASSESSMENT

Since consumption of mercury-contaminated fish from the Sudbury River resulted in a Hazard Index exceeding 1, it was necessary to develop a fish-tissue mercury concentration that could be used as a remediation goal (RG). A risk-based derivation was completed and it was determined that the fish-tissue mercury concentration that would result in an HI of 1 was 0.48 mg/kg. This calculation was based on the most sensitive receptor under the scenario with the highest ingestion rate (i.e., a child recreational angler). This value was adopted as the remediation goal (RG) for mercury in fish tissue. It is slightly higher than the average background methylmercury concentration (0.43 mg/kg) and is also higher than EPA's National Recommended Water Quality Criterion (NRWQC) of 0.3 mg/kg methylmercury in fish. The NRWQC was previously determined not to be relevant and appropriate due to it being below the average background concentration (refer to Nyanza OU4 ROD page 78).

In the 2010 ROD, EPA's modeling showed that Reach 3 would not achieve the 0.48 mg/kg cleanup level for mercury concentrations in fish tissue through natural processes within the same estimated 30-year timeframe as the other reaches (excluding Reach 8). As a result, ENR (via thin-layer sand capping) was selected to reduce the estimated 70 years that Reach 3 would otherwise have taken to achieve the cleanup levels, to approximately 30 years. Subsequent to the selection of the 2010 remedy, EPA completed various studies in support of the Remedial Design; this included (in 2014) the collection of edible-size fish from Reach 3. The purpose of the sampling was to document baseline conditions prior to remedy construction, as well as to recalculate the human health risk from the consumption of these fish.

EPA collected fish in 2014 according to an approved Sample and Analysis Plan (SAP) dated October 2014. The SAP details target species of fish (and sizes) to collect so as to allow for the recalculation of human health risk using fish that closely matched the cohort of fish collected in 2003. An overabundance (i.e., over-catch) of fish were harvested so as to allow fish to be "aged", as some of the fish collected previously were also aged. To the extent practicable, this allowed for the submission of fish of the same species, and of similar size and age to be used in the risk evaluation. The resulting average concentration (by species) were derived by employing ProUCL Version 5.0 to calculate the 95 percent upper confidence limit (95% UCL) as was done in the prior HHRA risk assessment. The table below summarizes the three species average concentration (denoted as C_{fish} below) and the recalculation of human health risk.

Human Health Risk Comparison (2003 vs 2014)
from the Consumption of Mercury-Contaminated Fish (Reach 3)

	Fish Collected in 2014			Fish Collected in 2003	
Exposure Factors	**Reasonable Maximum Exposure**			**Reasonable Maximum Exposure**	
	Adult Recreational Angler (using 2006 Exposure Factors)	**Adult Recreational Angler (using updated Exposure Factors)**	**Child Recreational Angler (Exposure Factors did not change)**	**Adult Recreational Angler**	**Child Recreational Angler**
C_{fish} (mg/kg)	0.74166	0.74166	0.74166	0.940	0.940
RfD for methylmercury (mg/kg-d)	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04
IR_{fish} (g/day)	18	18	6.9	18	6.9
FI (unitless)	0.5	0.5	0.5	0.5	0.5
CF (kg/g)	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
EF (days)	350	350	350	350	350
ED (years)	30	*26*	6	30	6
BW (kg)	70	*80*	15	70	15
$AT_{non\text{-}cancer}$ (days)	10950	9490	2190	10950	2190
CDI (mg/kg-d)	9.14E-05	8.00E-05	1.64E-04	1.15E-04	2.06E-04
HQ (mg/kg-d)	**0.9**	**0.8**	**1.6**	**1.2**	**2.1**

Italics values changed in 2014

Red value exceeds risk of adverse health effects

As reflected in the chart above, the updated risk evaluation (completed in 2015) for Reach 3 revealed a decrease (-21%) in the Hazard Index (HI) for adverse health effects for a child recreational angler consuming fish from Reach 3 from 2.1 calculated in 2006 to 1.6 in 2015. Other risk assessment factors were also updated as part of the 2015 risk evaluation, namely, the assumed weight for an adult individual was increased from 70 kg to 80 kg (OSWER Directive 92100.1-120). The risk to an adult recreational angler also decreased during this time frame from 1.2 to 0.8 when both the lower concentration of mercury in fish and the increased adult body weight are considered. Refer to Attachment B for complete copy of the updated risk summary memorandum for Reach 3. The more-recently calculated human health risks for Reach 3 are less than or equal to the risk(s) posed by other river reaches where MNR was the selected remedy in 2010 ROD. There is nothing unique about this reach (as compared to the other Sudbury river reaches) that would suggest it will not also recover in the same 30- year estimated cleanup time frame as the other river reaches.

In addition to the decrease in the HI for adverse health effects from edible-size fish, a statistically "significant reduction" was also observed in smaller (non-edible size) fish from Reach 3 as described in the "*Updated Trend Analysis for Total Mercury in Largemouth Bass and Yellow Perch collected in 2014 from Reach 3"* dated May 4, 2016 (see Attachment C).

The reduction in fish tissue concentration observed by EPA for fish caught from the Sudbury River is consistent with mercury reductions (in fish) observed by others (e.g., MassDEP). As published by Environmental Science & Technology (ES&T) in 2014, *Temporal and Spatial Trends in Freshwater Fish Tissue Mercury Concentrations Associated with Mercury Emissions Reductions*. Describes MassDEP's monitoring of fish mercury levels from 17 waterbodies between the years 1999 to 2011. The species most frequently collected in the MassDEP study include the same species collected from the Sudbury River (i.e., Large Mouth Bass (LMB) and Yellow Perch (YP)). MassDEP reports greater reduction in LMB and YP (44 and 43% respectively) over this time period in lakes that were immediately downwind of known atmospheric sources of mercury (e.g., municipal waste incinerators). The reduction of mercury in fish for waterbodies from other areas of the State were 13% and 19% for LMB and YP, respectively (ES&T, 2014). These reductions have been attributed to various legislative changes enacted as a result of the 1998 New England Governors and Eastern Canadian Premiers regional Mercury Action Plan (MAP). According to the Massachusetts State Anthropogenic Mercury Emissions Inventory Update, prepared in 2011 by the Northeast States for Coordinated Air Use Management (NESCAUM), there was been a 91% reduction in mercury emissions between 1996 and 2008.

In addition to the measured reduction of mercury concentrations in fish collected (in 2014) from Reach 3 of the Sudbury River, EPA also collected fish (in 2015) from other Sudbury River reaches where MNR had been selected (namely Reaches 2, 4, 6, 8, 9, and 10) and found that the reductions in Reach 3 were within the range of reductions found in other

reaches. The reduction in mercury concentration in these fish varied from -10 to -37% (ACOE, 2016).

Throughout periodic public outreach events, EPA has provided the community and local officials with information about the remedial progress, including studies and investigations during the Remedial Design. Since the 2010 ROD was issued, there has been significant community and municipal support for a less-invasive remedy than the thin-layer sand capping associated with the ENR.

Given the reduction in the risk of adverse health effects to recreational anglers (child and adult) which have occurred over the last 11 years (i.e., the period of time between fish-collection events in Reach 3) without the benefit(s) of the thin-layer sand cap originally selected, EPA believes that natural processes (i.e., burial and dilution) along with legislative measures enacted to reduce mercury emissions are working faster than expected to reduce mercury concentrations in fish tissue in the Sudbury River and throughout much of Massachusetts. Moreover, this reduction is faster than originally projected by a mercury fate and transport model used in the evaluation of remedial alternatives in the 2010 Feasibility Study. Based on the relatively low level of human health risk (i.e., HI < 2), EPA does not consider it to be cost effective to update the computer model which would entail calibrating the model with substantial new data. In addition, EPA believes outreach efforts consisting of annual inspection of fish consumption warnings signs coupled with the Commonwealth of Massachusetts' Nyanza-specific fish advisory are effective in educating the public, including recreational anglers, from consuming-mercury contaminated fish. Finally, with regard to opportunities for recreational fishing, Reach 3 is a former (1970s) emergency back-up water supply; however it is still under the day-to-day management of the Massachusetts Water Resource Authority. Accordingly, as a (former) drinking water reservoir, there are limited opportunities for recreational fishing by the general public due to absence of any widely available or promoted public access.

