FIRST FIVE-YEAR REVIEW REPORT
ONONDAGA LAKE BOTTOM SUBSITE
OF THE ONONDAGA LAKE SUPERFUND SITE
ONONDAGA COUNTY, NEW YORK

Prepared by

U.S. Environmental Protection Agency
Region 2
New York, New York

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Approved by: **Date:**

Sept. 25, 2015

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LIST OF ACRONYMS AND ABBREVIATIONS

BERA	baseline ecological risk assessment
BSQV	bioaccumulation-based sediment quality value
BTEX	benzene, toluene, ethylbenzene, xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIC	community involvement coordinator
CM	compliance monitoring
cm	centimeters
COC	chemical of concern
CPOI	chemical parameter of interest
CQAP	construction quality assurance plan
CY	cubic yard
DDTs	Dichlorodiphenyltrichloroethane and metabolites
DO	dissolved oxygen
EPA	Environmental Protection Agency
ESD	Explanation of Significant Difference
FS	feasibility study
GAC	granular activated carbon
GM	General Motors
GPS	global positioning system
HHRA	human health risk assessment
ILWD	in-Lake waste deposit
IRM	interim remedial measure
kg	kilogram
L	liter
LCP	Linden Chemicals and Plastics
LGAC	liquid granular activated carbon
LOAEL	lowest-observed-adverse-effect-level
MeHg	methylmercury
METRO	Metropolitan Syracuse Wastewater Treatment Plant
mg	milligram
msl	mean sea level
µg	microgram
MGP	manufactured gas plant
MMF	multi-media filter
MNR	monitored natural recovery
ng	nanograms
NAPL	non-aqueous-phase liquid
NOAEL	no-observed-adverse-effect-level
NPL	National Priorities List
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	operation, maintenance, and monitoring
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl

PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzofuran
PDI	preliminary design investigation
PEC	probable effect concentration
PECQ	probable effect concentration quotient
PM	performance monitoring
PRG	preliminary remediation goal
PRP	potentially responsible party
RA	Remediation Area
RI	remedial investigation
RME	reasonable maximum exposure
RPM	remedial project manager
RAO	Remedial Action Objective
ROD	Record of Decision
RSL	regional screening level
SCA	sediment consolidation area
SEC	sediment effect concentration
SMU	sediment management unit
SPA	sediment processing area
SPDES	State Pollutant Discharge Elimination System
TDG	total dissolved gases
TEQ	toxicity equivalent
THg	total mercury
TSS	total suspended solids
UFI	Upstate Freshwater Institute
VOC	volatile organic compound
WTP	Water Treatment Plant

Executive Summary

This is the first five-year review for the Onondaga Lake Bottom Subsite, which is Operable Unit (OU) 2 of the Onondaga Lake Superfund Site. The site is located in the Towns of Geddes and Salina, Villages of Solvay and Liverpool, and City of Syracuse, Onondaga County, New York. The purpose of this five-year review is to assess current information to determine if the remedy is and will continue to be protective of human health and the environment. The triggering action for this statutory five-year review was the on-site construction start date of the remedial action for the OU2 remedial action.

The Subsite remedy is being implemented consistent with the 2005 Record of Decision (ROD) and Explanations of Significant Difference issued in 2006 and 2014. Dredging and capping activities in Onondaga Lake commenced in July and August 2012, respectively, in accordance with the approved designs. Dredging activities were completed in November 2014. Capping and habitat enhancement operations are ongoing and are expected to be completed in 2016.

Implementation of the remedy is progressing as expected. Several process enhancements and modifications were implemented to improve overall dredge system performance and production capabilities. As a result, dredging of the Lake and three adjacent shoreline areas, which included removal of approximately 2.2 million cubic yards of sediments, was completed within three years instead of four years as anticipated in the design. Capping operations from 2012 through 2014 were consistent with design projected volumes and capping is projected to be completed within five years as originally planned.

Substantial monitoring and evaluation efforts which included various types of data analyses and mathematical modeling of natural recovery have been completed over several phases to assess the effectiveness of monitored natural recovery for the deep water portions of the Lake. These evaluation efforts confirmed the conclusions from the Onondaga Lake Remedial Investigation (RI) and Feasibility Study (FS) that profundal sediments with higher mercury concentrations are being buried by cleaner sediments. Since the RI/FS, the concentrations of mercury in the surface sediments have declined further, consistent with the substantial decline in mercury loadings entering the Lake that have been documented.

The addition of diluted calcium nitrate solution near the sediment/water interface in the deep water portions of the Lake has been demonstrated to be effective in inhibiting the release of methylmercury (MeHg) from sediment in the deep water portions of the Lake, resulting in lower concentrations of MeHg in Lake water and in zooplankton. The lower MeHg concentrations in zooplankton are expected to result in lower exposure of fish to MeHg. Similarly, reductions in MeHg exposures from the water column and through the food chain are anticipated over time to result in lower concentrations of MeHg in fish in Onondaga Lake which in turn will reduce potential risks to humans and wildlife that consume fish. The selected remedy anticipated a period of 10 years of monitored natural recovery to achieve sediment remediation goals for mercury in the profundal zone, and given the nature of biological systems (*e.g.*, reduction of fish-tissue concentrations for long-lived fish species), additional monitoring beyond 10 years may be needed to determine whether fish tissue concentrations are being met as anticipated by the Record of Decision. The ongoing monitoring program and future five-year reviews will continue to assess the performance of the selected remedy.

The OU2 remedy, which includes dredging, capping, habitat restoration, nitrate addition and monitored natural recovery, is expected to be protective of human health and the environment upon completion. In the interim, remedial activities conducted to date are operating as intended to protect human health and the environment.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Lake Bottom Subsite of the Onondaga Lake Site		
EPA ID: NYD986913580		
Region: 2	**State:** NY	**City/County:** Syracuse/Onondaga County

SITE STATUS	
NPL Status: Final	
Multiple OUs? Yes	**Has the site achieved construction completion?** No

REVIEW STATUS
Lead agency: State ***[If "Other Federal Agency", enter Agency name]*:** Click here to enter text.
Author name (Federal or State Project Manager): Robert Nunes
Author affiliation: EPA
Review period: 8/25/2010 - 8/25/2015
Date of site inspection: These inspections are ongoing as there is full time NYSDEC staff conducting oversight onsite.
Type of review: Statutory
Review number: 1
Triggering action date: 8/25/2010
Due date *(five years after triggering action date)*: 8/25/2015

Issues/Recommendations
OU(s) without Issues/Recommendations Identified in the Five-Year Review:
Lake Bottom Subsite (OU2).

Protectiveness Statement(s)		
Operable Unit: 2	*Protectiveness Determination:* Will be Protective	*Addendum Due Date (if applicable):* Click here to enter a date.
Protectiveness Statement: The OU2 remedy, which includes dredging, capping, habitat restoration, nitrate addition and monitored natural recovery, is expected to be protective of human health and the environment upon completion. In the interim, remedial activities conducted to date are operating as intended to protect human health and the environment.		

Introduction

The purpose of a five-year review is to evaluate the implementation and performance of a remedy in order to determine if the remedy is and will continue to be protective of human health and the environment and is functioning as intended by the decision documents. The methods, findings, and conclusions of reviews are documented in the five-year review. In addition, five-year review reports identify issues found during the review, if any, and document recommendations to address them.

The Onondaga Lake National Priorities List (NPL) site includes the Onondaga Lake Bottom Subsite and a number of other subsites, which are defined as any site that is situated on Onondaga Lake's shores or tributaries that has contributed contamination to, or threatens to contribute contamination to, Onondaga Lake. The New York State Department of Environmental Conservation (NYSDEC) and the Environmental Protection Agency (EPA) have, to date, identified eleven subsites as shown in Figure 1 (see Attachment 1 for figures). The subsites are considered to be operable units (OUs) of the NPL site by the EPA and actions at these subsites are required to meet the requirements of the Comprehensive Environmental Response, Compensation and Liability Act, as amended, 42 U.S.C. §9601 *et seq.* (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR Part 300. This Five-Year Review focuses only on the Lake Bottom Subsite, which is OU2 of the Onondaga Lake Site (Site).[1]

This is the first five-year review for the Lake Bottom Subsite of the Onondaga Lake Site. The site is located in the Towns of Geddes and Salina, Villages of Solvay and Liverpool, and City of Syracuse, Onondaga County, New York. This five-year review was conducted by Robert Nunes, the EPA Remedial Project Manager (RPM) for the Lake Bottom Subsite. The review was conducted pursuant to Section 121(c) of CERCLA, as amended, 42 U.S.C. §9601 *et seq.* and 40 CFR 300.430(f)(4)(ii), and in accordance with the *Comprehensive Five-Year Review Guidance*, OSWER Directive 9355.7-03B-P (June 2001). This report will become part of the Site file.

The triggering action for this statutory five-year review was the on-site construction start date of the remedial action for the OU2 remedial action. A five-year review is required at this site due to the fact that upon completion of the remedial action, hazardous substances, pollutants or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure.

Site Chronology

See Table 1 for the site chronology.

[1] Geddes Brook/Ninemile Creek (OU 20) is considered by NYSDEC to be an OU of the Onondaga Lake Bottom Subsite. A separate five year review will be conducted for the Geddes Brook/Ninemile Creek site by June 11, 2017.

Background

Physical Characteristics

Onondaga Lake is a 4.6-square-mile, 3,000-acre lake, approximately 4.5 miles long and 1 mile wide, with an average water depth of 36 feet, with two (northern and southern) deep basins. The city of Syracuse is located at the southern end of Onondaga Lake, and numerous towns, villages, and major roadways surround the Lake (see Figure 2). The Lake has three main tributaries--Ninemile Creek to the west; Onondaga Creek to the south; and Ley Creek to the southeast. In addition, several small tributaries flow into the Lake, including Bloody Brook, Sawmill Creek, Tributary 5A, the East Flume, and Harbor Brook. While Ninemile Creek and Onondaga Creek supply the vast majority of surface water to the Lake, approximately 20 percent of the inflow comes from the Metropolitan Syracuse Wastewater Treatment Plant (METRO). The Lake drains into the Seneca River through a single outlet located at the northern tip of the Lake.

The area around Onondaga Lake is the most urban in central New York State. The region experienced significant growth in the twentieth century, and in 2000, Onondaga County was the tenth most populous county in the State. There are approximately 320 acres of state-regulated wetlands and numerous smaller wetlands directly connected to Onondaga Lake or within its floodplains.

Site Geology/Hydrogeology

The bedrock geology beneath the Lake consists of 500 to 600 feet of sedimentary rocks of the Vernon Shale Formation, which are comprised of soft and erodible mudstones with some localized, discontinuous gypsum seams. The Syracuse Formation overlies the Vernon Formation to the south of Onondaga Lake to an elevation of 300 to 380 feet above mean sea level. The Syracuse Formation is approximately 600 feet thick and is comprised of shales, dolostones, and salts. In this formation, groundwater flowing upward to the north toward Onondaga Lake is the source of brines in the area that contribute to the background salinity levels in the Lake.

Onondaga Lake is underlain by a thick layer of soft, unconsolidated sediments ranging from approximately 80 feet to over 300 feet thick beneath the mouth of Onondaga Creek at the south end of the Lake.

Two primary hydrogeologic units exist at the Lake--unconsolidated deposits and underlying bedrock shale. The unconsolidated deposits were formed by the combination of glacial processes, postglacial (lacustrine) processes, and human activities. These unconsolidated deposits consist (from top to bottom) of layers of fill, marl, silt and clay, silt and fine sand, sand and gravel, and till overlying the shale bedrock.

Groundwater in the unconsolidated deposits, which overlies the silt and clay layer, comprises an unconfined groundwater zone that provides most of the discharge of groundwater to the Lake. There is limited groundwater discharge from the deeper unconsolidated units to the Lake. Groundwater from the bedrock discharges to the lower portion of the overlying unconsolidated deposits west of the Lake. Total quantities of groundwater discharged to the Lake are small compared to discharges of surface water to the Lake.

Land and Resource Use

From 1970 to 1985, fishing on the Lake was banned due to contamination. From 1986 to 1999, the fish consumption advisory for Onondaga Lake was “Don’t eat any fish” from the Lake. In 1999, the advisory was updated to “Don’t eat any walleye and eat up to one meal a month of all other species.” In 2007, the advisory was updated to “Don’t eat largemouth and smallmouth bass over 15 inches, and walleye. Eat up to one meal a month of smallmouth bass and largemouth bass less than 15 inches, carp, channel catfish, white perch and all other species.” In 2010, the advisory was updated to “Don’t eat largemouth bass and smallmouth bass greater than 15 inches, walleye, carp, channel catfish and white perch. Eat up to four meals a month of brown bullhead and pumpkinseed. Eat up to one meal a month of all other fish.” This advisory is currently in effect. Women under 50 and children under the age of 15 are advised not to eat any fish from Onondaga Lake. The fish consumption advisory is based on the presence of mercury, dioxin, and polychlorinated biphenyls (PCBs) in fish tissues.

In general, the eastern shore of Onondaga Lake is mainly urban and residential, and the northern shore is dominated by parkland, wooded areas, and wetlands. The northwest upland is primarily residential, with interspersed urban structures and several undeveloped areas. The southern and western shorelines are dominated by industrial waste beds, consisting mainly of ionic wastes, many of which have been revegetated. Urban centers and industrial zones dominate the landscape surrounding the south end of Onondaga Lake from approximately the New York State Fairgrounds to Ley Creek. Land around the southwest corner and southern portion of the Lake is generally industrial and has been significantly modified as part of long-term development of the Syracuse area. Land around much of the Lake is recreational, providing hiking and biking trails, picnicking, sports, and other recreational activities.

The primary objective of land-use planning efforts is to enhance the quality of the Lake and Lakeshore for recreational and commercial uses. Anticipated recreational uses of the Lake include fishing without Lake specific consumption advisories and swimming. In early 2014, Onondaga County announced plans to construct an amphitheater complex near Lakeview Point as part of a community revitalization effort that is supported by New York State. The proposed construction for the Onondaga County Lakeview Amphitheater and Community Revitalization Project commenced in March 2015 and was substantially completed in the late summer 2015. The Onondaga Nation is seeking to reestablish traditional uses on and around the Lake, including hunting, fishing, gathering medicinal and food plants and engaging in ceremonial uses of the area.

History of Contamination

Onondaga Lake has been the recipient of industrial and municipal sewage discharges for more than 100 years. Honeywell International, Inc.’s (Honeywell’s) predecessor companies (*e.g.*, Solvay Process Company, Allied Chemical Corp. and AlliedSignal, Inc.) have been major industrial waste contributors; however, other industries in the area have contributed contamination as well. Other contaminant sources to the Lake include the METRO facility, industrial facilities and landfills along Ley Creek, the Crucible Materials Corporation (via Tributary 5A) and the former giant bulk petroleum-products storage and transfer facility located north of the Barge Canal known as “Oil City”.

Honeywell’s predecessor companies operated three manufacturing facilities in Solvay, New York, from 1881 until 1986. The product lines were collectively known as the Syracuse Works. The major products manufactured during this period included soda ash (sodium carbonate) and related products; benzene, toluene, xylenes, naphthalene at the Syracuse Works' Main Plant; chlorinated benzenes, chlor-alkali products, and hydrochloric acid at the Willis Avenue Plant, and chlor-alkali products and hydrogen peroxide at the Bridge Street Plant.[2] The manufacturing processes resulted in releases of primarily mercury, benzene, toluene, ethylbenzene, xylenes, chlorinated benzenes, polycyclic aromatic hydrocarbons (PAHs) (especially naphthalene), PCBs, polychlorinated dibenzo-p-dioxin/polychlorinated dibenzofurans (PCDD/PCDFs), and calcite-related compounds.

Waste streams were discharged from the three facilities to at least four different destinations: the Semet Residue Ponds (coke byproduct recovery only); Geddes Brook and Ninemile Creek (via the West Flume); the Solvay wastebeds, and directly to the Lake (via the East Flume). The Solvay wastebeds are located in the towns of Camillus and Geddes, and in the city of Syracuse (see Figure 3). From approximately 1881 to 1986, the wastebeds were the primary means of disposal for the wastes produced by the Solvay operations. The wastebeds consist primarily of inorganic waste materials (Solvay waste) from the production of soda ash using the Solvay process. Initial Solvay waste disposal practices consisted of filling low-lying land adjacent to Onondaga Lake. Later, unlined wastebeds designed specifically for Solvay waste disposal were built using containment dikes constructed with native soils, Solvay waste, and cinders, or by using bulkheads made with timber along the Lakeshore. The Solvay wastebeds and/or the East Flume also reportedly received chlorinated benzene still bottoms and portions of waste streams from the Willis Avenue and/or Bridge Street chlor-alkali plants.

The discharge of waste through the East Flume caused the formation of a large in-Lake waste deposit (ILWD). The ILWD extends approximately 2,000 feet into the Lake, approximately 4,000 feet along the Lakeshore, and contains waste up to 45 feet thick. The majority of the ILWD is within the boundaries of Sediment Management Unit (SMU) 1 (see Figure 4), although some of the ILWD extends into the adjoining SMUs 2 and 7.[3] The ILWD contains waste from all of Honeywell's product lines. The discharges of waste to Geddes Brook and Ninemile Creek through the West Flume, as well as the overflow from Solvay Wastebeds 9 to 15, also caused the formation of deposits of Honeywell wastes and resulted in the development of the deposits in the Ninemile Creek delta in the Lake in SMU 4. The seeps overflow from Solvay Wastebeds 1 to 8 contributed to the formation of Honeywell wastes in the Lake itself.

Initial Response

The control of contamination migrating to the Lake from the various upland sites is an integral part of the overall cleanup of Onondaga Lake. Upland remedial activities are being implemented to address the migration of contaminants (via the groundwater and surface water pathways) to Onondaga Lake. To facilitate the coordination of investigation and remedial activities between the upland sites and the Lake, NYSDEC and the EPA have, to date, identified eleven subsites, as shown in Figure 1. These subsites are also considered to be operable units of the NPL site by the EPA and actions at these subsites are being performed consistent with CERCLA requirements.

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[2] The Bridge Street Facility was sold to Linden Chemicals and Plastics (LCP) in 1979. LCP operated the facility until it closed in 1988.

[3] Onondaga Lake was divided into eight different SMUs during the FS and ROD process, based on water depth, sources of water entering the Lake, physical and ecological characteristics, and chemical risk drivers. During the Remedial Design, the littoral areas were redefined into Remediation Areas (RAs) A through F so as to more accurately reflect the current understanding of in-Lake conditions. The SMU boundaries and RAs, as well as the extent of the ILWD based on additional data collected during design, are shown on Figure 5.