In light of this new information about declining mercury concentrations in fish tissue and associated risk reduction that has occurred through natural processes, the periodic monitoring of fish, the effectiveness of the institutional controls already in place and maintained annually, and that there is (generally) no promoted public access to Reach 3, EPA believes ENR (i.e., thin-layer sand capping) no longer provides a cost-effective approach at $8.5 million for the amount of added protectiveness to be gained over MNR at a cost of $1 million. Accordingly, EPA proposes, through this draft ESD, that the 2010 ROD's remedy of "Enhanced Natural Recovery" for Reach 3 be eliminated, and that the "Monitored Natural Recovery" remedy for other remaining reaches be expanded to include Reach 3.

The long-term monitoring requirements, as described in the Section L (i.e., The Selected Remedy) of the 2010 ROD, include periodic sediment sampling, periodic surface water sampling, and periodic fish tissue monitoring. Based on previous Human Health Risk

assessment, there is no unacceptable risk from either contact with or incidental ingestion of surface water or sediment. The remedy, as modified, includes monitored natural recovery consisting of periodic fish-tissue monitoring which will be used to recalculate the human health risk from the ingestion of mercury-contaminated fish, institutional controls (i.e., state-issued fishing advisories and annual sign inspections), and long-term monitoring. A long-term monitoring plan is being developed consistent with the requirements and objectives specified in Section L of the ROD.

B. Updating the ARARs

EPA also reviewed the federal and state ARARs cited in the 2010 ROD to determine whether or not those identified remain applicable or relevant and appropriate to the modified remedy. Policies and guidance cited as "To Be Considered" were also reviewed. Because the modified remedy no longer requires active remedial measures, a significant number of ARARs are no longer required (refer to Attachment A). The most significant changes are described below.

Chemical-specific ARARs listed in Attachment A consist of some of the guidance EPA uses when assessing and evaluating site risks. For this ESD, EPA used the 2014 updated exposure factors when updating its risk assessment. In addition, as explained in the 2010 ROD and referenced above, and as remains true with the issuance of this ESD based on data supporting the 2010 ROD, the Clean Water Act National Recommended Water Quality Criterion (NRWQC) were not identified as ARARs because both the NRWQC and the state water quality criteria are at concentrations that are below background concentrations for mercury and below the risk-based figure calculated for the Sudbury River.

The state fishing ban currently in place for the Sudbury River remains in effect and has been identified as the only location-specific ARAR for this modified remedy. Because no other action beyond periodic monitoring will occur, protected resources such as wetlands and floodplains will not be adversely affected; therefore, it is no longer necessary to identify regulations and executive orders that regulate actions in these areas or that regulate dredging and filling in waters of the United States.

There are also a number of action-specific ARARs that would potentially apply to handling and disposal of sampling waste in from monitoring activities; however, it is unlikely any of this waste will be hazardous. Only the regulations for identification of hazardous waste are listed in Attachment A. If the waste is determined to be hazardous, EPA would comply with additional hazardous waste requirements.

C. Summary of Costs

Using provisional estimates from the 2010 ROD, this modification to the ROD would decrease the total approximate cost of the remedy from $8.5 Million to $1.0 Million; this

corresponds to a decrease of approximately 88%. The reduction is greater when compared to the revised construction cost estimate as determined during the 2013 Remedial Design (11 Million); the corresponding percent reduction is approximately 91%.

IV. SUPPORTING AGENCY COMMENTS

EPA will accept comments on the draft ESD during a public comment period. In its final selection of a remedial alternative, EPA will consider comments the State may provide on the draft ESD and ultimately whether the State concurs with or opposes the remedy modification proposed. State comments or other information received from the State may result in the choice of an alternative other than the preferred alternative.

In the Final ESD, EPA will also respond to any comments it has received from the public on this draft ESD. EPA may modify or choose an alternative other than the preferred alternative based on comments or other information it receives from the public.

V. STATUTORY DETERMINATIONS

The remedy as modified herein remains protective of human health and the environment, complies with all federal and state requirements that are applicable or relevant and appropriate to the remedy, and is cost effective. In addition, the revised remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable for this site.

VI. PUBLIC PARTICIPATION COMPLIANCE

This ESD and supporting information are available for the public to review at the locations identified within this document. In addition, a Notice of availability of the ESD will be provided to a local newspaper of general circulation. This ESD will be finalized after consideration of comments received at the conclusion of the 30-day public comment period.

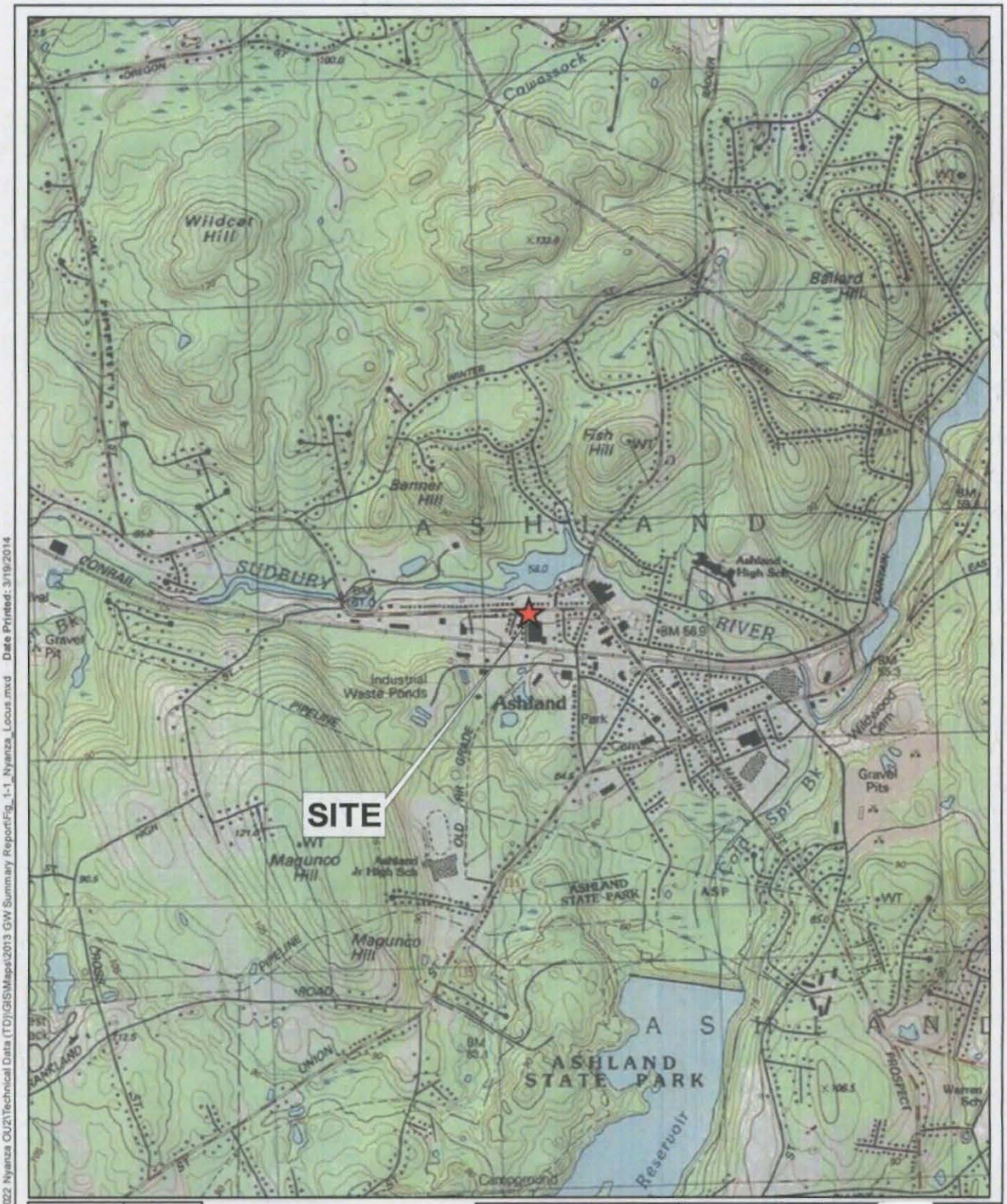
VII. DECLARATON

For the following reasons, by my signature below, I approve the issuance of an Explanation of Significant Differences for the Nyanza Chemical Waste Dump Site in Ashland, Massachusetts and the changes and conclusions stated therein.