Remedial activities at the upland subsites have been or are being performed via various means (*e.g.*, as part of the remedy selected in a Record of Decision (ROD) for the upland area, or as an interim remedial measure [IRM]). In general, these remedial activities have been or are being performed prior to the performance of remedial activities within a respective SMU, or a portion of a SMU, of Onondaga Lake. The status of each of the upland OUs/subsites and coordination of these subsites with implementation of the Lake remedy is further discussed in Attachment 2.

Basis for Taking Action

The Onondaga Lake Bottom Subsite includes the contaminated surface water and sediments in the 4.5-square mile Lake. Mercury contamination is found throughout the Lake, with the most elevated concentrations detected in the Ninemile Creek delta and in the sediments/wastes present in the southwestern portion of the Lake. Mercury contamination is widespread in the upper 6.5 feet of the sediments in the Lake, and it is even deeper in sediment in the Ninemile Creek delta and the ILWD. Other contaminants present with Lake sediments include benzene, toluene, ethylbenzene, xylenes (BTEX), chlorinated benzenes, PAHs, PCBs, and PCDD/PCDFs. Much of the contamination present in the southwestern portion of the Lake is present in the ILWD, which comprises an area of approximately 100 acres. Elevated concentrations of some contaminants in certain locations of the ILWD extend to a depth of 25 feet or more in Lake sediments. Elevated contaminant concentrations and visual evidence (*e.g.*, liquids, droplets, and sheens) indicate that chlorinated benzenes that were manufactured and released as a waste by Honeywell predecessor companies exist as non-aqueous-phase liquids (NAPLs) throughout the ILWD and in an area off the Honeywell causeway. Based on data collected during the RI/FS, it was determined that the NAPLs and highly contaminated waste materials in these areas of the Lake were highly mobile, at least when disturbed, have high concentrations of toxic compounds, and presented a significant risk to human health and the environment should exposure occur; therefore, they were characterized as principal threat wastes.

Concentrations of total mercury in the Lake water were highest in the nearshore areas around both Ninemile Creek and the ILWD. In the deep basins, water column total mercury concentrations increased significantly in the hypolimnion during summer stratification, with a high fraction of this hypolimnetic total mercury occurring in the dissolved phase. Concentrations of chlorobenzene and dichlorobenzenes in Lake water were highest near the Honeywell source areas in the vicinity of the East Flume and Harbor Brook and exceeded surface water quality standards.

Mercury, PCBs, hexachlorobenzene, and PCDD/PCDFs have bioaccumulated in Onondaga Lake fish, and mercury has been found at elevated levels in benthic macroinvertebrates. It is likely that these contaminants have bioaccumulated in other biota (*e.g.*, birds, mammals), as well. Fish tissue concentrations of mercury and PCBs in excess of diet-based toxicity reference values suggest injury to piscivorous birds and mammals that consume fish from the Lake. Chemicals of concern (COCs) in sediment shown to exhibit acute toxicity on a Lakewide basis include mercury, ethylbenzene, xylenes, certain chlorinated benzenes, PAHs and PCBs. COCs in surface water include mercury, chlorobenzene and dichlorobenzenes.

The human health risk assessment (HHRA) shows that cancer risks and non-cancer health hazards associated with ingestion of chemicals in sport fish *(e.g.*, largemouth bass) from Onondaga Lake are above levels of concern. Fish ingestion is the primary pathway for exposure to COCs and for potential adverse health effects. The HHRA also evaluated risks associated with direct contact with sediments (inadvertently ingesting small amounts of sediment or having sediment contact the skin) and this did not result in unacceptable risks.

Key results of the baseline ecological risk assessment (BERA) indicated that comparisons of measured tissue concentrations and modeled doses of chemicals to toxicity reference values showed exceedances of hazard quotients for site-related chemicals throughout the range of the point estimates of risk. Subsite-specific sediment toxicity data indicated that sediments are toxic to benthic macroinvertebrates on both an acute (short-term) and chronic (long-term) basis. Many of the contaminants in the Lake were persistent and, therefore, the risks associated with these contaminants were unlikely to decrease significantly in the absence of remediation. On the basis of these comparisons, it was determined through the BERA that all ecological receptors of concern were at risk. Contaminants and stressors in the Lake have either impacted or potentially impacted every trophic level examined in the BERA.

Remedial Actions

Remedy Selection

Site-specific sediment effect concentrations (SECs) and consensus-based probable effect concentrations (PECs) for COCs evaluated in the RI and the BERA were calculated using data from acute sediment toxicity testing using benthic macroinvertebrates. Benthic macroinvertebrates live in and around the sediments for most of their lives, and therefore experience the highest direct exposure to contamination in the Lake. Because of the large number of COCs and the differences in sources, transport, and fate, a further refinement of the SEC/PEC approach was used to develop a single number, the mean PEC quotient (PECQ), which takes into account the presence and the concentrations of multiple chemicals in the sediments. The mean PECQ approach provides a consistent method of comparing the overall acute toxicity risk from the mixture of contaminants at various locations of the Lake and to select a level of remediation that would address the risk of direct acute toxicity to the benthic macroinvertebrate community from the contamination in the Lake sediments. The mean PECQ was used as a basis for delineating areas of the Lake to be remediated. The areas of the Lake in which COC concentrations in the littoral sediment exceed a mean PECQ of 1 generally coincide well with those areas where acute toxicity to benthic macroinvertebrates was observed in the sediment toxicity tests. Therefore, the mean PECQ of 1 was determined to be protective and was selected as a remediation goal to address direct acute toxicity to benthic invertebrates. Because mercury in the Lake is a primary concern and elimination or reduction of mercury is part of all five Remedial Action Objectives (RAOs) discussed below, the mercury PEC of 2.2 milligrams per kilogram (mg/kg) was also selected as a remediation goal.

The selected remedy, which is presented in the ROD issued by NYSDEC and the EPA in July 2005, addresses all areas of the Lake where the surface sediments exceed a mean PECQ of 1 or a mercury PEC of 2.2 mg/kg. The selected remedy will also attain a 0.8 mg/kg bioaccumulation-based sediment quality value (BSQV) for mercury on an area-wide basis for the Lake and for other applicable areas of the Lake to be determined during the remedial design. The selected remedy is also intended to achieve Lakewide fish tissue mercury concentrations ranging from 0.14 mg/kg, which is for protection of ecological receptors, to 0.3 mg/kg, which is based on the EPA's MeHg National Recommended Water Quality criterion for the protection of human health for the consumption of organisms. This range encompasses the goal for protection of human health based on the reasonable maximum exposure scenario of 0.2 mg/kg of mercury in fish tissue (fillets).

The major components of the selected remedy identified in the ROD include:

- Dredging up to an estimated 2,653,000 cubic yards (CY) of contaminated sediment from the littoral zone (the portion of the Lake in which water depths range below 30 feet) in SMUs 1 through 7 to a depth that will prevent the loss of Lake surface area, ensure cap effectiveness, remove NAPLs, reduce contaminant mass, allow for erosion protection, and reestablish the littoral zone habitat. Most of the dredging will be performed in the ILWD (which largely exists in SMU1) and in SMU 2.
- Dredging, as needed, in the ILWD to remove materials within hot spots and to ensure stability of the cap.
- Placement of an isolation cap over an estimated 425 acres within SMUs 1 through 7.
- Construction/operation of a hydraulic control system along the SMU 7 shoreline to maintain cap effectiveness. In addition, the remedy for SMUs 1 and 2 will rely upon the proper operation of the hydraulic control system, which is being designed to control the migration of contamination to the Lake via groundwater from the adjacent upland areas.
- Placement of a thin-layer cap over an estimated 154 acres of the profundal zone (the portion of the Lake in which water depths exceed 30 feet) within SMU 8.
- Treatment and/or off-site disposal of the most highly contaminated materials (*e.g.*, pure phase chemicals segregated during the dredging/handling process). The balance of the dredged sediment will be placed in a Sediment Consolidation Area (SCA), which will be constructed on one or more of Honeywell's Solvay wastebeds that historically received process wastes from Honeywell's former operations. The containment area will include, at a minimum, the installation of a liner, a cap, and a leachate collection and treatment system.
- Treatment of water generated by the dredging and sediment handling processes to meet NYSDEC discharge limits.
- Completion of a comprehensive Lakewide habitat restoration plan.
- Habitat reestablishment will be performed consistent with the Lakewide habitat restoration plan in areas of dredging/capping.
- Performance of an oxygenation pilot study to evaluate the effectiveness of oxygenation at reducing the formation of MeHg in the water column, fish tissue MeHg concentrations, and methane gas ebullition as well as to understand any other impacts. The pilot study would be followed by full-scale implementation (if supported by the pilot study) in SMU 8.
- Monitored natural recovery (MNR) in SMU 8.
- Institutional controls consisting of notification of appropriate government agencies with authority for permitting potential future activities which could impact the implementation and effectiveness of the remedy.
- Implementation of a long-term operation, maintenance, and monitoring (O&M) program to monitor and maintain the effectiveness of the remedy (*e.g.*, cap repair).

The selected remedy also includes habitat enhancement, which is an improvement of habitat conditions in areas where CERCLA contaminants do not occur at levels that warrant active remediation, but where habitat impairment due to stressors has been identified as a concern. The ROD indicated that habitat enhancement would be performed along an estimated 1.5 miles of shoreline (SMU 3) and over approximately 23 acres (SMU 5) to stabilize calcite deposits and oncolites[4], and promote submerged aquatic plant growth.

[4] Oncolites are a form of calcite in littoral sediments of Onondaga Lake and are closely associated with discharges of calcium-laden wastes to the Lake by Honeywell.

Remedial Action Objectives/Remediation Goals

The RAOs for Onondaga Lake were based on site-specific information, including the nature and extent of chemical parameters of interest (CPOIs)[5], the transport and fate of mercury and other CPOIs, and the baseline human health and ecological risk assessments. The RAOs were developed during the RI as goals for controlling CPOIs within the Lake and protecting human health and the environment. The RAOs for Onondaga Lake are:

- RAO 1: To eliminate or reduce, to the extent practicable, methylation of mercury in the hypolimnion.
- RAO 2: To eliminate or reduce, to the extent practicable, releases of contaminants from the ILWD and other littoral areas around the Lake.
- RAO 3: To eliminate or reduce, to the extent practicable, releases of mercury from profundal sediments.
- RAO 4: To be protective of fish and wildlife by eliminating or reducing, to the extent practicable, existing and potential future adverse ecological effects on fish and wildlife resources and to be protective of human health by eliminating or reducing, to the extent practicable, potential risks to humans.
- RAO 5: To achieve surface water quality standards, to the extent practicable, associated with CPOIs.

In order to achieve the RAOs, Preliminary Remediation Goals (PRGs) were established for the three primary media that have been impacted by CPOIs: sediments, biological tissue, and surface water. The following three PRGs were developed, each addressing one of the affected media:

- PRG 1: Achieve applicable and appropriate SECs for CPOIs and the BSQV of 0.8 mg/kg for mercury, to the extent practicable, by reducing, containing, or controlling CPOIs in profundal and littoral sediments.
- PRG 2: Achieve CPOI concentrations in fish tissue that are protective of humans and wildlife that consume fish. This includes a mercury concentration of 0.2 mg/kg in fish tissue (fillets) for protection of human health based on the reasonable maximum exposure scenario assumptions from the Onondaga Lake Baseline Human Health Risk Assessment and the EPA's MeHg National Recommended Water Quality criterion for the protection of human health for the consumption of organisms of 0.3 mg/kg in fish tissue. This also includes a mercury concentration of 0.14 mg/kg in fish[6] (whole fish) for protection of ecological receptors (wildlife) based on the exposure assumptions from the Onondaga Lake Baseline Ecological Risk Assessment. These human health and ecological goals represent the range of fish tissue PRGs.
- PRG 3: Achieve surface water quality standards, to the extent practicable, associated with CPOIs.

In addition to the remediation goals for mercury in fish tissue, cited above, ecological target tissue concentrations for mercury based on the no-observed-adverse-effect levels (NOAELs), as well as target tissue concentrations for bioaccumulative organic contaminants, corresponding to various risk levels (including both the 10^{-4} and 10^{-5} cancer risk levels for human health exposure and both the LOAELs and NOAELs for ecological exposure), were developed in the Onondaga Lake

[5] The chemical parameters of interest, or CPOIs, are those elements or compounds that were identified as contaminants of potential concern, chemicals of concern, or stressors of concern for the Onondaga Lake RI/FS. The major classes of CPOIs include mercury and other metals, BTEX, chlorinated benzenes, PAHs, PCBs, PCDD/PCDFs, and calcite.

[6] This ecological goal was based on the lowest-observed-adverse-effect level (LOAEL) for the river otter.

Feasibility Study based on exposure parameters from the Onondaga Lake HHRA and BERA and were included in the ROD. These targets are not remediation goals, as presented in the ROD, but will be used as points of reference for future evaluations of reduction of risk for human and wildlife consumers of fish.

As indicated in the ROD, contaminants other than mercury, including PCBs, hexachlorobenzene, and PCDD/PCDFs, are not as widespread in sediments in the Lake (as compared to mercury) and are found primarily in a few specific areas of the Lake (*e.g.*, SMUs 1, 2, 6, and 7), which are undergoing aggressive active remediation (dredging and/or capping).

As the areas of the Lake with elevated concentrations of these bioaccumulative organic contaminants for which target tissue concentrations were developed are generally within the remedial areas based on exceedance of the cleanup criteria of the mean PECQ of 1 (which addresses multiple contaminants) plus the mercury PEC, the exposures to these compounds would be reduced to the same or greater extent as that of mercury. It was therefore expected that if the remediation goals for mercury in fish tissue are met in the future (*e.g.*, during the 10-year MNR period after completion of the dredging and capping), that the future fish tissue concentrations for the contaminants listed in Table 7 of the ROD would fall within the ranges shown in the table for each contaminant and receptor. If this assumption is proven not to be the case in the future, based on ongoing fish tissue monitoring, then an evaluation will take place to determine why this assumption may no longer be valid.

Target concentrations, PECs and/or remediation goals are further presented in Tables 2a, 2b, and 2c for fish, sediment, and surface water, respectively.

Explanations of Significant Difference

Two Explanations of Significant Difference (ESDs) have been issued since the issuance of the ROD to document modifications of the selected remedy.

Additional data were generated in 2005 and 2006 in SMU 2 as part of the pre-design investigation to more accurately define the extent of NAPLs in this area. These data showed that the site conditions and contaminant distribution were significantly different than were previously thought in SMU 2 along the causeway, and a small adjacent area in SMU 1. Based on the additional information, a revision to the portion of the remedy that pertains to the SMU 2 causeway area (and a small adjacent area in SMU 1) was evaluated. A modification to the remedy was documented in an ESD issued in December 2006. (The affected area is shown in Figure 6.) The ESD called for the placement of a portion of the Lakeshore barrier wall in the southwest portion of the Lake, backfilling behind the barrier wall with clean material, and collection of NAPLs present in the areas discussed above via wells with off-site treatment and/or disposal. The change was necessary to ensure the stability of the adjacent causeway and the adjacent area which includes a portion of I-690, and is supported by extensive sampling of the area which indicates that the areas containing NAPLs are significantly less extensive than estimated in the ROD.

The second ESD, issued in August 2014, addressed two issues; a geotechnical concern in the eastern end of the Lake, and the manipulation of redox conditions in the hypolimnion. During the remedial design phase, it was determined via a detailed geotechnical analysis that dredging in portions of SMUs 6 and 7 located immediately adjacent to the three active railroad lines at the south end of the Lake could result in shoreline and railroad line instability. (The affected area is shown in Figure 7.) The August 2014 ESD established a buffer zone where no dredging or capping will occur as the best means to prevent shoreline and railroad line instability. (The potentially affected shoreline area and railways are shown on Figure 8.) The modification includes additional measures to improve habitat and promote natural recovery in this area, such as a wave damper along a portion of the buffer zone to reduce wave energy along the shoreline, and active planting of primarily emergent wetland species in the buffer area.

The ROD also called for a post-ROD evaluation of the effectiveness of oxygenation of the deep Lake water in reducing the formation of MeHg in the water column. Wastewater treatment upgrades in 2004 at METRO resulted in higher levels of nitrate discharge and a two-fold increase in nitrate concentrations in Onondaga Lake at the onset of stratification in May. Additional wastewater treatment upgrades at METRO in 2005 to remove phosphorus resulted in marked reductions in phosphorus loading to the Lake and commensurate reductions in primary production of organic material and demand for oxygen and nitrate in the Lake's hypolimnion. A post-ROD study recognized that the METRO upgrades may have a beneficial effect in controlling MeHg concentrations in Lake water and initially identified nitrification of the hypolimnion (adding nitrate to the deep Lake water) as a possible alternative to oxygenation. Subsequently, a three-year nitrate addition pilot study was conducted from 2011 through 2013 to demonstrate the ability to maintain nitrate concentrations in the hypolimnion at levels sufficient to inhibit release of MeHg from Lake sediment to the overlying waters during summer stratification.

Based on the study's results, it was concluded that nitrate addition effectively inhibits the release of MeHg from sediment in the deep water portions of the Lake, resulting in lower concentrations of MeHg in Lake water and in zooplankton. The lower MeHg concentrations in zooplankton are expected to result in reduced exposure of fish to MeHg. Similarly, reductions in MeHg exposures from the water column and through the food chain are anticipated over time to result in lower concentrations of MeHg in fish in Onondaga Lake which would reduce potential risks to humans and wildlife that consume fish. Based on information gathered during the nitrate addition study discussed below, nitrate addition is being implemented instead of oxygenation. This modification to the selected remedy was documented in the August 2014 ESD. Monitoring associated with nitrate addition will continue to be conducted to ensure the effectiveness of the remedy in meeting the related goals specified in the ROD.

Supplemental Human Health Risk Assessment

Following the issuance of the ROD, Honeywell conducted a study of the potential SCA locations on the wastebeds and recommended that the SCA be constructed on an area called Wastebed 13.[7] NYSDEC and EPA concurred with the recommendation and the siting of the SCA at Wastebed 13. In response to requests from the community and elected officials, EPA conducted a supplemental HHRA in 2010 to identify any potential human health risks posed by sediment management and dewatering activities that would be conducted at the SCA. Risk estimates were designed to represent two hypothetical future scenarios: 1) exposure to contaminants that could migrate via air during the operation of the SCA and 2) exposure to sediments if, post-closure, the

[7] In a siting evaluation conducted in 2006, 16 separate potential on-site locations for the SCA were investigated. On-site disposal at Wastebed 13, an area historically used for waste disposal, was determined to be the best location for construction of an engineered lined disposal facility among the on-site wastebeds based on engineering evaluations. The selection criteria used to evaluate on-site options included wastebed capacity, geotechnical stability, potential impacts in the local community, construction requirements, and other factors. After a thorough review and public input, Wastebed 13 was selected by the NYSDEC and EPA as the site for the SCA. The selection of Wastebed 13 was included in the Consent Decree approved by the federal court in January 2007 and was announced in a fact sheet released to the public.

SCA were to fail, sediments were to be released, and people were to come onto Wastebed 13 and come into contact with the sediment on or near the SCA. Both of these potential future scenarios were intended to represent the reasonable maximum exposure potential and both assume individuals of all ages could be exposed. As such, these risk estimates are likely higher than what would likely be experienced by most receptors.

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

Remedy Implementation

Dredging

Dredging activities in Onondaga Lake commenced in July 2012 in accordance with the approved designs and were completed in November 2014. (Dredging areas are shown on Figures 9a and 9b.) Sediments were dredged hydraulically from designated areas within the Lake and select adjoining wetland areas. Once a specific area of the Lake was dredged, post-dredge surveys were conducted in accordance with a construction quality assurance plan (CQAP) to ensure that target elevations in the dredged area were achieved. Dredged material was transported via a series of booster pumps and a double-walled pipeline through non-residential areas to a lined sediment processing area (SPA) adjacent to the SCA. The SPA and SCA are located on a former Solvay wastebed, Wastebed 13. At the SPA, the dredge slurry was passed through a screening process, which was designed to remove oversized material. Oversized material was trucked to a Debris Management Area maintained at the SCA where the material was contained and covered. After screening, the slurry was conveyed to thickeners to reduce the volume of water that would need to be removed from the dredged material by geotextile tubes (geotubes). The thickened slurry then underwent polymer injection in order to precondition the slurry for dewatering within the geotubes. After the polymer injection, the preconditioned thickened slurry was conveyed to and discharged into the geotubes for dewatering and long-term isolation of the dredged material. The geotubes were managed within the lined SCA which collected and managed the geotube filtrate (water discharged from the geotubes).

The geotube filtrate and water coming into contact with filling tubes or dredged sediment (referred to as "contact water") was collected and routed to the Water Treatment Plant (WTP) constructed adjacent to the SCA for treatment of metals, volatile organic compounds (VOCs), semi-volatile organic compounds, PCBs, and total suspended solids (TSS). The treatment train in the WTP includes metals precipitation through pH adjustment and addition of alum/polymers, sludge thickening and separation in inclined plate clarifiers, removal of suspended solids with multimedia filters (MMFs), and removal of organics with liquid granular activated carbon units (LGACs). Thickened sludge from the clarifiers was discharged to a clarified sludge holding tank within the WTP and then conveyed to the geotubes for further dewatering and sequestration of the solid material. The treated effluent was then conveyed to METRO where it underwent additional treatment for ammonia prior to discharge to the Lake.[8]

Capping

Capping operations commenced in August 2012 and are ongoing. (Capping areas are shown on Figures 9a, 9b, and 9c.) The chemical isolation layer of the cap is being placed on approximately 420 acres over six RAs of the Lake and three adjacent areas. These areas include all areas which were dredged. The design for the isolation cap was accomplished following a multi-phased pre-design investigation and an extensive series of model simulations. Two models were used for these evaluations; an analytical steady state model and a time-variable numerical model. Both deterministic and probabilistic model evaluations were used in developing the chemical isolation layer design to ensure that the cap provides long-term protection of human health and the environment. The modeling was used to determine the chemical isolation layer design in each of the RAs having different modeling parameters. For each area, the model simulated the fate and transport within the cap for each of the 26 contaminants for which cap performance criteria have been established.

The chemical isolation layer consists primarily of sand. Based on treatability testing conducted during the remedial design, amendments are being incorporated into the chemical isolation layer in certain areas to ensure long-term effectiveness of the cap. These amendments consist of siderite (a naturally occurring mineral which consists mostly of iron carbonate) to neutralize elevated pH and maintain conditions conducive to long-term biological decay of key contaminants within the cap, and granular activated carbon (GAC) to improve sorption of contaminants within the cap and provide an added level of protectiveness. Amendments to the cap are being used in RAs B, C, D, the Wastebed B/Harbor Brook Outboard Area, the Wastebeds 1-8 connected wetlands, and in portions of RAs A (including the Ninemile Creek spits) and E. (See Figure 10 for locations of these adjacent areas included in the Lake remedy.)

In accordance with the ROD and the design, the isolation cap includes habitat, erosion protection, and chemical isolation layers in the littoral (shallow) zone of Onondaga Lake. The cap also includes an allowance for mixing the bottom of the chemical isolation layer with the underlying sediment. The different layers will ensure that the goals are met for habitat restoration, erosion protection and chemical isolation. The design thickness of the chemical isolation layer is a minimum of one foot except for the capped area in RA A and part of the capped area in RA E in the littoral zone with a water depth between 20 and 30 feet where the design includes a modified isolation layer with a minimum thickness of six inches. In addition to isolation capping in the littoral area of the Lake, the design calls for the placement of a thin-layer cap over approximately 27 acres in the profundal zone where the mean PECQ of 1 is exceeded. (See Figure 9a for location of thin-layer cap areas.) The required design thickness of this thin-layer cap is 4 centimeters (cm).

A hydraulic slurry capping system is being used for the placement of the majority of capping materials in the Lake. The capping system includes a land-based support system constructed on Wastebed B that is comprised of an upland hopper that feeds capping materials (*i.e.*, sand obtained

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[8] Operational modifications were made in 2014 that provide the option for wastewater generated by the dredging/sediment handling processes at the SCA and treated at the SCA water treatment facility to be discharged directly to the Lake in accordance with a supplemental treatment/Lake discharge operations work plan and a State-approved wastewater discharge permit. These modifications provided operators with the capability to maximize operational up-time for dredging operations during wet weather conditions.

from local quarries and borrow sources, and amendments) from a stockpile to a slurry system that mixes the capping materials with water from the Lake. Cap material requirements are verified through a series of checks and measures, including chemical and geotechnical laboratory analysis consistent with the CQAP. In accordance with the remedial design, cap amendments (*i.e.*, siderite, pre-soaked GAC) are mixed with sand in designated areas and hydraulically transported through a pipeline by a booster pump to a spreader barge. Amendment application rates are tightly controlled and monitored using gravimetric weigh belt feeders, peristaltic metering pumps, and a slurry density flow meter. The spreader barge is equipped with a diffuser plate that reduces the energy and evenly distributes the capping materials, resulting in 20-foot wide capping lanes. Capping system performance data is recorded, monitored, and displayed using state-of-the-art control and data acquisition systems which allow operators to continuously monitor and document in real time the performance of specific components within the capping system, allowing real-time system adjustments to be made to ensure that the required mix ratios are maintained and that design objectives are achieved.

Once a cap layer is placed in a given area, the thickness of the layer is verified consistent with construction quality assurance/quality control procedures established for the project. The procedures include the use of catch pans, gravity cores, bathymetric surveys, and/or global positioning system (GPS) elevation surveys to determine if cap thicknesses as specified in the design are being achieved. For each capping area, the minimum thickness of the cap layer (*e.g.*, sand/siderite, sand/GAC) need to be met in 90 percent of the collected samples, and the remaining measurements need to achieve 90 percent or greater of the design target thickness. The verification process of siderite in cap material includes heating, which temporarily converts the siderite to magnetite, followed by magnetic separation of magnetite from sand. The verification of GAC composition in cap material includes weighing samples before and after heating to 500 degrees Celsius which burns off the GAC. The difference in the measured weights provide the quantity of GAC in the sample. For each capping area where amendments are being placed, the minimum siderite application dose and GAC application dose need to be met in 90 percent of the collected samples, and the remaining measurements need to achieve 90 percent or greater of the design siderite and GAC application doses.

The land-based support system for a second hydraulic capping operation was constructed on Wastebeds 1-8 adjacent to Ninemile Creek in spring 2014. This second hydraulic capping operation is being used for capping operations in RA A. Other types of cap material, such as gravel and larger stone, are being placed over the sand layer in some locations to serve as protection from ice and erosion and to meet habitat requirements. The gravel and larger stone are being mechanically placed in the capping area by an excavator positioned on a barge.

Nitrate Addition

As discussed above, nitrate addition was incorporated into the remedy in 2014 following investigations and a successful three-year demonstration pilot which indicated that it was effective in inhibiting production of MeHg. Equipment and procedures used to apply nitrate in 2014 were virtually the same as was used during the pilot study. Nitrate addition consisted of routine applications of a diluted calcium nitrate solution to the bottom waters (generally three days per week from approximately early July through early October). A self-propelled barge measuring approximately 40 feet long and 24 feet wide was used to conduct each of the nitrate applications. The barge is designed to dilute liquid nitrate with epilimnetic Lake water (upper waters that are above the thermocline and well mixed) to achieve neutral buoyancy at the target water depth. The resulting solution was then pumped through flexible hosing to between seven feet and 17 feet above the Lake bottom at water depths between approximately 42 feet and 55 feet. The target dose for each daily application was typically 4,800 gallons of a solution of 49.8 percent calcium nitrate by weight including 8.55% nitrate-nitrogen. The dose could be easily controlled and modified to meet target nitrate levels in the Lake water. The added nitrate was able to spread laterally throughout the entire deep water area of the Lake by natural forces as determined with extensive Lake monitoring. Nitrate was added to the Lake at one of three locations during each day of application. (Nitrate application locations are shown on Figure 11.)

Between June 30, 2014 and the week of October 6, 2014, 27 nonconsecutive daily applications of nitrate were conducted. Nitrate-nitrogen concentrations throughout the hypolimnion were generally above 1.0 mg/L, which is the target concentration demonstrated to be sufficient to inhibit release of MeHg from Lake sediment, at all 34 monitored locations. The nitrate addition barge underwent winter demobilization following the application period. Nitrate applications are continuing in 2015 and into the future. The extent of nitrate needed in Onondaga Lake during summer months prior to fall turnover is expected to decline gradually over the coming years. Therefore, the need for continued nitrate addition will be evaluated annually based on the prior year's results, the Lake's fluctuating seasonal hydrologic and nitrate inputs, and other factors.

Monitored Natural Recovery

The selected remedy includes MNR to address mercury contamination in the profundal zone and hypolimnion of the Lake. Natural recovery is ongoing in SMU 8 (see Figure 5 for location of SMU 8) through burial of older sediment as new sediment enters the Lake as inflows from tributaries and direct runoff to the Lake. As the remediation of subsites impacted by mercury are completed, mercury concentrations in sediment entering the Lake are expected to further decline. The MNR monitoring scope includes several components that can aid in the assessment of the extent and rate of natural recovery in SMU 8. The components include:

- sampling and total mercury analysis of surface sediment samples and comparing these data with predicted concentrations obtained via site-specific natural recovery modeling;
- use of sediment trap data to monitor sediment deposition rates of solids and total mercury in settling sediment;
- measurement over time of the depth of sediment above fluorescent sand-sized microbeads, which were placed in nine plots in SMU 8 during 2009 to provide a vertical marker of the SMU 8 sediment, and which provide a quantitative demonstration of the extent of ongoing sediment burial;
- visual observations of varves/layers in frozen cores to assess vertical mixing of sediment; and
- assessment of abundance and composition of benthic macroinvertebrates (*e.g.*, worms), which if present in significant numbers, can affect ongoing natural recovery by increasing the extent to which sediment is vertically mixed.

Sediment remediation goals in the profundal zone include achieving the mercury PEC of 2.2 mg/kg or lower on a point basis and the mercury BSQV of 0.8 mg/kg or lower on an area-wide basis within 10 years following the remediation of upland sources, littoral sediments, and initial thin-layer capping in the profundal zone. The mercury BSQV is being applied over five subareas of the Lake bottom that together cover the entire surface area of the Lake. The five Lake subareas from north to south are designated as: North Basin, Ninemile Creek Outlet Area, Saddle, South Basin, and South Corner (see Figure 12).

Habitat Enhancement

The ROD remedy includes habitat enhancement along the SMU 3 shoreline to reduce sediment resuspension and turbidity. This portion of the remedy, which is being integrated with the Wastebeds 1-8 initial remedial measure (IRM), includes the placement of six inches, on average, of graded gravel from elevation 360 feet to 362.5 feet above mean sea level (msl) to stabilize the substrate. From elevation 362.5 feet to 366 feet above msl, the shoreline will be stabilized with 18 inches, on average, of run-of-the-bank material and topsoil, and planted and seeded with native vegetation. Shoreline stabilization was expanded to include much of the SMU 4 shoreline adjacent to Wastebeds 1-8. Shoreline stabilization along the SMUs 3 and 4 shorelines adjacent to Wastebeds 1-8 commenced in January 2014 and was substantially completed in early summer 2014. The plan for habitat enhancement for this area is being modified to incorporate the use of onshore downed trees and natural logs in lieu of coir logs which was specified in the design, as during initial coir log installation it was found that the underlying sediment was not capable of holding the coir log anchor stakes in place. Post remediation turbidity monitoring will be conducted following shoreline stabilization.

The ROD remedy included habitat enhancement over approximately 23 acres in SMU 5 (RA F) to stabilize calcite deposits and oncolites and promote submerged aquatic plant growth. The approach described in the ROD was based on stabilizing the oncolitic sediments to allow plant colonization. The target of 23 acres was based on increasing the percent cover of submerged aquatic plants in the littoral zone to provide optimal habitat for the largemouth bass. The information used in the ROD was based on plant surveys conducted in 2000, which documented a total of 17.8 acres in SMU 5 within the optimal water depth for plants.

Since that time, the area covered by plants has increased significantly, largely due to water quality improvements associated with the upgrades to the METRO facility. Based on a 2008 survey, there were approximately 314 acres of plants mapped in the Lake, including approximately 160 acres in RA F within the optimal water depth for submerged aquatic plants. As such, there is significantly more acreage covered by aquatic plants than would have resulted from implementation of the 23 acres of habitat enhancement. Moreover, the majority of the treatment areas identified in the Onondaga Lake FS for habitat enhancement have been naturally colonized by aquatic plants. Therefore, the goals outlined in the ROD for habitat enhancement in this area have already been met.

Habitat Restoration

The restoration of habitat is an integral component of the overall remedy for Onondaga Lake and is one of the important elements in the design for the dredging and capping activities specified for the Lake. Accordingly, the ROD called for the development of a comprehensive Lake-wide habitat restoration plan and required that habitat re-establishment be performed in all areas of dredging and capping consistent with the plan.

A goal of habitat restoration in these areas is to achieve ecological systems that function naturally, are self-sustaining, and are integrated with the surrounding habitats. One of the factors that was addressed during design was the type and thickness of the habitat restoration layer that would be placed above the isolation layer in a given area based on specific habitat needs in that area. Another factor that was considered was the types of structure and aquatic plants that might be placed in various areas of the Lake.

Habitat restoration activities are underway and are anticipated to be completed in 2016.

The monitoring and evaluation of the effectiveness of habitat restoration will be performed as part of the long-term O&M program (which is currently being developed).

System Operations/Operation and Maintenance

Dredging and SCA Operations

As a result of increased public reports of odors beginning in late August 2012, dredging operations were suspended from September 20 until October 11, 2012. During and following this period, several odor mitigation measures were identified, evaluated, and implemented to reduce site-related odors. These measures included:

- installation of a misting system;
- installation of stand-alone carbon filtration systems for the treatment of vapors from the thickeners and inside the WTP;
- use of an integrated geotube cover system;
- covering the East and West Basins[9] with a floating modular cover;
- installation of a modular cover system over the SCA perimeter channels;
- enhancements to the thickener operations, including the use of an alternative defoaming product to counteract foam accumulated in the thickeners during dredging of highly contaminated sediment so as to make them more efficient and to reduce volume of water to the active geotubes;
- activation of water spray bars over the screen shakers to remove fines;
- installation of a 30-foot tall wind screen along the northern perimeter with additional misting lines;
- installation of a modular cover system over the debris conveyor;
- routing of air vented from the polymer holding tanks through a carbon filter to remove potential odorous compounds;
- installation of an SCA drainage system including perforated riser sleeves and lateral pipes in the Phase 2 (central) area of the SCA to reduce surface flow on top of the geotubes and discharge to the outer edges of the tubes;
- large capacity fans to enhance dispersion;
- use of haul truck beds lined with zippered bags that can be closed for transport and offloading of debris;
- enhanced water management to reduce the flow of water to the geotubes; and
- applying roofing compound to exposed surfaces of the geotubes following active dewatering to mitigate odors.

Several other process enhancements and modifications were implemented to further improve overall dredge system performance, system uptime and dredging productivity including:

[9] The East and West Basins were constructed adjacent to the geotube layout area and were used as temporary storage locations for filtrate/contact water from the geotube layout area. The East Basin was also used to temporarily hold overflow water from the thickeners, and backwash water from the MMFs and LGACs, before being conveyed or redirected to the WTP. Prior to the start of the 2014 dredging season, modifications were made to allow for the diversion of treated effluent from the WTP to be directed to the West Basin during wet weather related events and the West Basin was repurposed to store this water.

- installation of a larger cutter head with more aggressive teeth and more power on the largest dredge so as to increase production capabilities for hard material found in specific areas of the Lake;
- mechanically excavating hard material found in the western Wastebed B/Harbor Brook Outboard Area to address areas of insufficient water depth for hydraulic dredging and to allow for work to continue through the winter months when hydraulic dredging is not feasible;
- installing an additional booster pump immediately downstream of the geotube feed pumps to improve the speed with which the thickened slurry was transferred to the geotubes;
- balancing and optimizing the booster pump control system which resulted in greater system capacity;
- implementing system enhancements to the dredge GPS control system which increased the level of dredge operability (*e.g.*, lateral control, elevation control) and which resulted in a decrease in the amount of overdredge volume removed by the dredge;
- use of the china clay test as a field measurement of polymer carryover which resulted in a decrease in residual polymer within the water being pumped to the WTP and thereby increased efficiency of WTP operations; and
- proactive replacement of key dredge slurry pipeline segments (*e.g.*, high-density polyethylene elbows and "Y" fittings) during the 2013-2014 winter shutdown period to preclude the need for replacing worn pipeline sections during the 2014 operational season.