_____ _____

Bryan Olson, Director
Office of Site Remediation and Restoration
USEPA, Region 1

Date



Map Location

USGS Topographic Map
Ashland, Massachusetts
Revised 1982

0 500 1,000 2,000
Feet
1 inch = 2,000 feet

N

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T(603) 224-4182
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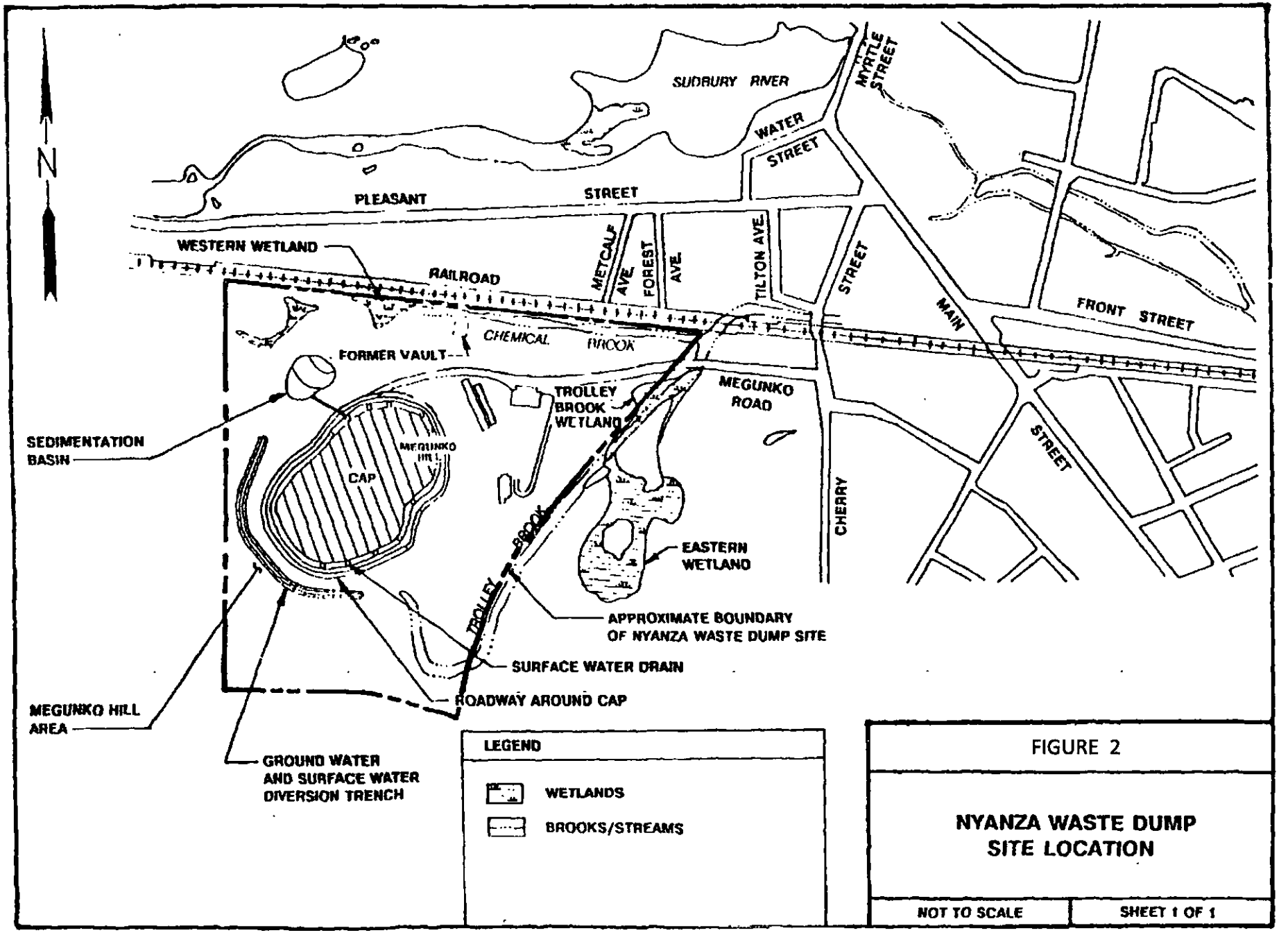
FIGURE 1

SITE LOCUS PLAN
NYANZA CHEMICAL WASTE DUMP
SUPERFUND SITE - OPERABLE UNIT II
ASHLAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: JL
PROJECT NO. 80022	DATE: MARCH 2014

Path: R:\80000 Task Orders\80022 Nyanza OU2\Technical Data (TD)\GIS\Maps\2013 GW Summary Report\Fig_1-1_Nyanza_Locus.mxd Date Printed: 3/19/2014


N
SUDBURY RIVER
MYRTLE STREET
WATER STREET
PLEASANT STREET
WESTERN WETLAND
RAILROAD
METCALF AVE.
FOREST AVE.
TILTON AVE.
MAIN STREET
FRONT STREET
CHEMICAL BROOK
FORMER VAULT
TROLLEY BROOK WETLAND
MEGUNKO ROAD
SEDIMENTATION BASIN
MEGUNKO HILL
CAP
CHERRY STREET
EASTERN WETLAND
TROLLEY BROOK
APPROXIMATE BOUNDARY OF NYANZA WASTE DUMP SITE
SURFACE WATER DRAIN
ROADWAY AROUND CAP
MEGUNKO HILL AREA
GROUND WATER AND SURFACE WATER DIVERSION TRENCH
LEGEND
WETLANDS
BROOKS/STREAMS
FIGURE 2
NYANZA WASTE DUMP SITE LOCATION
NOT TO SCALE
SHEET 1 OF 1