During dredging and SCA operations, real-time monitoring was performed at the SCA and Lakeshore work zone perimeters. Real-time monitoring consisted of 1) continuous air monitoring for dust and total VOCs, and 2) routine survey air monitoring for mercury, hydrogen sulfide, and odors. Routine air monitoring for noise was also performed at the SCA work zone perimeter. One 1-hour work perimeter limit exceedance for dust occurred at one station in 2012 due to evening shift change traffic by the air monitoring station. Levels for dust dropped to within limits immediately after the shift change and roads were watered the following morning. There were no other additional exceedances for dust. No exceedances of work perimeter limits or action levels occurred for total VOCs, mercury, hydrogen sulfide or noise. Long-term chemical air monitoring data are also being generated for 25 speciated VOCs identified as airborne contaminants of concern. These VOCs were identified as contaminants of potential concern for the air pathway in the Supplemental HHRA as they were contaminants which were detected in wind tunnel testing conducted during remedial design and/or they were chemicals which were identified as volatile and which had toxicity values for use in risk assessment. Samples are collected using summa canisters over 24-hour periods every six days. The samples are sent to a laboratory for analysis, and the results are compared, on an annual basis, to the long-term air quality criteria established in the EPA Supplemental HHRA and documented in the Remedial Operations Community Health and Safety Plan. Average annual concentrations were below the annual air quality criteria established in the site air quality monitoring program for all 25 VOCs identified at the onset of the project over each of the first two 12-month monitoring periods.

As part of the effort to curtail nuisance odors that occurred soon after the dredging commenced, additional investigations were conducted to further identify odor-causing compounds in the dredged material. Seven compounds, which include 1,2,3-trimethylbenzene, cumene, cyclohexane, decane, indene, octane, and styrene, and which were not among the 25 VOCs initially identified in the Supplemental HHRA, were among the primary odor causing compounds as determined by sampling and analysis of headspaces above three potential odor sources: (1) freshly–filled geotubes, (2) geotube effluent water, and (3) sediment slurry. The speciated VOC sampling and analysis was expanded to include these seven compounds beginning on March 25,

2014. Similar to the approach used for the 25 original VOCs, sample results were compared with the lower of the respective NYSDEC ambient air Annual-averaged-based Guideline Concentrations and EPA inhalation Regional Screening levels (RSLs) for industrial air.[10] Monitoring of the seven additional compounds was conducted for a 12-month monitoring period. Average concentrations were below the long-term air quality criteria for all seven VOCs and monitoring for the seven additional VOCs was discontinued after March 19, 2015. Long-term monitoring of the original 25 speciated VOCs is ongoing and will continue until the monitoring program is curtailed upon approval by NYSDEC and EPA.

During operation of the SCA WTP, the plant discharged both directly to Onondaga Lake under the substantive requirements of a State Pollutant Discharge Elimination System (SPDES) permit and to METRO under an Industrial Wastewater Discharge permit. Treated water was discharged to METRO under normal operating conditions and was only discharged to the Lake during short periods when METRO was unable to accept the treated water based on capacity limitations. In 2012, there were three instances when VOC Total Toxic Organics were non-compliant with METRO pre-treatment requirements. In 2013, there were three instances when mercury was non-compliant with METRO pre-treatment requirements. The exceedances in 2012 and 2013 were short in duration and not indicative of systemic challenges in meeting the prescribed effluent limits. The exceedances were addressed by minor plant modifications or minor changes to the standard operating procedures. In 2014, there was one slight exceedance of direct Lake discharge limits associated with the SPDES permit equivalent for ammonia. A reanalysis of the sample, however, resulted in a reported level just below the permit limit. Other than the permit exceedances discussed above, all discharges of treated water from the SCA WTP were within permit limits.

A comprehensive water quality management and monitoring program was implemented to prevent potential unacceptable water quality impacts as a result of sediment disturbances during the conduct of remedial activities in the Lake. The program was based on real-time turbidity monitoring at both near-field, performance monitoring (PM) stations, and far-field, compliance monitoring (CM) stations, supplemented periodically with water quality samples analyzed for site-related chemicals of interest to monitor the impacts of dredging and capping at CM stations.[11] Turbidity measurements were assessed against “alert” turbidity limits established for PM locations and “action” turbidity limits established for CM locations. No exceedances of the turbidity alert or action limits occurred during dredging activities. Occasional alert level turbidity exceedances during capping activities were noted; however, they were not indicative of persistent conditions requiring a modification to the capping activity. One action level turbidity exceedance recorded in 2013 at a CM station for capping activities in RA E was investigated and found to be the result of Onondaga Creek flow rather than capping operations. All water quality sample results were below NYSDEC aquatic (acute) surface water quality standards for site-related chemicals of interest.

The containment aspects of the SCA referred to above include a bermed, composite liner system, overlain by a gravel drainage layer that supports the geotextile tubes that contain the sediments dredged from the Lake. The gravel drainage layer effectively conveys the drainage from the overlying geotubes to sump areas where the filtrate collects before being pumped to the WTP. The composite liner system, which includes a geomembrane liner underlain by a natural clay barrier layer, prevents the water from draining into the underlying wastebed/groundwater system. Consistent with the substantive requirements of 6 NYCRR Part 360, groundwater monitoring is

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[10] There are no inhalation RSLs for decane, indene, and octane.

[11] Near-field PM stations were located outside of the turbidity controls (*e.g.*, silt curtains) in the vicinity of ongoing dredging or capping operations. Far-field CM stations were located some distance outside the RA boundaries.

being conducted on a quarterly basis in order to identify any potential releases from the SCA containment system. Based on data collected up to the fourth quarter of 2014, the constituents detected in the SCA monitoring wells around Wastebed 13 are consistent with historic data, indicating that the constituents are wastebed-related and that groundwater in the vicinity of the SCA has not been impacted by the SCA. In addition, geotechnical monitoring has been conducted during construction and operation of the SCA to evaluate the continued safety and performance of the SCA liner system during geotube filling. The geotechnical monitoring system includes the use of 29 settlement cells and up to 60 settlement monuments to monitor settlement, six inclinometers to monitor stability, and 23 piezometers to monitor groundwater levels in and around the SCA. Measurements obtained from the geotechnical monitoring system were generally consistent with what was anticipated as a result of geotextile tube filling operations (*i.e.*, subgrade loading) and precipitation events. Data analyses were performed using settlement cell and settlement monument data to confirm that positive drainage towards the sumps was being maintained. If necessary, adjustments were made in geotextile tube placement to maintain positive drainage based on analyses of the settlement cell and settlement monument data. In addition to confirming anticipated subsurface behavior, the monitoring data are being used to support long-term settlement predictions for the SCA final cover system.

A layered SCA final cover system will further isolate the sediments from the environment and minimize the potential for exposure. Construction of the final cover system commenced in spring 2015 and is anticipated to be completed in late 2016.

Capping Operations

While capping, an unexpected event was observed on September 5, 2012 in a small area within RA C. A slope failure caused disturbance of the sediment cap soon after placement, where some of the cap materials and the underlying sediment flowed downslope, traveling several hundred feet before coming to rest in the profundal zone (SMU 8). A second event in a small area within RA-C to the east of the initial disturbance occurred in October 2012 which resulted in the consolidation of cap material rather than lateral movement of the cap material and underlying sediment. The Lake design and operations teams conducted a review of site operations shortly following these events, which resulted in several operational changes (*i.e.*, lane directions and placement modifications) in an effort to continue capping operations and reduce the potential for additional events. In addition, a series of additional geotechnical investigations were implemented in this area of cap disturbances subsequent to the events. Subsequent field analyses indicate that unanticipated conditions (*i.e.*, softer sediment) exist in portions of the Lake remedy areas.

An additional disturbance area was noted in a small portion (of RA D in late 2014, which is also being evaluated. This evaluation, which is ongoing, includes the collection of additional geotechnical and chemistry data. The total area of the sediment cap within RAs C and D that was impacted was approximately 7.25 acres, which represents approximately 1.7% of the total capped area. The first disturbance event in RA C and the disturbance event in RA D also resulted in the disturbance of adjacent sediments in SMU 8 as evidenced in subsequent bathymetry surveys and investigations that indicated that littoral zone sediments migrated into SMU 8. Remedial measures for the SMU 8 areas as well as additional measures for the disturbance areas within RAs C and D, and other areas where soft sediment has been identified are being evaluated and are expected to be implemented in fall 2015 and/or 2016.

Several enhancements were implemented following the initiation of capping operations to improve capping productivity and cap stability. These improvements include:

- placing cap material in thinner targeted placement lifts to ensure stability in the underlying sediment;
- use of gravity cores collected after cap placement in lieu of catch pans placed on the sediment surface prior to cap placement to verify cap thickness and amendment doses;
- implementing a 24 hours/day capping schedule;
- balancing and optimizing the sand slurry pumping system;
- streamlining the siderite detection procedure;
- implementing process and equipment modifications at the siderite mine site to improve siderite production capacity; and
- adding a second hydraulic and a second mechanical capping unit to the Lake operations.

Nitrate Addition Operations

Operations and monitoring for adding nitrate to the hypolimnion of Onondaga Lake are being conducted in accordance with an approved operations and monitoring plan. Operations for adding nitrate to the Lake include barge operations, loading of nitrate onto the barge, and fueling. Calcium nitrate solution in water was selected as the source of nitrate to add to Onondaga Lake because it can be delivered as a liquid, is readily available as a common agricultural fertilizer, and was successfully applied during the pilot study.

In-Lake monitoring is conducted before, during, and following each annual nitrate addition program. Data collected as part of the nitrate addition monitoring program are used to guide rates and locations for future applications of the diluted calcium nitrate, track the fate of the nitrate addition, and verify there are no adverse impacts to water quality (none were observed during the pilot test or in 2014). The monitoring efforts are conducted with the same rapid profiling instrumentation used during the nitrate addition pilot test, which includes *in situ* ultraviolet spectrophotometer equipment technology to measure nitrate and sulfide concentrations in Lake water.

Improved phosphorus removal from METRO discharges since 2005 and the resulting decline in primary production of organic material by plants, algae, and certain bacteria in the Lake are expected to reduce the demand for oxygen and nitrate over time. In addition, ongoing natural recovery due to gradual burial of sediment by solids entering the Lake as runoff from upstream areas will reduce the mercury concentrations in surface sediments in the deep water portion of the Lake (*i.e.*, SMU 8). As a result, the extent of nitrate needed in Onondaga Lake during summer months is expected to decline gradually over the coming years. The need for continued nitrate addition will be evaluated annually based on the prior results and the Lake's fluctuating seasonal hydrologic and nitrate inputs, among other factors.

Climate Change Considerations

Potential site impacts from climate change have been assessed. Water level rises in Onondaga Lake due to climate change are not expected as the Lake is part of the New York State Barge Canal System and the elevation of the Lake is controlled by a dam on the Oswego River at Phoenix, New York, downstream of the site. In addition, based on ROD requirements and other project-specific considerations, the erosion protection layer component of the cap will be physically stable under conditions associated with 100-year return-interval waves or from impact by discharges from tributaries during a 100-year flood flow event. Incremental increases in erosive forces due to events with a return frequency of greater than 100 years tend to be smaller (when compared to frequencies lower than 100); hence, such effects are expected to be localized, resulting in minor damage potential and an easier repair of any resulting disrupted areas. Consequently, the performance of the remedy is currently not at risk due to the expected effects of climate change in the region and near the site.

Five-Year Review Process

Administrative Components

The five-year review team included Robert Nunes, Mark Granger, Pam Tames, Patricia Pierre, Tom Mongelli (EPA-RPMs]), Mindy Pensak (EPA-Ecological Risk Assessor), Michael Sivak (EPA-Human Health Risk Assessor), Ed Modica (EPA-Hydrogeologist), Larisa Romanowski (EPA-Community Involvement Coordinator [CIC]), Joel Singerman (EPA- Section Chief), Tim Larson, Rick Mustico, Tracy Smith (NYSDEC-Project Managers), Robert Edwards (NYSDEC-Project Manager, Senior Geologist), and Don Hesler (NYSDEC-Section Chief). This is a potentially responsible party (PRP)-lead site.

Community Involvement

The CIC, Larisa Romanowski, emailed a notice about the five-year review to the Villages of Liverpool and Solvay, Towns of Camillus, Geddes and Salina, and City of Syracuse on February 3, 2015 with a request that the notice be posted in the respective municipal offices. In addition, the notice was distributed via the NYSDEC's Onondaga Lake News listserv, which includes approximately 4,000 subscribers. On February 5, 2015 the Syracuse Post-Standard newspaper reported on the commencement of the review. The purpose of the notice was to inform the community that the EPA would be conducting the first five-year review to ensure that the remedy implemented at the Subsite remains protective of public health and is functioning as designed. In addition, the notice included the RPM's and the CIC's addresses and telephone numbers for questions related to the five-year review process for the Subsite.

A question regarding the five-year review was raised by a member of the public. The commenter asked why the five-year review was being performed in 2015, since dredging and capping operations only commenced in 2012. The response to the commenter, which was provided via email on February 5, 2015, noted that the triggering action for a statutory five-year review[12] is the date when on-site construction of the remedy commenced, not when operations were initiated. The start date for construction is the commencement of the construction of the SCA on Wastebed 13 on August 25, 2010.

Once the five-year review is completed, the results will be made available at the local site repositories, which are at the NYSDEC Albany and Syracuse offices; the Onondaga County Public Library, Syracuse Branch at the Galleries, 447 South Salina Street, Syracuse New York; the Atlantic States Legal Foundation, 658 West Onondaga Street, Syracuse, New York and on the EPA's Onondaga Lake Site webpage. In addition, efforts will be made to reach out to stakeholders and local public officials to inform them of the results.

Document Review

The documents, data and information which were reviewed in completing this five-year review are summarized in Table 3.

[12] A statutory five-year review is required at this site due to the fact that hazardous substances, pollutants or contaminants will remain above levels that allow for unlimited use and unrestricted exposure.

Data Review

A discussion of the performance of the remedy based on data for all relevant media (*e.g.*, surface water, sediment, fish tissue) is presented in this section. Data figures and tables referenced in this section associated with surface water/mercury methylation in the hypolimnion and natural recovery can be found in Attachments 3a and 3b, respectively. A summary of the data tables and figures associated with monitoring of fish tissue and a general description of the fish tissue monitoring program since 2008 is presented in Attachment 3c.

<u>Surface Water</u>

Dissolved mercury concentrations in surface water in the deep basins were evaluated in 1992 and 1999 as part of the Lake RI, and annually since 2008 as part of the Lake baseline monitoring and nitrate addition monitoring programs. Concentrations of dissolved mercury in Lake water have decreased in recent years as detailed below, likely as a result of ongoing reductions in mercury loading to the Lake from external sources such as tributaries and groundwater.

Concentrations of dissolved mercury measured in the hypolimnion and epilimnion have been below the 2.6 nanograms per liter (ng/L) water quality standard based on protection of wildlife since these analyses were first conducted on a regular basis beginning in 2008 as part of the Onondaga Lake baseline and nitrate addition monitoring programs. (See Table SW-1.) In addition, measured concentrations of dissolved mercury in the hypolimnion have not exceeded the 0.7 ng/L water quality standard based on human consumption of fish since measurements in this depth zone were initiated in 2012. The 0.7 ng/L standard has only been exceeded in the epilimnion on an infrequent, irregular basis throughout the baseline and nitrate addition monitoring programs.

These concentrations of dissolved mercury measured during the period between 2008 and 2014 are significantly lower than those measured during the RI. Concentrations of total dissolved mercury in the epilimnion and the hypolimnion often exceeded both the 0.7 ng/L and 2.6 ng/L criteria during the 1992 and 1999 sampling events. Specifically, in samples collected in 1992, the median concentrations of total dissolved mercury were 2.42 ng/L and 3.90 ng/L in the epilimnion and hypolimnion, respectively. In the 1999 samples, the median concentrations of total dissolved mercury were 1.84 ng/L and 2.29 ng/L in the epilimnion and hypolimnion, respectively.

Total (unfiltered) mercury (THg) concentrations in Lake water were measured in 1992 and 1999 as part of the Lake RI, and annually since 2008 as part of the Lake baseline and nitrate addition monitoring programs. Annual average concentrations of total mercury are generally less than 4 ng/L, although there is significant variability from year to year and no apparent pattern over time in total mercury concentrations. (See Figures SW-1 and SW-2.) This is to be expected because total mercury is primarily associated with suspended solids that can vary widely in concentration.

Although there have been a significant number of surface water samples collected and analyzed for mercury in the deep areas of the Lake, only a limited amount of surface water data have been collected during the baseline monitoring program and analyzed for the organic contaminants that exceeded the surface water quality standards during the RI (*e.g.*, chlorobenzene, dichlorobenzenes). As these data were primarily obtained in deeper waters for the baseline program for construction-period monitoring for dredging/capping, which was developed for comparison to acute standards due to the relatively short-term nature of dredging/capping activities, they are not discussed herein in relation to the remediation goals, which are based on surface water quality standards for the protection of wildlife (including chronic standards) and human consumption of fish. It is anticipated that surface water samples will be collected throughout the Lake (including in the near-shore exposure areas) and analyzed for the chemical parameters of interest for comparison to the remediation goals following completion of source control activities and in-Lake capping activities, and these data will be included in future five-year reviews.

Mercury Methylation in the Hypolimnion

As noted above, wastewater treatment upgrades in 2004 at METRO resulted in higher levels of nitrate discharge and a two-fold increase in nitrate concentrations in the Lake at the onset of stratification in May. Nitrate levels during stratification were further increased with the initiation of the nitrate addition pilot test in 2011. Higher nitrate concentrations have contributed to major reductions in accumulation of MeHg in hypolimnetic waters during summer stratification. (See Figure SW-3.) MeHg data were not collected from 1993 through 1999 and from 2001 through 2005.

MeHg concentrations were considerably lower in the Lake's hypolimnion in 2011 through 2014 compared to prior years. (See Figure SW-4.) Low MeHg concentrations in Onondaga Lake since 2011 are consistent with the higher nitrate concentrations (as a result of nitrate additions) in those years compared to prior years. MeHg concentrations in Onondaga Lake hypolimnion water have declined dramatically aided by the addition of nitrate. MeHg in the lower hypolimnion has been barely detectable (typically less than 0.1 ng/L) since 2012.

Dissolved oxygen concentrations in the Onondaga Lake hypolimnion, which play an important role with respect to production of MeHG, have been relatively consistent from year to year. As nitrate concentrations have increased as a result of Metro upgrades and adding nitrate to the lower hypolimnion, MeHg concentrations have declined dramatically. (See Figure SW-5.)

The combination of nitrate discharged from Metro and nitrate added during the Honeywell pilot test (2011 through 2013) and in 2014 has resulted in decreases in zooplankton MeHg concentrations. (See Figure SW-6.) Zooplankton results from 2014 for total mercury and MeHg are significantly lower than concentrations measured in 1992 during the RI, as shown in Table SW-2, and are the lowest on record. Lower zooplankton MeHg concentrations are expected to contribute to lower mercury concentrations in fish.

As discussed in the August 2014 ESD, applying nitrate to Onondaga Lake does not result in any potentially significant adverse effects on water quality, growth of algae, or biota in the Lake. The ultimate fate of nitrate added to the Lake is transformation to nitrogen gas, based on supporting studies conducted prior to the pilot test as well as the dissolved gas measurement data collected during the pilot test. Adding nitrate to the hypolimnion did not result in significant increases in dissolved gases during the pilot test. No adverse impacts to fish are evident in Onondaga Lake from dissolved gases.

The surface water quality standard for nitrite (100 micrograms per liter as nitrogen) was exceeded on only two days during 2014, and the exceedances have been generally less significant since nitrate addition was initiated. Concentrations of nitrite remained below the New York State surface water quality standard in the upper waters where fish reside.

Through the early 2000s, annual maximum concentrations of nitrite and total ammonia in the epilimnion of Onondaga Lake routinely exceeded 0.2 mg/L and 2.0 mg/L, respectively as nitrogen. Treatment upgrades at Metro in 1999 and 2004 and pretreatment of pharmaceutical waste beginning in 1999 have resulted in reduced loadings of nitrite and ammonia to the Lake. The applicable New York State surface water quality standard for ammonia varies with pH and temperature. Onondaga Lake hypolimnion pH and temperature are 7.2 to 7.8 standard units and 50 to 55 degrees Fahrenheit, respectively, which corresponds to a New York State surface water quality standard for ammonia of 2.0 to 2.2 mg/L as ammonia or 1.6 to 1.8 mg/L as ammonia-nitrogen. Concentrations of ammonia-nitrogen measured in the hypolimnion where nitrate is added have not exceeded 1.0 mg/L as ammonia-nitrogen, which is in compliance with the New York State surface water quality standard for ammonia.

Levels of total dissolved gases (TDG) have been consistent from 2007 through 2014. Despite natural oversaturation of nitrogen gas, TDG levels in the hypolimnion have consistently remained at or slightly below 100 percent saturation.

Natural Recovery

Mercury concentrations measured in 2014 in surface sediment throughout SMU 8 (see Figures SED-1A and -1B) are lower than they were projected to be as part of the Final Design analysis. Table SED-1 presents a comparison of SMU 8 surface sediment (0 to 4 cm) concentrations predicted for 2014 based on the design analysis and actual measured 2014 SMU 8 surface sediment concentrations (average of samples from the 0 to 2 cm and 2 to 4 cm intervals). The 15 sediment sample locations included in Table SED-1 are the locations that were sampled in 2014 and also modeled as part of the Final Design analysis.

Recent measured mercury concentrations on settling sediments are lower than they were assumed to be during remediation for purposes of natural recovery modeling completed during the Final Design. Figure SED-2 presents average annual mercury concentrations on SMU 8 sediment trap solids since 2009 when these measurements began. Average concentrations of mercury on settling solids declined from 1.7 mg/kg in 2009 to 0.91 mg/kg in 2014. The Final Design analysis assumed an average concentration on settling solids of 1.0 to 1.9 mg/kg for various areas of SMU 8 prior to remediation being completed (blue shaded area on Figure SED-2) and 0.4 mg/kg to represent conditions in the Lake after remediation is completed.

Figure SED-3 presents average annual sedimentation rates based on SMU 8 sediment trap measurements. Average annual sedimentation rates since 2009 have been higher than the sedimentation rate assumed in the Final Design analysis for predicting natural recovery rates. As the measured 2014 surface sediment mercury concentrations in SMU 8 are lower than the concentrations for 2014 predicted by the model during design, and as sedimentation rates have been greater than the rate assumed in the model, it is concluded that natural recovery is progressing faster than predicted and the modeling conducted during the design was conservative.

Estimated surface-weighted average sediment mercury concentrations inclusive of the littoral zone and SMU 8 (Table SED-2) have declined since the time of the Final Design to concentrations that are close to or have reached the BSQV for mercury of 0.8 mg/kg in all of the zones of Onondaga Lake except the South Basin. The last column in Table SED-2 presents 2014 mercury sediment surface-weighted average concentrations across Onondaga Lake in each of the five Lake zones (see Figure 12 for locations of zones) based on applying a surface sediment mercury concentration of 0.1 mg/kg for areas that have been or will be capped and the most recent surface sediment mercury data for areas in the littoral zone not remediated based on Appendix N of the Final Design. For SMU 8 sediment locations, an average percent reduction was quantified for each Lake zone and applied to the concentrations from the Final Design analysis based on reductions in concentrations observed at locations sampled both in 2014 and in prior years. As can be seen in the last column of Table SED-2, estimated surface sediment mercury concentrations for four of the five zones across the entire Lake are close to or below the BSQV of 0.8 mg/kg. For the South Basin zone, although the estimated average concentration (1.9 mg/kg) is above the BSQV, this value is less than the value estimated in the design for this zone immediately following dredging and capping (2.5 mg/kg, as per Appendix N) and is projected to fall below the BSQV within the 10-year MNR period.

As noted above, sediment trap results indicate sediment deposition rates are greater than what was assumed in the Final Design analysis (Figure SED-3). Visual observations of sediment depths above the visible sand microbead marker layer in the microbead plots are used as an independent method for assessing deposition rates. Deposition rates of 0.3 and 1.3 cm per year have been observed to date at a total of two locations in two microbead plots in the North Basin (Table SED-3). The sediment deposition rate assumed in the Final Design analysis (as shown in Figure SED-3) was 1.0 cm per year (6,850 milligrams per square meter per day as presented in the design analysis). Due to limited recovery of microbead marker material from the cores collected in 2014, additional cores will be collected from three of the microbead plots in 2015.

Mixing depths observed in SMU 8 since 2011 have been generally within ranges measured or assumed previously as part of the Final Design. Sediment mixing depths in SMU 8 are assessed based on visual observations of depths to the first varve or layer in a sediment core that has been frozen and sliced. Table SED-3 presents a summary of mixing depth observations in SMU 8 since 2011. The depth to the first varve or layer in most (13 out of 17) cores since 2011 is 3 cm or less, which is lower than the 4 cm mixing depth for SMU 8 assumed in the Final Design. The only exceptions to date are two cores in the North Basin and two cores in the South Basin, where depths to the first varve or layer were 6 to 13 cm. These observations could indicate higher-than-typical localized rates of sediment deposition and/or surface sediment mixing.

As discussed above, natural recovery is occurring faster than predicted, and field data related to sediment deposition rates, mercury concentrations on settling particles, and mixing depth observations verify that natural recovery modeling completed in the Final Design is conservative. Benthic macroinvertebrate community information is another parameter that is being monitored, because the potential exists for increased mixing depth if the benthic macroinvertebrate community in SMU 8 increases significantly. Benthic macroinvertebrate community data are limited, as noted below, but will be monitored in the future as part of the overall MNR program.

Benthic macroinvertebrates were collected in SMU 8 at ten locations during July-August 1992, at three locations in August 2000, at two locations in August 2008 and at three locations in June and August 2012 as shown on Table SED-4. While the numbers of benthic macroinvertebrates counted during the sampling events have increased in SMU 8 since 1992, the collections since then have been limited in number of samples and range of water depths; therefore, a full description of the extent of macroinvertebrate populations in SMU 8 is not possible. As part of the ongoing MNR program, additional benthic community data will be obtained during the oxic and anoxic periods in 2015 at multiple water depths along three transects across SMU 8.

As a comparison to the benthic community results in SMU 8 as presented in Table SED-4, the total number of individual benthic macroinvertebrates collected in 2010 at nine locations throughout Onondaga Lake where water depths were less than 10 feet ranged from approximately 150 to over 300.

Although there are not enough data to develop a strict correlation between macroinvertebrate densities and depth of mixing, frozen cores collected in June 2012 show shallow sediment layers beginning below the top of sediment at depths on the order of centimeters, which, while less than the 4 cm compliance (mixing) depth applied in the design at most locations, is much deeper than the millimeter scale depths of varves recorded in earlier sediment studies (*e.g.*, 1988).

Fish Tissue

Contaminant data from fish tissue in Onondaga Lake are being used to assess the progress of the remediation in several contexts. These include the exposure of the public from consuming fish, and exposure to two types of wildlife (those consuming smaller fish, and those consuming larger fish). In addition, the trends in the data will be used to assess improvements (*i.e.*, declines) in the contaminant concentrations due to the remediation. Both Honeywell and NYSDEC have collected fish over the time frame both prior to, and during implementation of remedial activities, although they typically sample different species, with NYSDEC concentrating on largemouth bass, with other species being less consistently collected.

Clear changes in the contaminant concentrations in the fish tissue from the Lake may take several years following remediation to become apparent and may be uneven across species, due to the nature of the biota and the nature of the remediation. Documentation of any trends will require numerous annual data points even if changes are occurring rapidly, so that confirmation of improvements will likely take several years after remediation is complete. As noted in the ROD, a long-term monitoring plan (post remediation), including fish tissue and other media, would be needed to evaluate the effectiveness of the remedy in achieving the RAOs and remediation goals. The details of future fish tissue monitoring are being developed as part of the completion of the Onondaga Lake Monitoring and Maintenance Scoping Document.

As discussed in other sections of this five-year review report, the remediation of Onondaga Lake is progressing on several fronts at varying time frames, including reduction of inputs from external sources (upland sites and tributaries), control of methylmercury releases in the Lake hypolimnion via nitrate application, dredging and capping of areas of the Lake bottom exceeding the sediment criteria established in the ROD, and MNR. The overall expectation is that the frequency and magnitude of biota exposures to site-related contamination has been, and is still, declining, but at different rates, with remediation not yet complete. As discussed in the ROD Responsiveness Summary, it was expected that reduction of these exposures would produce declines in contaminant levels in biota.

The nature of the biota will also affect the rate at which changes in contaminant concentrations can be seen. The different species are exposed to contaminants in different ways. The larger sport fish (*e.g.*, bass and walleye) were shown by radio tagging to move throughout much of the Lake (based on monitoring in 2010 and 2011) and some smaller prey fish (*e.g.*, alewife and gizzard shad) are expected from literature to also roam over large areas, and generally do not show differences in contaminant concentrations with location. Other fish species (*e.g.*, sport fish such as brown bullhead and pumpkinseed, and prey fish such as minnows) tend to be more localized and feed more heavily in the littoral zone. One aspect of this localized behavior is that individual fish may vary greatly in contaminant concentrations depending on the location where they are exposed and subsequently collected for analysis. Therefore, concentrations for these localized fish species are reported by location (*i.e.*, SMU).

The feeding habits also affect the rate at which contaminant concentrations will decline, since some contaminants (*e.g.*, mercury) clearly increase with trophic level, so that the top of the food chain piscivores (*e.g.*, walleye and bass) have higher concentrations to start with. Mercury is also clearly associated with age in fish, and so the longer-lived fish (*e.g.*, bass that are sampled are typically 5 to 7 years old and may be well into their teens, and walleye over 20 years old have been collected) may tend to be slower in response to reductions in mercury exposures. This is in contrast to shorter-lived species which react to changes in exposure more quickly. For organic compounds, the amount of lipid (fat) a fish contains will influence the contaminant concentrations with higher lipid content (such as in the larger sport fish including bass, walleye, and carp) causing higher concentrations. Thus, it is expected that any improvement in the contaminant levels in biota due to remediation will vary greatly across species.

The figures referenced in the discussion below can be found in Attachment 3c along with a general description of the fish tissue monitoring program since 2008 and a summary of the data sets used in this assessment. As noted in Attachment 3c, target tissue concentrations other than the remediation goals for mercury in fish are not shown on the Sets 1, 2, and 3 figures and contaminants other than mercury are not included in the discussion of results for the Sets 1, 2, and 3 figures below. Contaminants other than mercury are included in the discussion of the Set 4 figures below.

Sport Fish (Set 1)

Sport fish (*e.g.*, bass, walleye, bullhead, pumpkinseed, carp) were collected and fillet samples analyzed with the primary purpose of assessing the exposure of the public to site-related contaminants from consuming fish. To accomplish this, larger fish normally consumed by the public were collected, and only the edible portions were analyzed. These data are presented in the Set 1 figures.

There are obvious differences in the mercury concentrations in the sport fish fillet samples among species. The larger, higher trophic level, longer-lived fish (*e.g.*, bass and walleye) have higher concentrations than other species such as pumpkinseed. For the large piscivorous fish (smallmouth bass and walleye collected by Honeywell and largemouth bass collected by NYSDEC), mercury concentrations (about 0.5 to 3 mg/kg wet weight) are well above the human health goal of 0.2 mg/kg. For the other species collected by Honeywell (pumpkinseed, brown bullhead, and carp), mercury concentrations in 2013 and 2014 were less than 1 mg/kg (with the exception of one brown bullhead sample in 2013). For the other species collected by NYSDEC (carp, yellow perch, white perch, channel catfish), mercury concentrations since 2010 have been less than approximately 1.5 mg/kg.

Small Prey Fish (Set 2)

Small prey fish (*e.g.*, minnows, killifish) were collected to assess exposure to smaller wildlife which consume fish (*e.g.*, mink, belted kingfisher). The whole fish was analyzed, since these species would consume the entire fish. For the purposes of this report, this category of samples in this size class (3 to 18 cm) includes six prey fish species grouped together to provide an assessment of this exposure. However, because of this grouping of different species with differing habits, there tends to be more variability in the data reflected in a large range in the box-and-whisker plots. These data are presented in the Set 2 figures. Specific analysis of these data for long-term trends post remediation will be conducted in the future.

Mercury concentrations in small prey fish in 2013 and 2014 ranged from less than 0.05 mg/kg to 0.35 mg/kg, which is above the ecological goal of 0.14 mg/kg.

Large Prey Fish (Set 3)

Larger prey fish (*e.g.*, sport fish and white sucker) were collected to assess exposure to larger wildlife which consume fish (*e.g.*, otter, great blue heron, osprey). Estimated or measured concentrations of whole fish in this size class (18 to 60 cm) are presented since these wildlife would also consume the entire fish. This category of samples includes six species to provide an assessment of this exposure, including whole-body samples of white sucker analyzed by Honeywell in 2014 along with the five large sport fish (smallmouth bass, walleye, pumpkinseed, and brown bullhead from the Honeywell data set and largemouth bass from the NYSDEC data set) corrected to provide an estimate of the whole-body concentrations (based on the fillet to whole-body factors used in the BERA). These data are presented in the Set 3 figures.

There are obvious differences in the mercury concentrations in the whole-body samples among species. The larger, higher trophic level, longer-lived fish (*e.g.*, bass and walleye) have higher concentrations than other species such as pumpkinseed. For the large piscivorous fish (smallmouth bass and walleye collected by Honeywell and largemouth bass collected by NYSDEC), mercury concentrations (about 0.3 to 2 mg/kg) are above the ecological goal of 0.14 mg/kg. For the smaller sport fish (*i.e.*, pumpkinseed and bullhead), mercury concentrations in 2013 and 2014 ranged from less than 0.05 mg/kg to 0.84 mg/kg. Mercury concentrations in white sucker, first sampled in 2014, appear to be similar to the smaller sport fish.

Additional Reporting to Assess Potential Impacts of Remediation (Set 4)

The previous sections reported the concentrations in fish tissue as they would appear to the consumers of those fish, as fillet or whole-body samples on a wet-weight basis. As discussed above, there are factors that will affect the concentrations of contaminants, causing increased variability that will make it more difficult to discern trends and understand the mechanisms influencing the results in the context of remedial success. These factors include the trophic level and age of fish for mercury, lipid content for organic contaminants, and location for species with limited home ranges. As the statistical methods to evaluate trends have not yet been formalized, the following descriptions reflect the general observations of the data. These data and additional data to be collected will be used for trend analysis following the completion of the remedy. These normalized data are presented in the Set 4 figures.

Mercury

Mercury results were normalized by dividing the concentration by length (which is a surrogate for age). As can be seen, there is a clear difference with decreasing mercury concentrations with trophic level (walleye>bass>pumpkinseed, bullhead, carp). For small prey fish (whole body), the standard deviation is relatively large compared to the mean values, indicating a relatively large amount of noise. This is due to the combining of the species of prey fish, including both littoral zone (*e.g.*, minnows) and pelagic zone (*e.g.*, alewife) species, as well as the influence of localized exposures, as further discussed below under "Location Effects." The NYSDEC data show similar differences with trophic levels, although not as distinctly as the Honeywell data.

PCBs

Based on the lipid-normalized PCB data from Honeywell, there is not a clear separation of the species by trophic levels. The small prey fish (whole body) again show the standard deviation is relatively large compared to the mean values, indicating a relatively large amount of noise resulting from multiple species and locations. The NYSDEC data for lipid-normalized PCBs do not show a distinct separation due to species.

PCDD/PCDFs

The Honeywell lipid-normalized data for PCDD/PCDFs appear to show a distinct difference in that the bullhead and pumpkinseed appear much more variable. Sample sizes for these contaminants are much smaller which may require more rounds of data for robust analysis.

Dichlorodiphenyltrichloroethane and Metabolites

The Honeywell lipid-normalized data for Dichlorodiphenyltrichloroethane and metabolites (DDTs) in sport fish do not show a distinct difference among species. The NYSDEC lipid-normalized data suggest some variation with species (with yellow perch being consistently lower).

Hexachlorobenzene

The Honeywell lipid-normalized hexachlorobenzene data do not show clear distinctions among species, except that the more localized species are again more variable. The prey fish show a great deal of variability as reflected in the large standard deviations. In particular, the larger standard deviations in 2008 and 2014 may be due to species differences, as discussed below. The NYSDEC lipid-normalized data for sport fish are similar to the Honeywell sport fish data, although yellow perch appear lower than other species (consistent with DDTs).

Location Effects

The prey fish data suggest that there may be location-specific differences in fish tissue concentrations in the Lake. It is anticipated that future analyses will examine these potential differences in detail. As discussed above, there is a relatively large amount of variability in the prey fish (and in some of the more localized sport fish) likely due to effects of multiple species and multiple locations for these relatively localized species. For the discussions in the sections (and figures) above, the small prey fish data set included all species collected, including alewife and gizzard shad. Both of these species are pelagic, roaming over large areas of the Lake, and are greatly influenced by the plankton-based food web, and thus would add to the variability seen in the entire small prey fish data set. Therefore, these two species are not included in the location-specific descriptions below (*i.e.*, the remaining four small prey fish species collected are grouped as "localized small prey fish"). If alewife and gizzard shad are collected in future monitoring, consideration will be given to presenting these data separately from the localized small prey fish. In addition, it should be noted that when presenting these localized small prey fish that the numbers of composite samples in each specific SMU are small (generally 0 to 5 composite samples per SMU, although some locations/years have more robust numbers for mercury analysis).