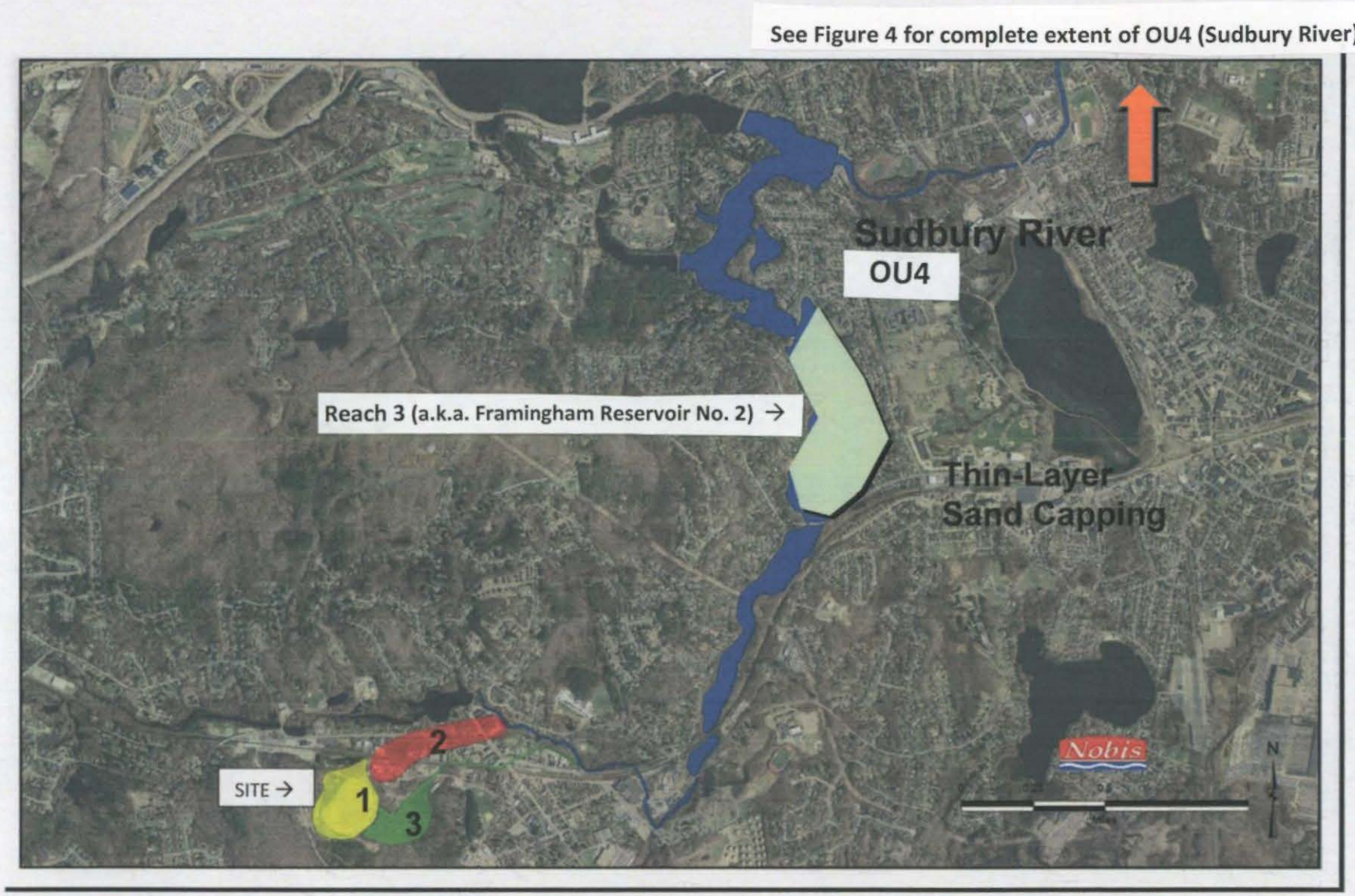


Figure 3 – Approximate Extents of Nyanza Chemcial Waste Dump Site Operable Units (OUs)

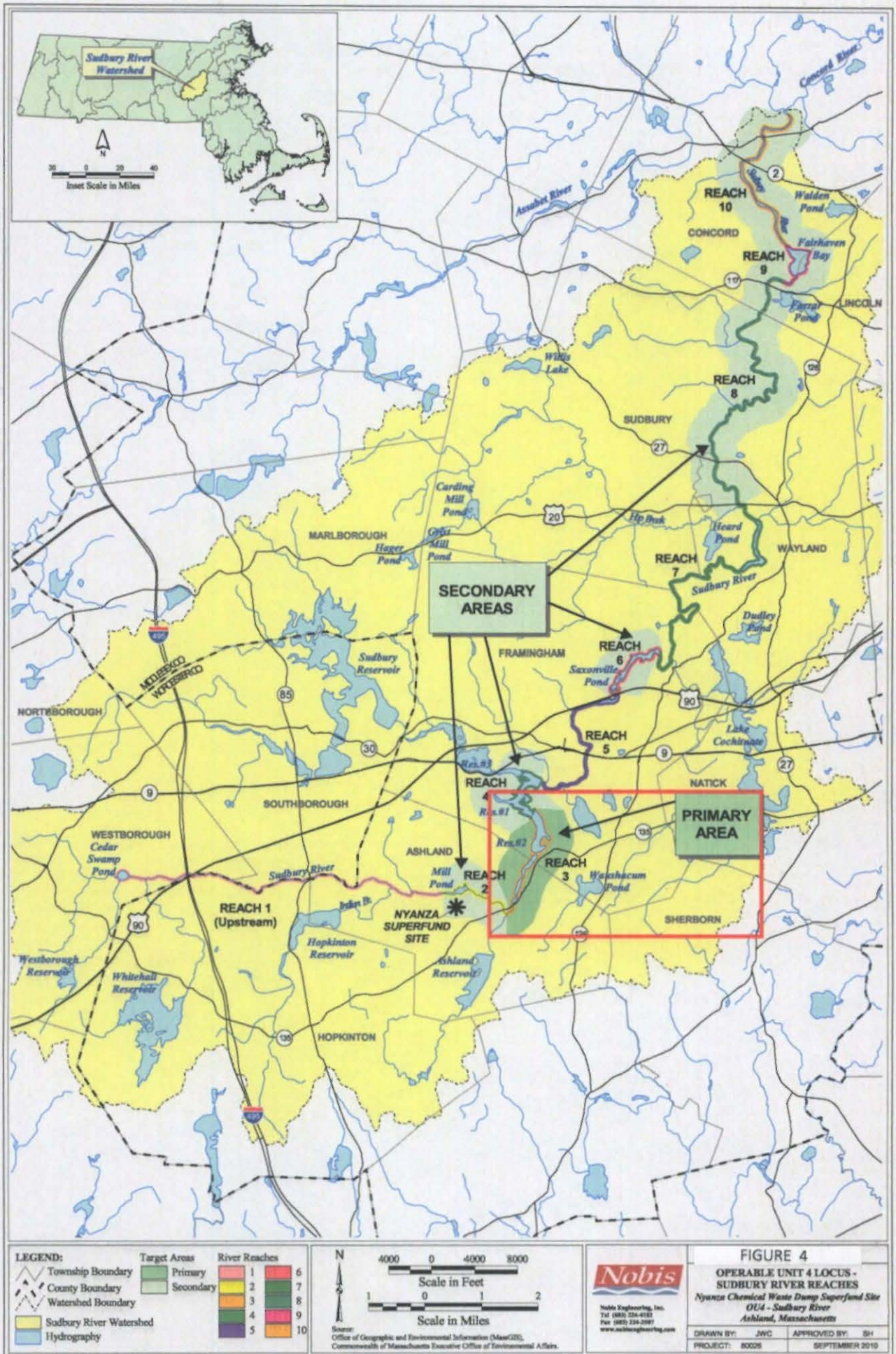


FIGURE 4

OPERABLE UNIT 4 LOCUS - SUDBURY RIVER REACHES

Nyanza Chemical Waste Dump Superfund Site
OU4 - Sudbury River
Ashland, Massachusetts

DRAWN BY: JWC	APPROVED BY: SH
PROJECT: 80026	SEPTEMBER 2010

C:\Nyanza\APR\GIS_aquatic_maps_2010.apr | Reaches11x17 | c:\nyanza\aspx\2010_maps\fig-1_reaches_091410.aprx | 1:39 PM, 9/14/2010


Sudbury River Watershed
Reaches 2, 3, and 4
ENHANCED NATURAL RECOVERY
Specifed in 2010 ROD
Via Thin-Layer Sand
Framingham Dam No.2
Fountain Street
LEGEND:
Sediment Samples
< 2000
2,000 - 10,000
> 10,000
Sediment Core Samples
< 2000
2,000 - 10,000
> 10,000
Wetland Habitat
Open Water
Deep Marsh
Shallow Marsh
Shrub Swamp
Deciduous Wood Swamp
Mixed Wood Swamp
Note: Sediment results are in units of ug/kg Hg.
Reach
Reach 2
Reach 3
Reach 4
N
500 0 500 1000
Scale in Feet
200 0 200 400
Scale in Meters
Source:
Office of Geographic and Environmental Information (MassGIS),
Commonwealth of Massachusetts Executive Office of Environmental Affairs.
Nobis
Nobis Engineering, Inc.
Tel: (603) 224-4182
Fax: (603) 224-2507
www.nobisengineering.com
FIGURE 5
REACH 3
Nyanza Chemical Waste Dump Superfund Site
OU4 - Sudbury River
Ashland, Massachusetts
DRAWN BY: JWC
APPROVED BY: SH
PROJECT: 80029
SEPTEMBER 2010

Attachment A – Updated ARARs Table
Attachment B – Human Health Risk Memorandum (March 16, 2015)
Attachment C – Updated Trend Analysis (May 4, 2016)
Attachment D – MassDEP ESD Letter of Support (to be assessed after comment period)
Attachment E – Responsiveness Summary (to be completed after comment period)

Attachment A

Updated ARARs Table

Chemical-Specific ARARs

Requirement	Synopsis	Status	Action to be Taken to Attain Requirement
Federal ARARs			
EPA Risk Reference Doses (RfDs)	RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	To Be Considered	RfDs were used to characterize human health risks due to non-carcinogens in site media.
Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, Feb. 2014. OSWER Directive 9200.1-120	This guidance updates EPA exposure factors .	To Be Considered	Updated exposure factors were used in 2015 recalculated risk assessment for this ESD.
State ARARs			
None			

Location-Specific ARARs

Requirement	Requirement Synopsis	Determination of Applicability	Action to be Taken to Attain Requirement
Federal ARARs			
None			
State ARARs			
State and/or local fish advisories	The Massachusetts Department of Public Health currently advises against consumption of any fish from the Sudbury River between Ashland and Concord, due to mercury contamination.	TBC.	EPA will consider these advisories in implementing institutional controls under the selected remedy.