Location Effects – Mercury

As can be seen in the Set 4 figures showing normalized concentrations vs. SMUs, higher concentrations of mercury can be seen in localized small prey fish collected in SMUs 2, 4, and 7, which are areas of the Lake documented to have higher concentrations of mercury near source areas (Lake sediments and tributaries). The differences in concentrations among these three locations and the rest of the Lake may contribute to a high standard deviation in the combined data set. It should be noted that the length-normalized mercury concentrations have dropped for these localized small prey fish in these three SMUs in 2013 and 2014 (close to the levels seen in the other SMUs).

Location Effects – PCBs

As can be seen in the Set 4 figures showing normalized concentrations vs. SMUs, higher concentrations of lipid-normalized PCBs can be seen in localized small prey fish collected in SMU 6 and, to a lesser extent in SMU 7, both documented source areas with higher concentrations of PCBs. These locations may add to the variability of the combined data set. The lipid-normalized concentrations of PCBs in SMU 6 have dropped in 2014.

Location Effects – DDTs

As can be seen in the Set 4 figures showing normalized concentrations vs. SMUs, higher concentrations of lipid-normalized DDTs can be seen in localized small prey fish collected in SMUs 6 and 7, and also in SMU 2 in 2013. The lipid-normalized concentrations of DDTs in each of these SMUs have dropped in 2014.

Location Effects – Hexachlorobenzene

As can be seen in the Set 4 figures showing normalized concentrations vs. SMUs, concentrations of lipid-normalized hexachlorobenzene in localized small prey fish are all consistently low except for those in SMU 7. In SMU 7, the mean concentrations in 2008 (prior to remediation) and 2014 (during remediation) are higher than in the other SMUs, with higher variability, but not in 2013. It is believed that this is due to differences among species. Golden shiners were collected in SMU 7 in 2008 and 2014 (and only two composite samples in each year). The lipid-normalized hexachlorobenzene concentrations in the golden shiners were almost two orders-of-magnitude greater than concentrations seen in any other small prey fish species. These concentrations in a few individuals of a single species in a particular location caused the high concentrations of hexachlorobenzene in the combined prey fish results for those years. While it is not clear why the hexachlorobenzene concentrations in golden shiner are greater than in the other localized small prey fish species (based on this limited data set), a review of the data in this series suggests that this is not the case for the other contaminants of concern.

As pumpkinseed and brown bullhead tend to be more localized and feed more heavily in the littoral zone than the other adult sport fish collected, figures for these species are also included in this subset. However, the differences in concentrations of mercury, PCBs, DDTs, and hexachlorobenzene among locations are not as apparent as for the small prey fish based on the Set 4 figures.

Fish Tissue Conclusions

Due to the scheduling of various aspects of the remedial program, ongoing Lake and shore remedial activities, and the nature of biological systems, it is premature in this first five-year review to analyze trends in fish tissue concentrations and make a definitive statement whether remediation will achieve the remediation goals for mercury in fish tissue identified in the ROD. Future five-year reviews will provide the opportunity to review data over sufficiently longer time frames to more definitively evaluate impacts of site remediation on progress towards meeting fish tissue goals in the ROD.

Dredging, Isolation/Thin Layer Capping, Wetland and Habitat Restoration, and Shoreline Stabilization

Post-dredging sampling has not been conducted as all dredged areas are receiving an isolation cap. As capping activities in the Lake are still ongoing, no analytical data to evaluate cap effectiveness are available at this time. Data relating to cap effectiveness will be generated and evaluated relative to cap performance criteria as part of the next five-year review.

Other components of the remedy include stabilization of the shoreline area adjacent to Wastebeds 1-8 with graded gravel and run-of-the-bank material to reduce sediment resuspension and turbidity associated with the presence of calcite and oncolites, and wetland/habitat restoration. This work was substantially completed in early summer 2014. Some additional work will be needed in areas where dredging occurred adjacent to Wastebeds 1-8, including the connected wetland where restoration activities are ongoing. Data associated with these remedy components will be obtained and evaluated for the next five-year review.

Site Inspection

Because the remediation is still in progress, site inspections are routinely performed throughout the year. NYSDEC and its contractors have maintained presence at the site 24 hours per day, six days per week since the commencement of remedial activities. In addition, the EPA RPM and other EPA representatives have observed remedial activities on the site on numerous occasions. Representatives of the Onondaga Nation, NYSDEC and EPA observed initial activities relating to closure of the SCA on May 27, 2015.

Interviews

No interviews were conducted for this review.

Institutional Controls Verification

Institutional controls as prescribed by the ROD remedy include the notification of appropriate government agencies with authority for permitting potential future activities that could impact the implementation and effectiveness of the remedy. Institutional controls are also needed to ensure long-term effectiveness of the isolation cap placed in the Lake so as to minimize disturbance of the caps by dredging or other in-water construction activities. It is anticipated that "No Dredge Areas" will be established over the capping areas, other than the New York State Canal Corporation navigation channel, to minimize disturbance of the capping materials. The restrictions can be marked on the National Oceanic and Atmospheric Administration Navigation Chart for Onondaga Lake (currently included as Chart Number 14786 for the Small-Craft. Book Chart for the New York State Barge Canal System). The New York State Office of Parks, Recreation and Historic Preservation currently maintains navigation buoys in Onondaga Lake to warn boaters of hazards in water less than 4 feet in depth and beyond 100 feet from shore. As appropriate, additional navigation buoys may be placed.

It is anticipated that institutional controls will be in place within one year following completion of capping and habitat reestablishment related activities.

Technical Assessment

Question A: Is the remedy functioning as intended by the decision documents?

The implemented components of the remedy are functioning as intended by the ROD. The dredging component of the remedy has been completed, resulting in the removal of 2.2 million CY from the Lake, along with the Wastebed B Outboard Area, the Wastebeds 1-8 subsite-lake connected wetland area, and the Spits at the mouth of Ninemile Creek to support the ongoing capping component of the remedy.

It is anticipated that operating procedures, monitoring, and maintenance as currently being implemented, will maintain the effectiveness of the remedy.

Operations and monitoring for adding liquid nitrate to the hypolimnion of Onondaga Lake are being conducted in accordance with an approved operations and monitoring plan. Liquid nitrate is applied to the Lake using a self-propelled barge. The liquid nitrate is loaded onto the barge and then it is diluted with epilimnetic Lake water to achieve neutral buoyancy at the target water depth. The diluted nitrate solution is then pumped through flexible hoses to water depths between 42 feet and 55 feet in the profundal zone where it can spread laterally throughout the entire deep water of the Lake by natural forces as determined with extensive Lake monitoring. Nitrate is being added to the Lake at one of three locations during each day of application. (Nitrate application locations are shown on Figure 11.)

In-Lake monitoring is conducted before, during, and following each annual nitrate addition program. Data collected as part of the nitrate addition monitoring program are used to guide rates and locations for future applications of the diluted calcium nitrate, track the fate of the nitrate addition, and verify there are no adverse impacts to water quality (none were observed during the pilot test or in 2014). The monitoring efforts are conducted with the same rapid profiling instrumentation used during the nitrate addition pilot test, which includes *in situ* ultraviolet spectrophotometer equipment technology to measure nitrate and sulfide concentrations in Lake water.

Sediments dredged from Onondaga Lake as part of the remediation of the Lake were transported via pipeline to permeable geotextile tubes located at the SCA for dewatering. The SCA includes a composite liner system, overlain by a gravel drainage layer which support the geotextile tubes that contain the lake sediments. The composite liner system includes a geomembrane liner underlain by a natural clay barrier layer. Above this, a gravel drainage layer conveys the drainage from the filled geotextile tubes to sump areas where the filtrate is collected and then pumped to an on-site wastewater treatment system for the treatment of suspended solids, metals and organics. The treated effluent is then conveyed to METRO where it undergoes additional treatment for ammonia prior to discharge to the Lake. The SCA will be covered with an engineered cap and properly closed to prevent rain and snow melt from impacting the containment system. The engineered cap includes a soil leveling layer above the geotextile tubes, then a geomembrane which will be overlain by a barrier protection soil layer, which in turn is overlain by a vegetated topsoil layer. The engineered cap is currently under construction. Once it is constructed, it will be monitored and maintained to ensure that it is protective of human health and the environment.

Because capping and wetland/habitat restorations activities in the Lake are ongoing, and shoreline stabilization was recently completed, no data to evaluate the effectiveness of these remedial components are available at this time. Data relating to these components of the remedy will be generated and evaluated relative to performance and success criteria as part of the next five-year review.

Based on data collected to date, and comparing levels to pre-remedial conditions, MeHg concentrations were considerably lower in the Lake's hypolimnion in 2011 through 2014 compared to prior years. As nitrate concentrations have increased as a result of METRO upgrades and adding nitrate to the lower hypolimnion, MeHg concentrations have declined dramatically. MeHg in the lower hypolimnion has been barely detectable since 2012. The combination of nitrate discharged from METRO and nitrate added by Honeywell since 2011 has also resulted in decreases in zooplankton MeHg concentrations. Zooplankton results from 2014 for total mercury and MeHg are significantly lower than concentrations measured in 1992 during the RI and are the lowest on record. Lower zooplankton MeHg concentrations are expected to contribute to lower mercury concentrations in fish.

Concentrations of dissolved mercury are significantly lower in surface water samples collected between 2008 and 2014 relative to dissolved mercury levels in samples collected during the RI. This is likely attributable to reductions in mercury loading to the Lake from external sources such as tributaries and groundwater. Further reductions in dissolved mercury are expected from the implementation of the selected remedy.

Mercury concentrations measured in 2014 in surface sediment throughout SMU 8 are lower than they were projected to be as part of the Final Design analysis and recent measured mercury concentrations on settling sediments are lower than they were assumed to be during remediation for purposes of natural recovery modeling completed during the Final Design. Also, average annual sedimentation rates since 2009 have been higher than the sedimentation rate assumed in the Final Design analysis for predicting natural recovery rates. Consequently, natural recovery is progressing faster than predicted and the modeling conducted during the design was conservative.

Although there have been a significant number of surface water samples collected and analyzed for mercury in the deep areas of the Lake, only a limited amount of surface water data have been collected during the baseline monitoring program and analyzed for the organic contaminants that exceeded the surface water quality standards during the RI (*e.g.*, chlorobenzene, dichlorobenzenes). As these data were primarily obtained in deeper waters for the baseline program for construction-period monitoring for dredging/capping, which was developed for comparison to acute standards due to the relatively short-term nature of dredging/capping activities, they are not discussed herein in relation to the remediation goals, which are based on surface water quality standards for the protection of wildlife (including chronic standards) and human consumption of fish. It is anticipated that surface water samples will be collected throughout the Lake (including in the near-shore exposure areas) and analyzed for the chemical parameters of interest for comparison to the remediation goals following completion of source control activities and in-Lake capping activities, and these data will be included in future five-year reviews.

Due to the ongoing Lake and shore remedial activities and the nature of biological systems, it is premature in this first five-year review to analyze trends in fish tissue concentrations and make a definitive statement whether remediation will achieve the remediation goals for mercury in fish tissue identified in the ROD. Future five-year reviews will provide the opportunity to review data over sufficiently longer time frames to more definitively evaluate impacts of site remediation on progress towards meeting fish tissue goals in the ROD.

In accordance with the remediation operations community, health, and safety plan, fencing and/or highly visible warning signs are in place at all land-based project work areas to restrict unauthorized access. These areas include shoreline support areas, slurry pump stations, the SPA, SCA, and the WTP. Site workers also provide security surveillance which deters trespassers and work areas are properly barricaded and/or illuminated during non-work hours, as necessary. In-Lake work zones are clearly marked with buoys and/or high visibility demarcation booms to alert the boating public of the presence of active work areas. Air horns or other appropriate means are also used, as needed, to warn non-project vessels approaching an active work area to keep away. To date, the implemented security measures have been effective in maintaining site security, and protecting both the public and site workers.

Institutional controls are not yet in place. It is anticipated that they will be in place within one year following completion of capping and habitat reestablishment related activities.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy still valid?

The exposure assumptions, toxicity data, cleanup levels and remedial action objectives used at the time of the remedy are still valid. The risk assessment methodology used to complete the 2002 BERA was consistent with both EPA and NYSDEC guidance. Assessment and measurement endpoints encompassed the sustainability (survival, growth, and reproduction) of organisms at the base of the food web (aquatic macrophytes, phytoplankton, zooplankton, benthic invertebrate and terrestrial plants) and up the food chain (fish, amphibian and reptile, insectivorous birds, benthivorous waterfowl, piscivorous birds, carnivorous birds, insectivorous mammals and piscivorous mammals). Measurement endpoints included measured or modeled concentrations of chemicals and stressors in water, sediment, fish, birds, and mammals, laboratory toxicity studies, and field observations. Toxicity Reference Values were selected based on LOAELs and/or NOAELs from laboratory and/or field-based studies reported in the scientific literature. Reproductive effects (*e.g.*, egg maturation, egg hatchability, and survival of juveniles) were generally the most sensitive exposure endpoints and were selected when available and appropriate. Site-specific SECs using toxicity and chemistry data were derived to allow assessment of whether the sediment chemical concentrations found at various stations in the Lake would result in adverse biological effects. These SECs were then used to derive consensus-based PECs for use in determining areas of the Lake bottom that potentially pose a risk to the benthic community.

The exposure assumptions and toxicity values that were used in the 2002 HHRA to estimate the potential risk and hazards to human health from exposure to the contaminants followed the general practice at the time that the risk assessment was performed. Although specific parameters and toxicity values may have changed, the risk assessment process that was used is still consistent with current practices, and the conclusions remain valid.

The RAOs identified in the ROD include reducing or eliminating potential risks to humans and ecological receptors. Currently, there are advisories in place that recommend that consumption of fish is limited to certain types and specific meal frequencies. The actions taken through the implementation of the remedy to date include reducing methylation rates of mercury, completion of dredging, and implementation of capping. The State's fish consumption advisories currently in place help to reduce exposure through ingestion. Fish tissue monitoring will continue, and it is expected that concentrations will decrease once the remedy is fully implemented.

Sediment-based cleanup levels identified at the time of the remedy incorporated site-specific criteria established during the RI/FS and were developed consistent with published scientific literature. Fish-based remediation goals include fish tissue mercury concentrations ranging from 0.14 mg/kg, which is for protection of ecological receptors, to 0.3 mg/kg, which is based on the EPA's MeHg National Recommended Water Quality criterion for the protection of human health for the consumption of organisms. This range encompasses the goal for protection of human health based on the reasonable maximum exposure scenario of 0.2 mg/kg of mercury in fish tissue (fillets).

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

There is no new information that calls into question the protectiveness of the remedy.

Technical Assessment Summary

Based upon the results of this first five-year review, it has been concluded that:

- Concentrations of dissolved mercury are significantly lower in surface water samples collected between 2008 and 2014 relative to samples collected during the RI. This is likely attributable to reductions in mercury loading to the Lake from external sources such as tributaries and groundwater. Further reductions in dissolved mercury are expected from the implementation of the selected remedy;
- As a result of METRO upgrades and adding diluted calcium nitrate near the sediment/water interface in the deep water portions of the Lake since 2011, MeHg concentrations in Lake water and in zooplankton have declined dramatically. Lower MeHg exposures from the water column and through the food chain are expected to contribute to lower mercury concentrations in fish;
- The combination of lower than projected concentrations of mercury in surface sediment and settling sediments, and higher average annual sedimentation rates than the rate assumed in the Final Design indicate that natural recovery in the Lake is progressing faster than predicted;
- Due to the scheduling of various aspects of the remedial program and the nature of biological systems, it is premature in this first five-year review to determine whether the remediation has achieved the goals for mercury in fish tissue identified in the ROD; and
- Future five-year reviews will have the opportunity to review data over sufficiently long time frames to determine the extent of compliance with the goals in the ROD.

Issues, Recommendations and Follow-Up Actions

No issues or recommendations were identified in this five-year review. Remedial activities, including capping and habitat restoration, are ongoing. Data will continue to be collected and evaluated to determine attainment of and/or progress towards achieving the RAOs in the ROD.

Protectiveness Statement

The OU2 remedy, which includes dredging, capping, habitat restoration, nitrate addition and monitored natural recovery, is expected to be protective of human health and the environment upon completion. In the interim, remedial activities conducted to date are operating as intended to protect human health and the environment.

Next Review

The next five-year review report for the Lake Bottom Subsite of the Onondaga Lake Superfund Site is required five years from the completion date of this review.

Tables

Table 1: Chronology of Site Events

Event	Date
Production of soda ash and related products at Main Plant begins	1884
Production of benzene, toluene, xylenes, naphthalene at Main Plant begins	1917
Production of chlorinated benzenes, and non-mercury cell process chlor-alkali products (*e.g.*, caustic soda, chorine) At Willis Avenue Plant begins	1918
Mercury cell process added to Willis Avenue chlor-alkali plant	1947
Bridge Street mercury cell chlor-alkali plant opens	1953
Production of benzene, toluene, xylenes, naphthalene at Main Plant ends	1970
Fishing banned in Onondaga Lake	1970
Willis Avenue chlorinated benzene and chlor-alkali plants closed	1977
Allied-Signal sells Bridge Street chlor-alkali plant to LCP	1979
Catch and release fishing allowed in Onondaga Lake	1986
Production of soda ash and related products at Main Plant ends	1986
LCP closes Bridge Street chlor-alkali plant	1988
Initial discovery of problem or contamination	April 23, 1989
Consent Decree for Site Investigation entered into by Honeywell and NYSDEC	March 16, 1992
Cooperative Agreement entered into by NYSDEC and EPA	1993
Final NPL listing	December 16, 1994
Ban on consuming certain Onondaga Lake fish species replaced with fish consumption advisories	1999
Revised RI report finalized	December 2002
FS report completed	November 2004
ROD issued	July 1, 2005
ESD #1	December 14, 2006
Consent Decree for Site Remediation entered into by Honeywell and NYSDEC	January 4, 2007
Remedial design start	January 4, 2007

Table 1: Chronology of Site Events	
Event	**Date**
On-site remedial action construction start (SCA)	August 25, 2010
Completion of 1.5 mile long underground barrier wall/groundwater collection system along the Semet/Willis Ave/Wastebed B/Harbor Brook shoreline	April 2012
Remedial design complete	May 8, 2012
Initiation of dredging activities	July 2012
Initiation of capping activities	August 2012
ESD #2	August 5, 2014
Completion of dredging activities	November 2014

Table 2a: Target Tissue Concentrations for Fish (all concentrations in mg/kg wet weight)		
Contaminants of Concern	**Target Tissue Concentrations**	
Human Health – Fish Fillets	**Reasonable Maximum Exposure**	
Mercury (as MeHg)[4]	0.2	
Total PCBs[5]	0.03 to 0.3	
PCDD/PCDFs (TEQ as 2,3,7,8-TCDD)[6]	4×10^{-7} to 4×10^{-6}	
Ecological Exposure Small Fish (3-18 cm) - Whole Fish	**NOAEL**	**LOAEL**
Mercury (as MeHg)	0.009	0.187
Total PCBs	0.013	3.15
DDT and metabolites (sum)	0.005	0.049
Ecological Exposure Large Fish (18-60 cm) - Whole Fish	**NOAEL**	**LOAEL**
Mercury (as MeHg)	0.014	0.341
Total PCBs	0.19	9.6
DDT and metabolites (sum)	0.014	0.15

Table 2a Notes:
1. NOAEL = no-observed-adverse-effect-level; LOAEL = lowest-observed-adverse-effect-level.
2. NOAELs and LOAELs for small (3 to 18 cm) fish are based on the belted kingfisher and mink. NOAELs and LOAELs for large (18 to 60 cm) fish are based on the great blue heron, osprey, and river otter.
3. Only avian fish target concentrations are presented for DDT and metabolites.
4. The human health target tissue concentration for mercury (0.2 mg/kg) is based on young child reasonable maximum exposure (RME) (non-cancer effects). The RME target concentration for adults is slightly higher (0.3 mg/kg).
5. The human health target tissue concentrations for total PCBs are based on RME carcinogenic risks at risk targets ranging from 1E-05 (0.03 mg/kg) to 1E-04 (0.3 mg/kg). The RME targets based on non-cancer effects of 0.04 mg/kg for high molecular weight PCBs and 0.1 mg/kg for low molecular weight PCBs fall within the range based on carcinogenic risks. A target concentration based on the 1E-06 risk level was not selected as a goal since it is much lower than mean background concentrations in US waters and may not be achievable (see Appendix G of the Onondaga Lake FS).
6. TEQ = toxicity equivalent (toxicity-weighted mass of dioxin mixtures). The human health target tissue concentrations for PCDD/PCDFs are based on RME carcinogenic risks at risk targets ranging from 1E-05 (4E-07 mg/kg) to 1E-04 (4E-06 mg/kg). Non-carcinogenic targets could not be developed for PCDD/PCDFs. A target concentration based on the 1E-06 risk level was not selected as a goal since it is much lower than mean background concentrations in US waters and may not be achievable (see Appendix G of the Onondaga Lake FS).

Table 2b: Sediment Probable Effect Concentrations (PECs)	
Contaminants of Concern	**Performance Criteria Micrograms per Kilogram (µg/kg)**
Mercury	2,200
Ethylbenzene	176
Xylenes	560.8
Chlorobenzene	428
Dichlorobenzenes	239
Trichlorobenzenes	347
Acenapthene	861
Acenaphthylene	1,301
Anthracene	207
Benz[a]anthracene	192
Benzo[a]pyrene	146
Benzo[b]fluoranthene	908
Benzo[ghi]perylene	780
Benzo[k]fluoranthene	203
Chrysene	253
Dibenz[a,h]anthracene	157
Fluoranthene	1,436
Fluorene	264
Indeno[1,2,3-cd]pyrene	183
Naphthalene	917
Phenanthrene	543
Pyrene	344
Total PCBs	295

Table 2b Notes: The 23 site-specific PECs developed during the RI phase which are included in this table were used in the calculations for the mean PECQ approach. In the littoral zone, sediment remediation goals include achieving the mean PECQ of 1 or lower and the mercury PEC of 2.2 mg/kg or lower. In the profundal zone, sediment remediation goals include achieving the mean PECQ of 1 or lower, and achieving the mercury PEC or lower on a point basis and a BSQV of 0.8 mg/kg or lower on an area-wide basis within 10 years following the remediation of upland sources, littoral sediments, and initial thin-layer capping. The 23 PECs and NYSDEC sediment screening criteria for benzene, toluene, and phenol are also chemical isolation performance criteria for capped areas in the Lake's littoral zone, the Wastebed B Outboard Area, the Wastebeds 1-8 connected wetland, and the Spits at the mouth of Ninemile Creek.

Table 2c: Remediation Goals for Surface Water	
Contaminants of Concern	**New York State Surface Water Quality Standards**
Dissolved Mercury	0.7 ng/L
Chlorobenzene	5 µg/L
Dichlorobenzenes	5 µg/L

Table 2c Notes: Remediation goals for surface water are based on the NYSDEC aquatic (chronic) (A[C]) water quality standard for chlorobenzene and dichlorobenzenes and human health fish consumption (H[FC]) for dissolved mercury.

Table 3: Documents, Data and Information Reviewed in Completing the Five-Year Review	
Document Title, Author(s)	**Submittal Date**
Field Change Forms	Various
Response Letter from Robert Nunes to Joseph Heath Regarding Onondaga Nation Comments on a July 2015 Draft Lake Bottom Five Year Review Report. EPA.	August 25, 2015
Transmittal Letter from Joseph Heath to Robert Nunes Commenting on a July 2015 Draft Lake Bottom Five Year Review Report. Joseph Heath, General Counsel for the Onondaga Nation.	August 7, 2015
Email from Ed Glaza to Robert Nunes Providing Comments on a July 2015 Draft Lake Bottom Five Year Review Report. Parsons.	August 5, 2015
Draft Assessment of Contaminant Migration Potential Under Current Conditions from the Niagara Mohawk – Hiawatha Blvd Former MGP Subsite to Onondaga Lake. EPA.	June 25, 2015
VOC Data Summary – First 41 Weeks of 12-Month Data Summary. Honeywell.	June 11, 2015
2015 Cap Geotechnical Evaluation Work Plan. Honeywell.	May 4, 2015
2015 RA-D and SMU 8 Sediment Investigation Work Plan. Honeywell.	April 24, 2015
SCA Final Cover Design Report 2015 Construction. Parsons.	April 2015
SCA WTP Lake Discharge Operations Plan (Post Dredging). Honeyewell.	April 2015
Onondaga Lake Sediment Consolidation Area (SCA) Final Cover Design Report for 2015 Construction. Parsons and Geosyntec.	April 2015
GM-Inland Fisher Guide Site OU2 Record of Decision, NYSDEC and EPA.	March 2015
Wastebed B/Harbor Brook Revised Remedial Investigation Report. O'Brien & Gere.	March 2015
Revised Hydrogeologic Investigation to Support Groundwater Monitoring at the SCA. O'Brien & Gere.	December 2014
SCA Environmental Monitoring Plan for 2013. O'Brien & Gere.	December 2014
Geddes Brook/Ninemile Creek 2013 Annual Monitoring and Maintenance Report. Parsons.	December 2014
Wastebeds 1-8 OU 1 Record of Decision. NYSDEC and EPA.	December 2014

Table 3: Documents, Data and Information Reviewed in Completing the Five-Year Review	
Document Title, Author(s)	**Submittal Date**
Construction Completion Report for the Geddes Brook Interim Remedial Measure. Parsons.	November 2014
LCP Bridge Street Annual Operation, Maintenance and Monitoring Report. Parsons.	November 2014
Onondaga Lake Sediment Management Unit 8 Microbead Marker Placement Report. Parsons and Environmental Tracing Systems.	October 2014
Dredge and Dewatering System Decommissioning Plan. Parsons.	October 2014
2014 Source Control Summary for the Onondaga Lake Bottom Subsite. Parsons, In Association With O'Brien & Gere.	October 2014
Draft SCA Final Cover Design Report. Parsons.	October 2014
2nd Quarter 2012 to 1st Quarter 2013 Data Validation Report, Closure Investigation, Wastebeds 9-15 Site, Geddes and Camillus, New York. O'Brien & Gere.	October 2014
2nd Quarter to 4th Quarter 2013 Data Validation Report, Closure Investigation, Wastebeds 9-15 Site, Geddes and Camillus, New York. O'Brien & Gere.	October 2014
Onondaga Lake Baseline Monitoring Report on Sediment Resuspension Along the Wastebeds 1-8 Shoreline. Parsons.	October 2014
Onondaga Lake Capping, Dredging, Habitat and Profundal Zone (SMU 8) Final Design METRO Outfall Vicinity Design Addendum	October 2014
Onondaga Lake: Cap Porewater Sampling Methods Demonstration Work Plan. Parsons.	September 2014
Lower Ley Creek Record of Decision, EPA.	September 2014
Upper Harbor Brook Construction Completion Report, O'Brien & Gere.	September 2014
Monitored Natural Recovery Work Plan for 2014 - 2015. Parsons, Anchor QEA.	September 2014
Willis Avenue Remedial Investigation Report. O'Brien & Gere.	September 2014
Operations and Monitoring Plan for Adding Nitrate Full Scale to the Hypolimnion of Onondaga Lake. Parsons and Upstate Freshwater Institute (UFI).	August 2014
Onondaga Lake Capping Dredging, Habitat and Profundal Zone (SMU 8) Final Design, Remedial Area E Shoreline Design Addendum. Parsons.	August 2014

Table 3: Documents, Data and Information Reviewed in Completing the Five-Year Review

Document Title, Author(s)	Submittal Date
Onondaga Lake Capping Dredging, Habitat and Profundal Zone (SMU 8) Final Design, Onondaga Creek Navigation Channel Design Addendum. Parsons.	August 2014
Explanation of Significant Differences, Onondaga Lake Bottom Subsite of the Onondaga Lake Site. NYSDEC and EPA.	August 2014
2008-2013 Operation, Maintenance and Monitoring Report, LCP Bridge Street Site (OU-1). Parsons and Anchor/QEA.	July 2014
Report for the Third of Three Years of the Nitrate Addition Pilot Test (2013) in the Hypolimnion of Onondaga Lake. Parsons and UFI.	June 2014
Supplemental Treatment and Lake Discharge Completion Report. Honeywell SCA WTP. O'Brien and Gere.	June 2014
Construction Summary Report, Onondaga Lake Through 2013, Parsons.	June 2014
Revised Proposed Plan to Add Seven Compounds to Speciated VOC List Air Quality Monitoring Program. Onondaga Lake Remediation. Honeywell.	May 5, 2014
Supplemental Treatment and Lake Discharge Design, Construction, and Operations work Plan. O'Brien & Gere, Honeywell.	January 2014
Work Plan for Baseline Monitoring of Sediment Resuspension along the Wastebeds 1-8 Shoreline of Onondaga Lake. Parsons.	January 2014
Capping Field Demonstration Summary Report. Parsons.	December 2013
2012 and 2013 Source Control Summary for the Onondaga Lake Bottom Subsite. Parsons, In Association With O'Brien & Gere.	December 2013
Real Time Benzene Monitoring Evaluation Results Technical Memorandum. O'Brien & Gere.	November 2013
SCA West Basin - Design Concepts and Operations Plan. O'Brien & Gere.	October 2013
Baseline Monitoring Report for 2011 - Revised 10/11/13 (with replacement pages dated March 24, 2015). Parsons, Exponent, and Anchor QEA.	September 2013
Report for the Second Year of the Nitrate Addition Pilot Test (2012) in the Hypolimnion of Onondaga Lake. Parsons and UFI.	September 2013
SCA WTP Stormwater Pollution Prevention Plan Modification. O'Brien & Gere.	September 2013

Table 3: Documents, Data and Information Reviewed in Completing the Five-Year Review	
Document Title, Author(s)	**Submittal Date**
Onondaga Lake Capping, Dredging, Habitat and Profundal Zone (SMU 8) Final Design Cap Sampling Port Addendum. Parsons.	August 2013
Onondaga Lake Tissue and Biological Monitoring Report for 2012. Parsons.	August 2013
Addendum 1 (2013) to Onondaga Lake Tissue Monitoring Work Plan for 2012. Parsons, Anchor QEA, and Exponent.	July 2013
Addendum 2 (2013) to Work Plan for Pilot Test to Add Nitrate to the Hypolimnion of Onondaga Lake. Parsons and UFI.	June 2013
Phase II SCA Construction Quality Assurance Final Report. Geosyntec	April 2013
Sediment Management Winter 2013 Additional Odor Mitigation Plan. Parsons, O'Brien & Gere.	April 2013
Odor Characterization Sampling and Analysis Plan. O'Brien & Gere.	February 2013
Baseline Monitoring Report for 2011. Parsons, Exponent, and Anchor QEA.	December 2012
Mitigation Plan for Archaeological Properties in the Onondaga Lake Bottom, Subsite of the Onondaga Lake Superfund Site. Lake Champlain Maritime Museum.	January 2013
Construction Quality Assurance (CQA) Final Report, Sediment Management System Basins, Consolidation Area. Geosyntec.	October 2012
Construction Quality Assurance Final Report, Phase I-Sediment Consolidation Area Construction. Geosyntec.	October 2012
Granby Quarry Investigation Data Summary Report. Parsons.	October 2012
Capping Calibration Work Plan. Parsons.	August 2012
First Year of the Nitrate Addition Pilot Test in the Hypolimnion of Onondaga Lake (2011). Parsons.	August 2012
Construction Quality Assurance Plan. Anchor QEA.	August 2012
Phase I SCA Construction Quality Assurance Final Report - Revision 2. Geosyntec.	July 2012
Habitat and Biological Monitoring Work Plan for 2012. Parsons.	June 2012
Onondaga Lake Tissue Monitoring Work Plan for 2012. Parsons, Anchor QEA, and Exponent.	June 2012

Table 3: Documents, Data and Information Reviewed in Completing the Five-Year Review	
Document Title, Author(s)	**Submittal Date**
Quality Assurance Project Plan Air Quality Monitoring Program, Onondaga Lake Dredging, Sediment Management and Water Treatment Project. O'Brien & Gere.	June 2012
Sediment Management Final Design Addendum 1. Parsons.	May 2012
Remediation Operations Community Health and Safety Plan. Parsons.	May 2012
Water Quality Management and Monitoring Plan. Anchor QEA, Parsons.	May 2012
Addendum 1 (2012) to Work Plan for Pilot Test to Add Nitrate to the Hypolimnion. Parsons.	May 2012
PDI Phase VI GAC Adsorption Isotherm Study Final Report. Parsons.	April 2012
Draft Onondaga Lake Monitoring and Maintenance Scoping Document. Parsons, Anchor QEA and Exponent.	April 2012
Onondaga Lake Capping Dredging, Habitat and Profundal Zone (SMU 8) Final Design. Parsons/Anchor QEA.	March 2012
Draft Assessment of PCB Sources to Onondaga Lake: Whether Ley Creek is a Significant Current Source of PCBs to Lake Sediments. Response to EPA's March 20. 2012 Comment. AECOM.	March 30, 2012
Draft Assessment of PCB Sources to Onondaga Lake: Whether Ley Creek is a Significant Current Source of PCBs to Lake Sediments. AECOM.	March 9, 2012
Earthen Materials Investigation Work Plan, Granby Quarry Investigation. Parsons.	January 2012
Baseline Monitoring Report for 2010. Parsons, Exponent, and Anchor QEA.	December 2011
Baseline Monitoring Report for 2008 – Final. Parsons.	November 2011
Geotechnical Instrumentation Installation Report - 2010 and 2011 Onondaga Lake Sediment Consolidation Area. Geosyntec.	November 2011
Groundwater Flow Model Version 3 – Final. O'Brien & Gere.	November 2011
Siderite Column Studies Data Report. Anchor QEA.	October 2011
Cultural Resource Investigation, Slurry Pipeline from Station 136+89 to Station 145+63, Onondaga Upland Project. SUNY Binghamton.	October 2011
Baseline Monitoring Report for 2009. Parsons.	October 2011
Capping Field Demonstration Work Plan. Parsons.	October 2011

Table 3: Documents, Data and Information Reviewed in Completing the Five-Year Review	
Document Title, Author(s)	**Submittal Date**
Final Phase 1B Underwater Archaeological Report for the Onondaga Lake Bottom. Lake Champlain Maritime Museum.	October 2011
Onondaga Lake Sediment Management Final Design. Parsons.	September 2011
Phase 1 Cultural Resource Management Report for the Upland and Shoreline Area & Lakeshore Complex. SUNY Binghamton.	July 2011
Data Report: Sediment Incubations & Supporting Studies for SMU 8. Exponent.	July 2011
Addendum 1 (2011) to Baseline Monitoring Book 3 Tributary Monitoring Work Plan for 2009. Parsons.	June 2011
Addendum 3 (2011) to Baseline Monitoring Book 1 Deep Basin Water & Zooplankton Monitoring Work Plan for 2008. Parsons.	May 2011
Addendum 3 (2011) to Baseline Monitoring Book 2 Fish, Invertebrate, & Littoral Water Monitoring for 2008. Parsons.	May 2011
Water Quality Monitoring for Construction Baseline Work Plan. Parsons.	May 2011
Cultural Resource Management Report. Phase 1B Slurry Pipeline & Fiber Optic Line. SUNY Binghamton.	April 2011
Stormwater Pollution Prevention Plan. Water Treatment Plant & SCA. O’Brien & Gere.	April 2011
SCA Civil and Geotechnical Final Design.	April 2011
Work Plan for Pilot Test to Add Nitrate to the Hypolimnion. Parsons.	March 2011
30 and 24” Force Main Rehabilitation. O’Brien & Gere.	February 2011
Baseline Monitoring Book 3 Tributary Monitoring Work Plan for 2009. Parsons.	February 2011
Effler, S.W., O'Donnell, S. M., Prestigiacomo, A.R., O'Donnell, D.M., Gelda, R.K., Matthews, D.A. The Effect of Municipal Wastewater Effluent on Nitrogen Levels in Onondaga Lake, a 36-Year Record. Water Environment Research 82, 3-19.	2010
Final Design Package # 3 SCA Water Treatment Plant. O’Brien & Gere.	October 2010
Stormwater Pollution Prevention Plan for the Water Treatment Plant & SCA. O’Brien & Gere.	August 2010