Action-Specific ARARs

Requirement	Requirement Synopsis	Determination of Applicability	Action to be Taken to Attain Requirement
Federal ARARs			
Hazardous Waste Rules, Identification and Listing of Hazardous Wastes (310 CMR 30.100	These rules establish requirements for determining whether wastes are hazardous.	Applicable	These standards would apply to characterization of sampling-related waste. EPA believes this waste is unlikely to be hazardous but sampling and analysis will be performed to confirm.
Invasive Species (Executive Order 13112)	When undertaking actions that impact the environment, federal agencies are directed to prevent the introduction of invasive species and to provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause.	TBC.	Steps will be taken to address invasive species consistent with the EO.
State ARARs			
None			

Attachment B

Human Health Risk Memorandum

(March 16, 2015)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region 1
5 Post Office Square, Suite 100
BOSTON, MA 02109-3912

Date: March 16, 2015

From: Chau Vu, Human Health Risk Assessor, Technical & Enforcement Support Section

To: Dan Keefe, RPM, MA Superfund Section

Subject: Risk evaluation update for fish consumption at Nyanza Reach 3 (Reservoir 2)

The purpose of this memorandum is to update the risk evaluation for child and adult recreational anglers at Reach 3 (Reservoir 2) exposed to fish contaminated with methylmercury at the Nyanza Site.

In 2014, new fish data of brown bullheads, largemouth bass, and yellow perch were collected for Reach 3. EPA statistical software ProUCL version 5.0.00 is used to calculate the 95 percent upper confidence limit (95% UCL) for each fish species. Based on ProUCL, the Student's t-Test values are recommended as 95% UCL for methylmercury concentration for each species with 0.8657 mg/kg for brown bullheads, 0.871 mg/kg for largemouth bass, and 0.4883 mg/kg for yellow perch. To be consistent with the approach used in the 2006 Final Human Health Risk Assessment (HHRA) for Nyanza Operable Unit 4, it is assumed that anglers eat an equal portion of each fish species from the Site. Thus, the methylmercury fish exposure point concentration (EPC) of 0.74166 mg/kg is derived by averaging the 95% UCL of three fish species. This EPC value of 0.74166 mg/kg is approximately 20% less than the EPC value of 0.94 mg/kg used in the 2006 HHRA.

Using the new fish EPC of 0.74166 mg/kg and risk equations from 1989 EPA Risk Assessment Guidance for Superfund Part A, hazard quotients for recreational anglers exposed to contaminated fish at Reach 3 are calculated under two assumptions: 1) all exposure factors stay the same as those used for the 2006 HHRA and 2) some exposure factors are updated according to the 2014 OSWER Directive 9200.1-120 Update of Standard Default Exposure Factors. Hazard quotients are calculated for both Reasonable Maximum Exposure (RME) and Central Tendency Exposure (CTE) scenarios.

Below are the equations and factors used to calculate the hazard quotients:

Chronic Daily Intake: CDI (mg/kg-d) = C_{fish} x IR_{fish} x FI x CF x EF x ED x 1/BW x $1/AT_{non\text{-}cancer}$

Hazard Quotient: $HQ = CDI/RfD_{methylmercury}$

Nyanza Reach 3 fish ingestion exposure factors and hazard quotients

Exposure Factors	Reasonable Maximum Exposure			Central Tendency Exposure		
	Adult Recreational Angler (HHRA Exposure Factors)	**Adult Recreational Angler (2014 Exposure Factors)**	**Child Recreational Angler**	**Adult Recreational Angler (HHRA Exposure Factors)**	**Adult Recreational Angler (2014 Exposure Factors)**	**Child Recreational Angler**
C_{fish} (mg/kg)	0.74166	0.74166	0.74166	0.74166	0.74166	0.74166
RfD for methylmercury (mg/kg-d)	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04
IR_{fish} (g/day)	18	18	6.9	6.1	6.1	2.7
FI (unitless)	0.5	0.5	0.5	0.5	0.5	0.5
CF (kg/g)	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
EF (days)	350	350	350	350	350	350
ED (years)	30	*26*	6	9	*9*	2
BW (kg)	70	*80*	15	70	*80*	15
$AT_{non\text{-}cancer}$ (days)	10950	9490	2190	3285	3285	730
CDI (mg/kg-d)	9.14E-05	8.00E-05	1.64E-04	3.10E-05	2.71E-05	6.40E-05
HQ (mg/kg-d)	**0.9**	**0.8**	**1.6**	**0.3**	**0.3**	**0.6**

Italics values changed in 2014

Since there is no change to exposure factors used to evaluate HQ for child recreational angler between the 2006 HHRA and 2014 OSWER Directive, the table does not have a separate column for child recreational angler based on 2014 exposure factors.

Based on the evaluation of the 2014 fish data and the updated exposure factors, all hazard quotients calculated are below EPA acceptable level of 1 except for child recreational angler under RME scenario. Although there is a decrease from the HQ level of 2.1 calculated for the 2006 HHRA, the new HQ level of 1.6 for child recreational angler still exceeds the acceptable level of 1 at Reach 3 under current condition.

References

Part A, Baseline Risk Assessment. Interim Final. December 1989. EPA 540/1-89/002. NTIS PB90-155581.

ProUCL Software. Oct. 2013. EPA website
http://www.epa.gov/osp/hstl/tsc/software.htm

Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. Feb. 2014. OSWER Directive 9200.1-120

Attachment C

Updated Trend Analysis

(May 4, 2016)

Updated trend analysis for total mercury in largemouth bass and yellow perch collected in 2014 from Reach 3 (Reservoir 2) in the Sudbury River downstream from the Nyanza Chemical Superfund Site, Ashland, MA.

TDF No. 816B
Task Order No. 06
Task No. 01

Submitted to the:

Task Order Contract Officer Representative
Office of Environmental Measurement and Evaluation
USEPA - New England Regional Laboratory
11 Technology Drive
North Chelmsford, MA 01863-2431

Submitted by:

ESAT - Region I
TechLaw, Inc.
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May 4, 2016

EPA Contract EP-W-13-021

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May 4, 2016

Office of Environmental Measurement and Evaluation
US EPA - Region I
11 Technology Drive
North Chelmsford, Massachusetts 01863-2431

To: Mr. Bart Hoskins, EPA TOCOR
Via: Mr. Louis Macri, ESAT Program Manager

Task Order No. 06
Task No. 01
TDF No. 816A,B (SA)

Subject: Updated trend analysis for total mercury in largemouth bass and yellow perch collected in 2014 from Reach 3 (Reservoir 2) in the Sudbury River downstream from the Nyanza Chemical Superfund Site, Ashland, MA.

Dear Mr. Hoskins:

The Environmental Services Assistance Team (ESAT) provided the following support as requested in Technical Direction Form (TDF) No. 816B:

- Use age and length information to suggest which of the largemouth bass, yellow perch, and bullheads collected in 2014 from Reach 3 (Reservoir 2) in the Sudbury River should be selected for Total Mercury (TotHg) tissue analysis.

- Update a trend analysis submitted to EPA in 2009 by including fish tissue TotHg data for largemouth bass and yellow perch collected in 2014 from Reach 3 (Reservoir 2).

The task was requested by you, the task order contract officer representative, and was authorized under TDF No. 816B. An earlier version of this memorandum was submitted on April 8, 2016 as an interim deliverable for internal Agency review. ESAT incorporated the EPA comments in the current version. The final completion date for the task is May 5, 2016.

Do not hesitate to contact me at (617)918-8669 or (207)883-4780 with questions or comments.

Sincerely,

Stanislas Pauwels

Stan Pauwels
Expert Consultant
TechLaw, Inc.

Mr. Louis Macri
ESAT Program Manager
TechLaw, Inc.

1.0 GENERAL INTRODUCTION

1.1 Technical Direction Form

The Environmental Protection Agency (EPA) issued Technical Direction Form (TDF) No. 816 on January 4, 2016. The TDF requested that the Environmental Services Assistance Team (ESAT) update a 2009 trend analysis for changes in the levels of Total Mercury (TotHg) in Largemouth Bass (LMB), Yellow Perch (YP), and bullheads collected from Reach 3, a.k.a, Framingham Reservoir 2 (called herein Reservoir 2) of the Sudbury River located downstream of the Nyanza Chemical Superfund Site (the Site), Ashland, MA. As part of this TDF, ESAT also used fish age and fish length information to identify extra LMB and YP for TotHg analysis in order to complement the existing 2014 Reach 3 dataset.

The original 2009 trend analysis, entitled "Final Trend Analysis of Sediment, Surface Water, and Fish Mercury Data for the Nyanza Chemical Superfund Site, Ashland, MA" was submitted by TechLaw to EPA on May 14, 2009. It evaluated the long-term trends of mercury in fish, surface water and sediment. The 2009 Memorandum also provided background information about the strengths and limitations of the historical fish tissue databases and the reductive approach used on the fish residue analytical data, including deriving "age-equivalent" $TotHg_{whole\ body}$ concentrations for unaged fish collected in the 1990's.

The TDF was modified a first time on January 27, 2016 (TDF No. 816A) to allow more time to obtain the fish age and the TotHg tissue data needed to complete the task. EPA modified the TDF a second time on March 31, 2016 (TDF No. 816B) to request that ESAT provide an interim deliverable of the trend analysis by April 8, 2016, and a final deliverable on the original completion date of May 5, 2016.

1.2 Site history

The Site was occupied from 1917 through 1978 by several companies which manufactured textile dye intermediates, colloidal solids, and acrylic polymers. Over the decades, large volumes of chemical wastes (e.g., partially-treated process water, chemical sludges, solid process wastes, solvent recovery distillation residue, various chemicals, and off-specification products) were disposed of in pits, below-ground containment structures, and lagoons scattered throughout the Site. Hg was one of the compounds used as a catalyst to produce textile dyes. It has been estimated that between 45 and 57 metric tons of Hg were released into the Sudbury River over a 30-year period starting in 1940.

Regulatory concerns at the Site started in 1972. EPA placed the Site on the National Priorities List (NPL) in 1982. Site investigations started at that time. These studies determined that large sections of the Sudbury River between the Site and its confluence with the Assabet River (about 26 miles) were contaminated with Hg at levels of potential concern. The available analytical results were used to develop Baseline Ecological Risk Assessments (BERAs) in 1992 and 1999. The studies at that time determined the potential for ecological risk, but also identified significant data gaps. Additional field work was started in 2003 to better quantify the exposures and risks to aquatic, semi-aquatic, and terrestrial receptors living or foraging in the Sudbury River upstream and downstream of the Site. A final Supplemental BERA, submitted in December 2008, did not identify actionable (population-level) ecological risk in the Sudbury River.

The Sudbury River was divided into ten river "reaches" to support many of the earlier assessments. Each of these reaches was a logical division of a specific stretch of river based on flow characteristics (e.g., impoundment, fast flowing, etc...). Of particular concern was Reach 3 (a.k.a. Reservoir No. 2) because it is the first impoundment downstream of the Site and the location of the highest Hg levels in both sediment and fish found in the Sudbury River. In 2010, EPA selected a final remedy for the river which included, in part, adding a thin-layer sand cap over a portion of the substrate of Reach 3. EPA resampled this reach in 2014 for largemouth bass, yellow perch, and bullheads in preparation of the remedial efforts to document the pre-capping TotHg levels in fish. The Agency collected these fish with the aim of duplicating the same size and species mix obtained in 2003 for use in

the 2006 Human Health Risk Assessment (HHRA). To better match the specimens collected previously, an excess number of fish were caught in 2014 and subsequently aged (by scale and otolith) to help select the fish that most-closely corresponded to those used in the HHRA. These data were used in 2015 to recalculate the human health risk from consuming mercury-contaminated fish under pre-capping conditions.

EPA did not originally plan to update the 2009 trend analysis because of the broadly dissimilar fish sizes needed to re-calculate the human health risks as compared to the fish used in the trend analysis. However, a secondary objective emerged based on the available number and size of the extra fish collected in 2014 from Reservoir No. 2. As a result, the Agency requested that ESAT extend the 2009 Reach 3 trend analysis using some of the extra 2014 fish which fell into the required age brackets. Some of those fish were submitted for TotHg analysis for use in the updated trend analysis.

This technical memorandum is organized as follows: Section 2.0 describes the process of selecting fish from Reach 3 to update the trend analysis; Section 3.0 discusses the outcome of the updated trend analysis; and Section 4.0 provides a summary and conclusions.

2.0 SELECTING FISH FROM REACH 3 TO UPDATE THE TREND ANALYSIS

2.1 Introduction

The original 2009 trend analysis focused specifically on three age groups of LMB (namely, 3- and 4-year old fish, 3- to 5-year old fish, and 5- to 7-year old fish) and one age group of YP (namely, 1- to 3-year old fish). Bullheads were excluded from the 2009 trend analysis because these fish had not been aged up to that point. The 2014 bullheads were aged using their otoliths but these more recent fish could not be matched up properly with the un-aged bullheads obtained from Reservoir 2 during earlier sampling campaigns. ESAT discussed this issue with EPA, after which the Agency decided to exclude bullheads from the analysis. As a result, bullheads were not used in this updated trend analysis and are not further discussed.

2.2 Data preparation

Attachment 1 provides the entire data set for all LMB and YP collected from Reach 3 (Reservoir 2) in 2014. Only those fish highlighted in grey were retained for use in the updated trend analysis. The other fish were either not analyzed or only provided data for the HHRA. The following issues should be kept in mind when reviewing this information.

- EPA collected fish from the three sub-reaches of Reservoir 2 on the Sudbury River in 2014. These fish were combined by species across the sub-reaches into single datasets to represent Reach 3 in support of the updated trend analysis. This approach was also used for the original 2009 trend analysis.

- Only fillets were obtained from the 2014 Reach 3 fish for analysis of TotHg , whereas the original 2009 trend analysis was performed on the basis of whole body TotHg residue data. ESAT used the following regression equations to convert $TotHg_{fillet}$ to $TotHg_{whole\ body}$ based on data presented in the 2009 trend analysis:

    - For LMB: $TotHg_{whole\ fish}$ (µg/kg, ww) = -9.70 + [0.70 * $TotHg_{fillet}$ (µg/kg, ww)]

    - For YP : $TotHg_{whole\ fish}$ (µg/kg, ww) = 19.72 + [0.61 * $TotHg_{fillet}$ (µg/kg, ww)]

  The $TotHg_{whole\ fish}$ levels are bolded in **Attachment 1** for easy reference.

Attachments 2 and 3 provide the individual datasets for the 2014 LMB and YP, respectively, used in the updated trend analysis. These two tables show how the fish were divided into age groups, together with the number of fish within each age group. This process was straightforward for YP, and mostly so for LMB, with the following two exceptions:

- LMB-2-01 was 7-years old based on scale reading, but 10-years old based on its otoliths. This bass was deemed much too short (34.7 cm) to be 10-years old based on the available length-age data for LMB in Reach 3. It was retained as a 7-year old LMB for use in the trend analysis.

- LMB-2-07 was 7-years old based on scale reading, but 12-years old based on its otoliths. This bass was deemed much too long (45.6 cm) to be 7-years old based on the available length-age data for LMB in Reach 3. Its $TotHg_{whole\ fish}$ concentration was also about double the expected value for a 7-year old LMB. This fish was excluded from the updated trend analysis.

3.0 UPDATING THE TREND ANALYSIS

3.1 Introduction

The 2014 $TotHg_{whole\ fish}$ data for Reach 3 from the three LMB age groups and the one YP age group presented in **Attachments 2 and 3** were added to the Excel spreadsheets prepared for the original 2009 trend analysis. These values were then entered into the SigmaPlot software program to prepare the four graphs shown in **Figure 1**.

ESAT used a one-way Analysis of Variance (ANOVA), followed by Tukey's HSD (Honest Significant Difference) test, to identify statistically-significant differences in whole body LMB and YP TotHg levels across sampling years and age groups. The one-way ANOVAs identified significant differences in each of the three LMB age groups and the one YP age group. **Attachment 4** summarizes the outcome of the multiple comparisons. These results are indicated by different letters in **Figure 1**.

3.2 Results of the updated trend analysis for Reservoir 2

3.2.1 Largemouth bass

Figures 1.1 to 1.3 show the $TotHg_{whole\ body}$ levels for the three LMB age groups collected from Reach 3 (Reservoir 2) between 1993 and 2014. These data can be summarized as follows:

- 3- and 4-year old (or age-equivalent) LMB [Figure 1.1]: *The one-way ANOVA identified a significant difference ($p < 0.0001$) in the mean total Hg levels measured in 3- and 4-year old (or age-equivalent) LMB between 1993 and 2014.* Tukey's HSD test noted significant decreases between 1993 and 2014, 1994 and 2014, 2003 and 2014, and 2008 and 2014 (see **Attachment 4**). Note that relatively few LMB (n = 3 and 4) were collected in 1993, 1994, and 2003. The average concentrations in LMB in 1993 and 2014 equaled 483 and 305 µg/kg (ww), respectively.

- 3- to 5-year old (or age-equivalent) LMB [Figure 1.2]: *The one-way ANOVA identified a significant difference ($p < 0.000001$) in the mean TotHg levels measured in 3- to 5-year old (or age-equivalent) LMB between 1993 and 2014.* Tukey's HSD test noted significant decreases between 1993 and 2014, 1994 and 2008, 1994 and 2014, 2003 and 2014, and 2008 and 2014. The average concentrations in LMB in 1993 and 2014 equaled 595 and 323 µg/kg (ww), respectively.

- 5- to 7-year old (or age-equivalent) LMB [Figure 1.3]: *The one-way ANOVA identified a*

significant difference (p = 0.001) in the mean TotHg levels measured in 5- to 7-year old (or age-equivalent) LMB between 1993 and 2014. Tukey's HSD test noted significant decreases between 1994 and 2014, and 2003 and 2014. The average total Hg in fish collected in 1993 and 2014 equaled 632 and 394 µg/kg (ww), respectively.

3.2.2 Yellow perch

- 1- to 3-year old YP (Figure 1.4): *The one-way ANOVA identified a significant difference (p = 0.01) in the mean TotHg levels measured in 1- to 3-year old YP between 1994 and 2014.* Tukey's HSD test noted a significant decrease only between 2003 and 2014. This statistical response was unexpected because the YP mean $TotHg_{whole\ body}$ levels were lower in 2009 (141 µg/kg, ww) compared to 2014 (146 µg/kg, ww). It appears that the small 2008 sample size (n = 3) and reduced range of TotHg levels (i.e., 143, 126, and 155 µg/kg, ww) in that data set may have in part been responsible for this unforeseen pattern.

4.0 SUMMARY AND CONCLUSIONS

EPA requested that ESAT update a 2009 trend analysis of whole body TotHg levels in LMB and YP collected in 2014 from Reach 3 (Reservoir 2) in the Sudbury River.

The trend analysis showed a significant decrease in TotHg levels between 1993 and 2014 in the three LMB age groups of concern. The strongest signal was associated with the TotHg levels in the LMB collected in 2014.

The trend analysis showed a significant decrease in the TotHg levels of 1- to 3-year old YP, but only between 2003 and 2014. This response was unexpected because the YP mean $TotHg_{whole\ body}$ levels were lower in 2009 compared to 2014. It appears that the small sample size (n = 3) and reduced range of TotHg levels (i.e., 143, 126, and 155 µg/kg, ww) in 2008 may have in part been responsible for this unforeseen pattern.

Attachment 1: Age and TotHg data of fish collected in 2014 from Reservoir 2 on the Sudbury River									
Sample ID	Reservoir 2 Lobe	Length (cm)	Weight (g)	Age		Fillet TotHg (ug/kg, ww)	Whole Fish THg (ug/kg, ww)	used in the trend analysis	used in the HHRA
				scales	otoliths				
LARGEMOUTH BASS[a]									
LMB-1-01	1	28.3	339.9	--	4	453	307	X	
LMB-1-02	1	26.5	205.5	--	4	464	308	X	
LMB-1-03	1	29.8	376.2	4	4	408	276	X	
LMB-1-04	1	33.1	597.6	5	5	240	168	X	X
LMB-1-05	1	43.6	1161.5	9	13	1090	763		X
LMB-1-06	1	40	884.1	9	15	not analyzed	not analyzed		
LMB-1-07	1	39	1011.6	8	12	797	548		X
LMB-2-01	2	34.7	551.7	7	not avail.	830	571	X	X
LMB-2-02	2	33.5	605.1	6	6	533	363	X	X
LMB-2-03	2	28.6	333.1	--	3	416	282	X	
LMB-2-04	2	32.5	509.2	5	5	635	436	X	
LMB-2-05	2	39.5	981.1	8	9	not analyzed	not analyzed		
LMB-2-06	2	30.3	358.3	--	4	414	280	X	
LMB-2-07	2	45.6	1366.3	7	12	1210	837		X
LMB-3-01	3	32.5	477.2	6	5	531	362	X	
LMB-3-02	3	33.8	531.5	6	6	583	398	X	X
LMB-3-03	3	35.5	670.9	5	7	609	417	X	X
LMB-3-04	3	36.8	719.1	6	7	not analyzed	not analyzed		
LMB-3-05	3	31.5	425.6	4	4	533	363	X	X
LMB-3-06	3	33.9	564.5	6	6	not analyzed	not analyzed		
LMB-3-07	3	28.7	331	--	3	370	249	X	
LMB-3-08	3	28.5	288.8	--	4	449	305	X	
LMB-3-09	3	30.6	348.1	3	3	544	371	X	
LMB-3-10	3	27.4	264.1	5	5	594	409	X	
LMB-3-11	3	37.1	737.3	6	6	not analyzed	not analyzed		
LMB-3-12	3	36.5	782.6	6	7	631	432	X	X
YELLOW PERCH									
YP-1-01	1	25.3	196.3	--	6	485	316		X
YP-1-02	1	23.3	147.1	--	4	239	166		X
YP-1-03	1	23	151.4	--	4	388	256		X
YP-1-04	1	21.2	117.1	--	5	601	386		X
YP-1-05	1	23.3	137.6	--	4	502	326		X
YP-1-06	1	22.5	123.4	--	6	not analyzed	not analyzed		
YP-1-08	1	19.1	81.6	--	4	273	186		X
YP-1-10	1	18.8	74.7	--	3	240	166	X	
YP-1-11	1	18.8	79.6	--	4	not analyzed	not analyzed		
YP-1-13	1	18.9	85.9	--	3	236	164	X	
YP-1-16	1	24	180.9	--	6	632	405		X
YP-1-17	1	26.3	267.5	--	7	655	419		X
YP-2-01	2	24.5	184.5	--	4	259	178		X
YP-2-02	2	21.8	117.2	--	4	255	176		X
YP-3-01	3	25.7	173	--	4	327	219		X
YP-3-02	3	24.6	183.3	--	4	273	186		X
YP-3-03	3	21	94.8	--	2	172	125	X	
YP-3-04	3	18.4	72.6	--	2	142	106	X	
YP-3-05	3	20	86.1	--	4	not analyzed	not analyzed		
YP-3-06	3	--	--	--	2	208	145	X	
YP-3-07	3	22.4	112.9	--	3	167	134	X	
YP-3-08	3	22.5	135.3	--	3	233	162	X	
YP-3-09	3	22.1	130.2	--	3	267	183	X	
YP-3-10	3	21.7	124.7	--	2	182	131	X	

[a] the original TotHg data represented fillets samples; the whole body TotHg levels were derived using the following species-specific regression equations (see Appendix 1)

for LMB: $TotHg_{whole\ fish}$ (ug/kg, ww) = -9.70 + 0.70 * $TotHg_{fillet}$ (ug/kg, ww)

for YP: $TotHg_{whole\ fish}$ (ug/kg, ww) = 19.72 + 0.81 * $TotHg_{fillet}$ (ug/kg, ww)

grey shading identifies fish caught in 2014 from Reservoir 2 that were included in the updated trend analysis

bolded values: the updated trend analysis used the whole fish TotHg levels

Attachment 2: Selection of LMB collected in 2014 from Reservoir 2 for use in the updated trend analysis							
Sample ID	Length (cm)	Age		Whole Fish THg (ug/kg, ww)	3- & 4- year olds	3- to 5- year olds	5- to 7- year olds
		scales	otoliths				
LMB-1-01	28.3	–	4	307	X	X	
LMB-1-02	26.5	–	4	308	X	X	
LMB-1-03	29.8	4	4	276	X	X	
LMB-1-04	33.1	5	5	158		X	X
LMB-1-05	43.6	9	13	753			
LMB-1-07	39	8	12	548			
LMB-2-01	34.7	7	not avail.	571			X
LMB-2-02	33.5	6	6	363			X
LMB-2-03	28.6	–	3	282	X	X	
LMB-2-04	32.5	5	5	435		X	X
LMB-2-06	30.3	–	4	280	X	X	
LMB-2-07	45.6	7	12	837			
LMB-3-01	32.5	6	5	362		X	X
LMB-3-02	33.8	6	6	398			X
LMB-3-03	35.5	5	7	417		X	X
LMB-3-05	31.5	4	4	363	X	X	
LMB-3-07	28.7	–	3	249	X	X	
LMB-3-08	28.5	–	4	305	X	X	
LMB-3-09	30.6	3	3	371	X	X	
LMB-3-10	27.4	5	5	406		X	X
LMB-3-12	36.5	6	7	432			X
				TOTALS	9	14	9

Attachment 3: Selection of YP collected in 2014 from Reservoir 2 for use in the updated trend analysis					
Sample ID	Length (cm)	Age		Whole Fish THg (ug/kg, ww)	1- to 3-year olds
		scales	otoliths		
YP-1-01	25.3	--	6	316	
YP-1-02	23.3	--	4	166	
YP-1-03	23	--	4	256	
YP-1-04	21.2	--	5	386	
YP-1-05	23.3	--	4	326	
YP-1-08	19.1	--	4	186	
YP-1-10	18.8	--	3	166	X
YP-1-13	18.9	--	3	164	X
YP-1-16	24	--	6	405	
YP-1-17	28.3	--	7	419	
YP-2-01	24.5	--	4	178	
YP-2-02	21.8	--	4	175	
YP-3-01	25.7	--	4	219	
YP-3-02	24.6	--	4	186	
YP-3-03	21	--	2	125	X
YP-3-04	18.4	--	2	106	X
YP-3-06	--	--	2	145	X
YP-3-07	22.4	--	3	134	X
YP-3-08	22.5	--	3	162	X
YP-3-09	22.1	--	3	183	X
YP-3-10	21.7	--	2	131	X
				TOTAL	9

Attachment 4: Tukey's HSD test for whole body TotHg in fish collected from Reservoir 2 between 1993 and 2014			
Treatment pairs	**Tukey's HSD statistic**	**Tukey's HSD p-value**	**Conclusion**
3- and 4-year old largemouth bass			
1993 vs. 1994	1.7874	0.6934	not significant
1993 vs. 2003	0.4144	0.9000	not significant
1993 vs. 2008	0.3514	0.9000	not significant
1993 vs. 2014	5.6243	0.0052	$p < 0.01$
1994 vs. 2003	1.4037	0.8403	not significant
1994 vs. 2008	1.6591	0.7425	not significant
1994 vs. 2014	7.1173	0.0010	$p < 0.01$
2003 vs. 2008	0.1161	0.9000	not significant
2003 vs. 2014	6.1119	0.0023	$p < 0.01$
2008 vs. 2014	7.1435	0.0010	$p < 0.01$
3- to 5-year old largemouth bass			
1993 vs. 1994	2.6811	0.3332	not significant
1993 vs. 2003	0.4690	0.9000	not significant
1993 vs. 2008	1.5195	0.7957	not significant
1993 vs. 2014	6.7691	0.0010	$p < 0.01$
1994 vs. 2003	3.0894	0.2027	not significant
1994 vs. 2008	4.4683	0.0217	$p < 0.05$
1994 vs. 2014	10.3567	0.0010	$p < 0.01$
2003 vs. 2008	0.9793	0.9000	not significant
2003 vs. 2014	6.0112	0.0010	$p < 0.01$
2008 vs. 2014	5.4829	0.0028	$p < 0.01$
5- to 7-year old largemouth bass			
1993 vs. 1994	2.1725	0.5410	not significant
1993 vs. 2003	2.2612	0.5064	not significant
1993 vs. 2008	0.5657	0.9000	not significant
1993 vs. 2014	3.6822	0.0903	not significant
1994 vs. 2003	0.5172	0.9000	not significant
1994 vs. 2008	2.7060	0.3283	not significant
1994 vs. 2014	6.6971	0.0010	$p < 0.01$
2003 vs. 2008	2.7241	0.3218	not significant
2003 vs. 2014	5.9078	0.0015	$p < 0.01$
2008 vs. 2014	2.9237	0.2556	not significant
1- to 3-year old yellow perch			
1994 vs. 2003	0.5101	0.9000	not significant
1994 vs. 2008	2.6476	0.2566	not significant
1994 vs. 2014	3.6528	0.0630	not significant
2003 vs. 2008	2.9529	0.1750	not significant
2003 vs. 2014	4.1364	0.0281	$p < 0.05$
2008 vs. 2014	0.2015	0.9000	not significant

HSD = honest significant difference

grey shading highlights statistically significant differences

Figure 1: Whole body TotHg in YP and LMB collected from Reach 3 (Reservoir 2) in the Sudbury River between 1993 and 2014

Figure 1.1: Whole body total Hg in 3- and 4-year old (or age-equivalent) largemouth bass collected from reach 3 (Reservoir 2) in the Sudbury River

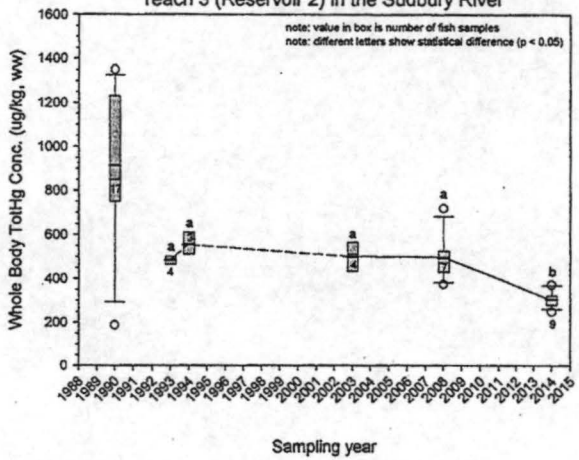

Figure 1.2: Whole body total Hg in 3- to 5-year old (or age-equivalent) largemouth bass collected from reach 3 (Reservoir 2) in the Sudbury River

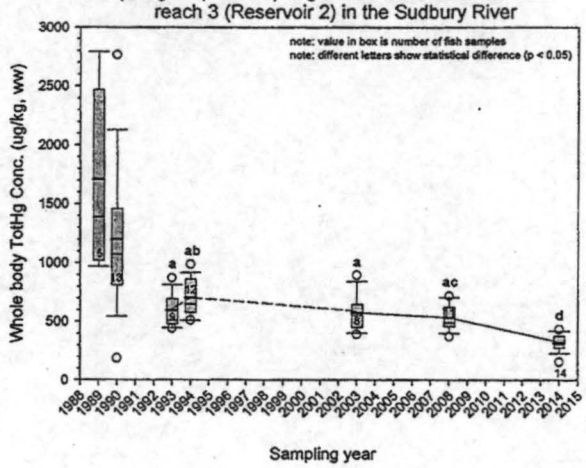

Figure 1.3: Whole body total Hg in 5- to 7-year old (or age-equivalent) largemouth bass collected from reach 3 (Reservoir 2) in the Sudbury River

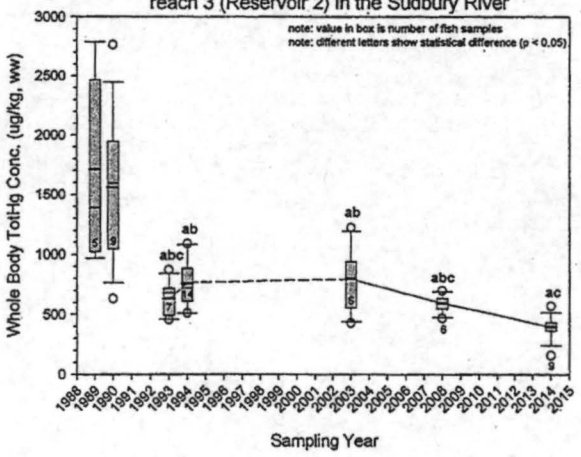

Figure 1.4: Whole body total Hg in 1- to 3-year old (or age-equivalent) yellow perch collected from reach 3 (Reservoir 2) in the Sudbury River