Table 3: Documents, Data and Information Reviewed in Completing the Five-Year Review	
Document Title, Author(s)	**Submittal Date**
Frequently Asked Questions: Human Health Risk Assessment, Onondaga Lake, Lake Bottom Subsite: Sediment Consolidation Area. EPA, NYSDEC, NYSDOH.	August 2010
Baseline Monitoring Scoping Document. Parsons.	July 2010
Baseline Monitoring Book 2 Addendum 2 (2010) Fish, Invertebrate & Littoral Water monitoring for 2008. Parsons.	July 2010
Human Health Risk Assessment, Onondaga Lake, Lake Bottom Subsite: Sediment Consolidation Area. EPA.	June 2010
PDI Phase VI Addendum 1 Carbon Isotherm Study Work Plan Revised Letter Work Plan. Parsons.	May 2010
PDI Phase VI Addendum 2 - pH Column Studies Letter Work Plan. Parsons.	May 2010
SCA Water Treatment Plant Draft Design Package #2. O'Brien & Gere.	May 2010
Baseline Monitoring Book 1 Addendum 2 (2010) to Deep Basin Water & Zooplankton Monitoring Work Plan. Parsons.	April 2010
Frequently Asked Questions: Onondaga Lake Dredging Project Sediment Consolidation Area (SCA) at Wastebed 13. NYSDEC, NYSDOH, EPA.	April 2010
Wetlands/Floodplain Assessment Final Report. O'Brien & Gere.	March 2010
Remedial Design SCA Water Treatment Plant Design Package # 1. O'Brien & Gere.	March 2010
Baseline Monitoring - Book 3 Addendum, Tributary Monitoring Work Plan for 2009. Parsons.	February 2010
SCA Civil & Geotechnical Draft Final Design. Parsons.	January 2010
Remedial Design Elements for Habitat Restoration. Parsons.	December 2009
Record of Decision for Operable Unit 2 of the Geddes Brook/Ninemile Creek Site. NYSDEC/EPA.	October 2009
PDI Phase V Addendum 2 - Biological Decay Batch Study Letter Work Plan (to support cap design). Parsons.	September 2009
Baseline Monitoring Book 1 Addendum 1 Deep Basin Water and Zooplankton Monitoring Work Plan for 2008. UFI.	September 2009

Table 3: Documents, Data and Information Reviewed in Completing the Five-Year Review

Document Title, Author(s)	Submittal Date
Microbead Marker 2008 Pre-Mobilization Field Test Data Summary Report. Parsons and Environmental Tracing Systems.	August 2009
PDI: Phase IV Addendum 7 - Additional Scope. Parsons.	June 2009
Record of Decision for Operable Unit 1 of the Geddes Brook/Ninemile Creek Site. NYSDEC/EPA.	April 2009
Remedial Design Work Plan. Parsons.	March 2009
SCA Dewatering Evaluation. Parsons.	February 2009
PDI: Phase IV Addendum 3: Cap Design Bench-Scale Testing; Additional Column Studies and Isotope Degradation Evaluation Work Plan. Honeywell.	January 2009
PDI: Wastebed 13 Settlement Pilot Study Monitoring Data - Year 2. Parsons.	December 2008
PDI: Phase IV Addendum 7: Cap pH Amendment Evaluation. Parsons.	November 2008
PDI: Phase IV Work Plan Addendum 8 SMU 8 High-Resolution Cores. Parsons.	November 2008
Cultural Resource Management Report, Phase 1B Archaeological Work Plan. Onondaga Lake Project, Upland and Shoreline Area Settling Basins 12-15, Geddes Brook IRM, Ninemile Creek RI/FS and Harbor Brook IRM. SUNY Binghamton.	November 2008
Data Usability and Summary Report Evaluation of Nitrate Addition to Control Methylmercury Production: 2007 Study. Exponent.	September 2008
Baseline Monitoring Book 2 Work Plan Fish, Invertebrate, and Littoral Water Monitoring for 2008. Parsons, Exponent, QEA	September 2008
Microbead Marker for Monitoring Natural Recovery in SMU 8 Work Plan. Parsons, Anchor Environmental, and Environmental Tracing Systems.	September 2008
PDI: Wastebed 13 Settlement Pilot Study Monitoring Data - Year 2. Parsons.	July 2008
PDI: Phase IV Addendum 2 Cap Amendment Study Isotherm Development. Parsons.	July 2008
Underwater & Shoreline Archaeological Resources Phase 1B Work Plan. Parsons.	July 2008
PDI: Wastebed 13 Settlement Pilot Study Data Summary Report. Parsons.	June 2008

Table 3: Documents, Data and Information Reviewed in Completing the Five-Year Review	
Document Title, Author(s)	**Submittal Date**
PDI: Phase III Addendum 6 Data Summary Report. Parsons, Exponent, and Anchor Environmental.	June 2008
PDI: Phase I Wind Tunnel Testing Report revised from 3/06. Service Engineering Group.	June 2008
Air Dispersion Modeling Protocol. Parsons.	May 2008
Baseline Monitoring Book 1: Deep Basin Water & Zooplankton Monitoring Work Plan for 2008. UFI.	May 2008
Interpretive Report Evaluation of Nitrate Addition to control Methylmercury Production: 2006 Study. Syracuse University.	April 2008
PDI: Phase II & III Odorant Characterization and Analysis Summary Report. Parsons, Barr, St. Croix Sensory.	February 2008
Onondaga Lake PDI: Phase III Work Plan Addendum 6. SMU 8 Sampling to Monitor Natural Recovery. Parsons, Exponent, and Anchor Environmental.	January 2008
Evaluation of Nitrate Addition to Control Methylmercury Production Work Plan - Appendix B QAPP, Syracuse University.	January 2008
PDI: Meteorological Monitoring Program Manual. Parsons.	January 2008
SMU 8 Sediment Incubations and Supporting Studies Work Plan. Parsons.	December 2007
Preliminary Feasibility Analysis for Control of Methylmercury Production in the Lower Waters of Onondaga Lake Through Nitrate Addition. UFI.	May 2007
Work Plan for Evaluation of Nitrate Addition to Control Methylmercury Production, 2007 Study. Syracuse University and UFI.	May 2007
Explanation of Significant Differences, Onondaga Lake Bottom Subsite of the Onondaga Lake Site. NYSDEC and EPA.	December 2006
PDI: Equilibrium Study Work Plan. Parsons.	August 2006
Van den Berg, M., L.S. Birnbaum, M. Denison, et al. The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds. Toxicol Sci 93(2):223−241.	2006
Record of Decision. NYSDEC and EPA.	July 2005
Feasibility Study Report, Parsons.	November 2004

Table 3: Documents, Data and Information Reviewed in Completing the Five-Year Review	
Document Title, Author(s)	**Submittal Date**
Human Health Risk Assessment. NYSDEC/TAMS.	December 2002
Baseline Ecological Risk Assessment. NYSDEC/TAMS.	December 2002
Remedial Investigation Report. NYSDEC/TAMS.	December 2002
Sloan, R.J., M. Kane, and L. Skinner. 1999 as a Special Spatial Year for PCBs in Hudson River Fish. NYSDEC Div. of Fish, Wildlife, and Marine Resources. Albany, NY.	May 2002
Guidelines for Ecological Risk Assessment. Risk Assessment Forum, EPA/630/R-95/002F. EPA.	April 1998
Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. EPA/540/R-97/006. EPA.	June 1997
Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites (FWIA). NYSDEC Division of Fish and Wildlife.	October 1994
Onondaga Lake RI/FS Site History Report. PTI Environmental Services.	July 1992

Onondaga Lake First Five-Year Review

Attachments

Attachment 1: Figures

Attachment 2: Status Update on Upland OUs/Subsites

Attachment 3: Data Summary Tables and Figures

Onondaga Lake First Five-Year Review

Attachment 1

Figures

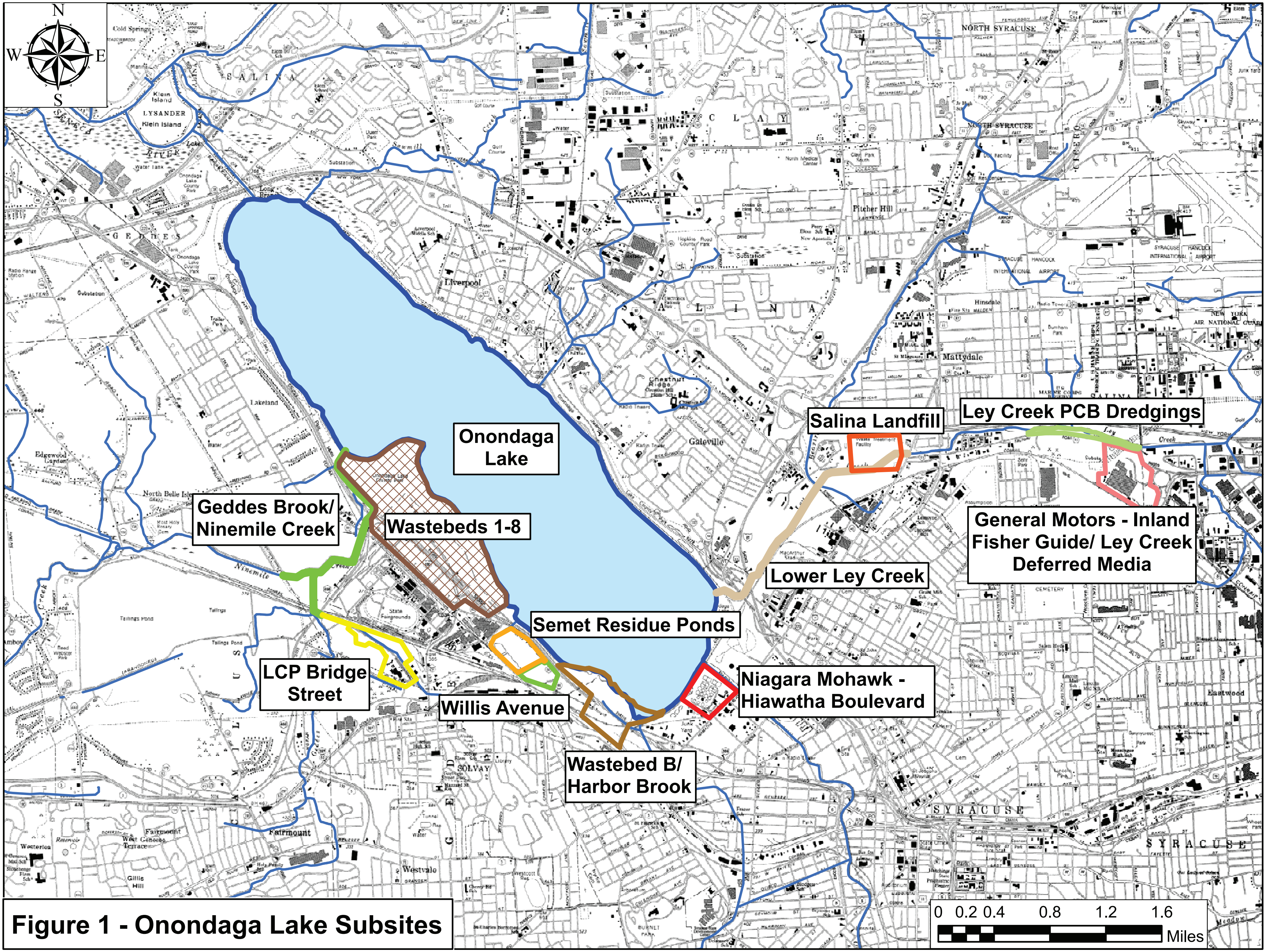


Figure 1 - Onondaga Lake Subsites

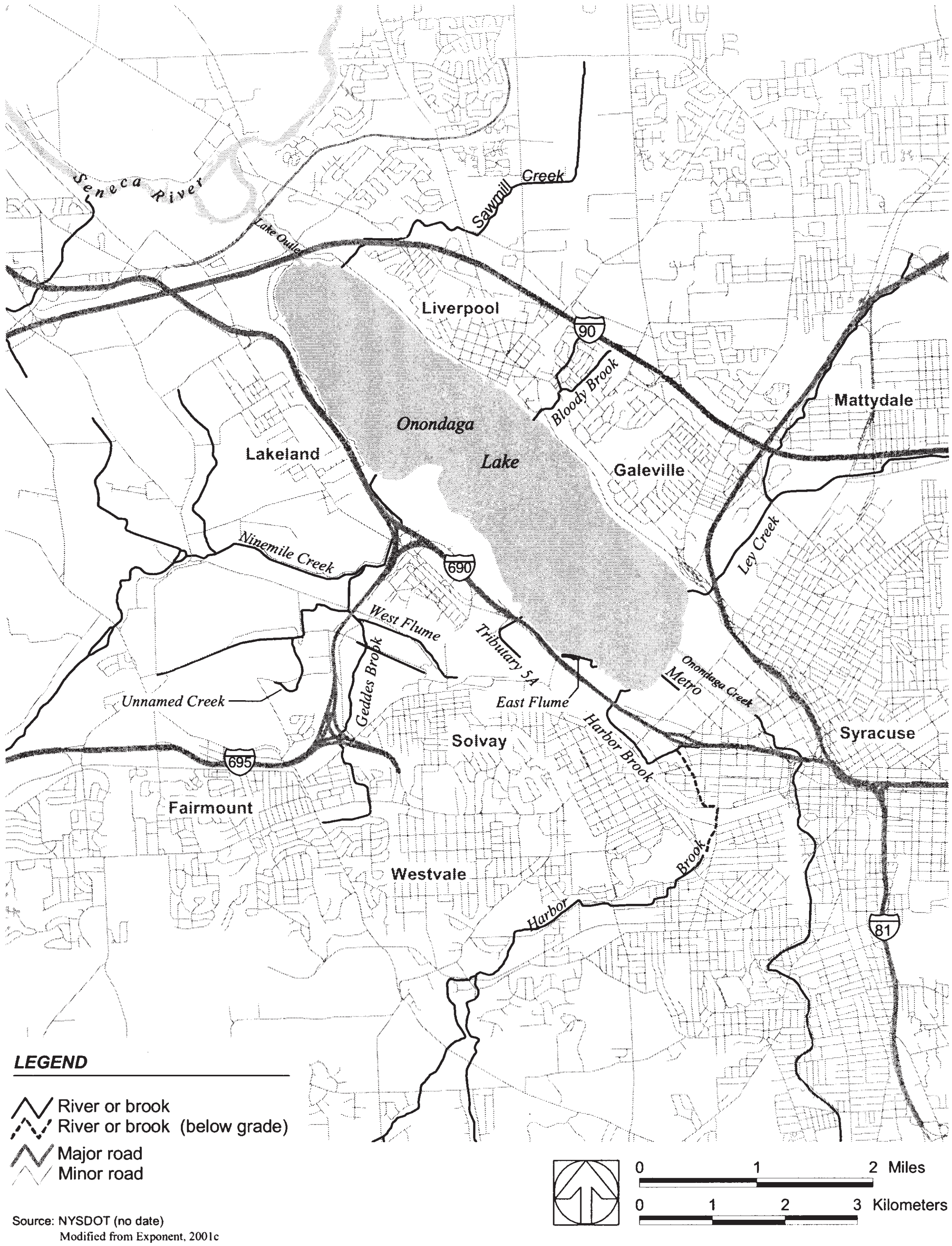


Figure 2 Onondaga Lake Area Tributaries and Roads

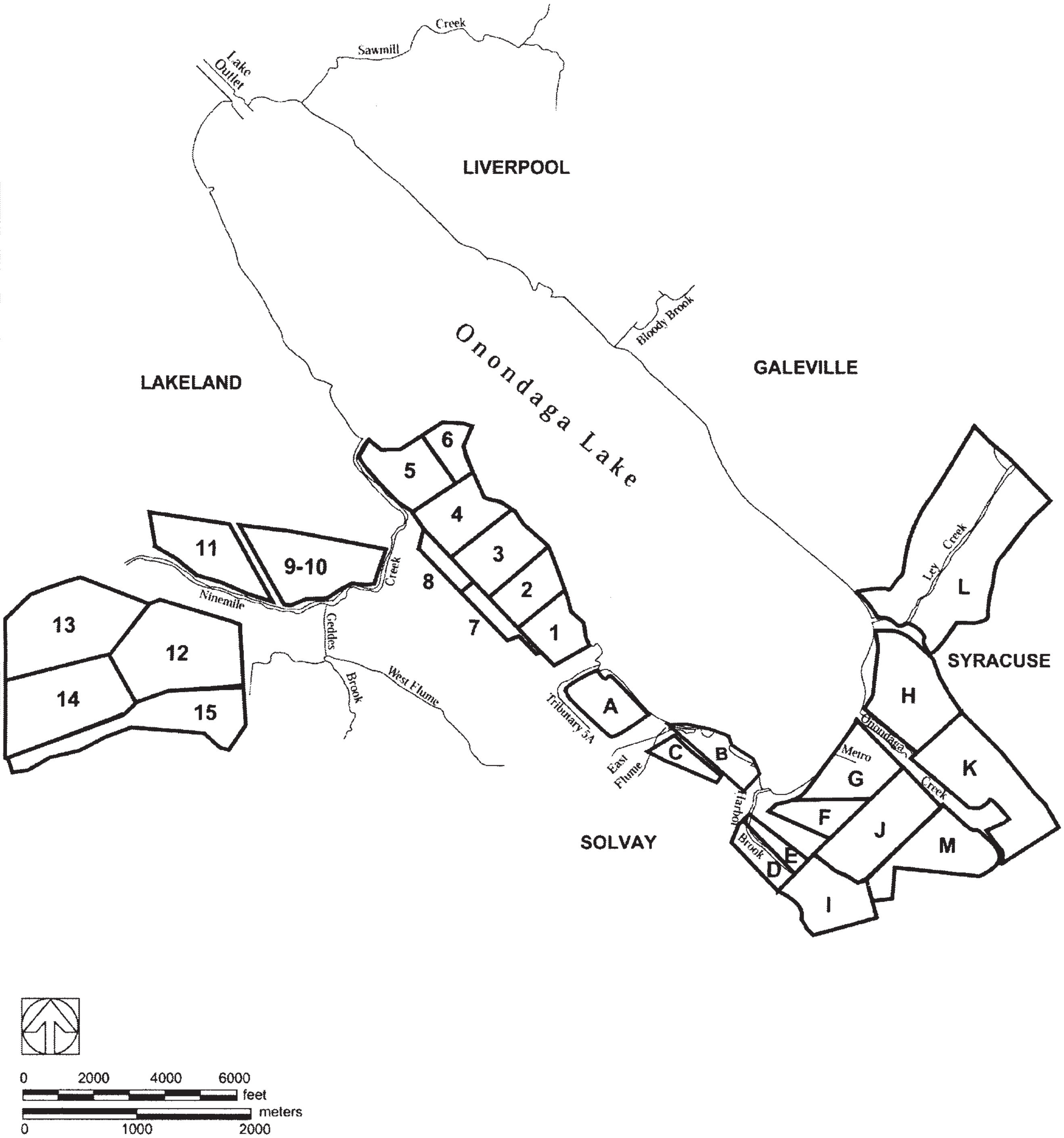
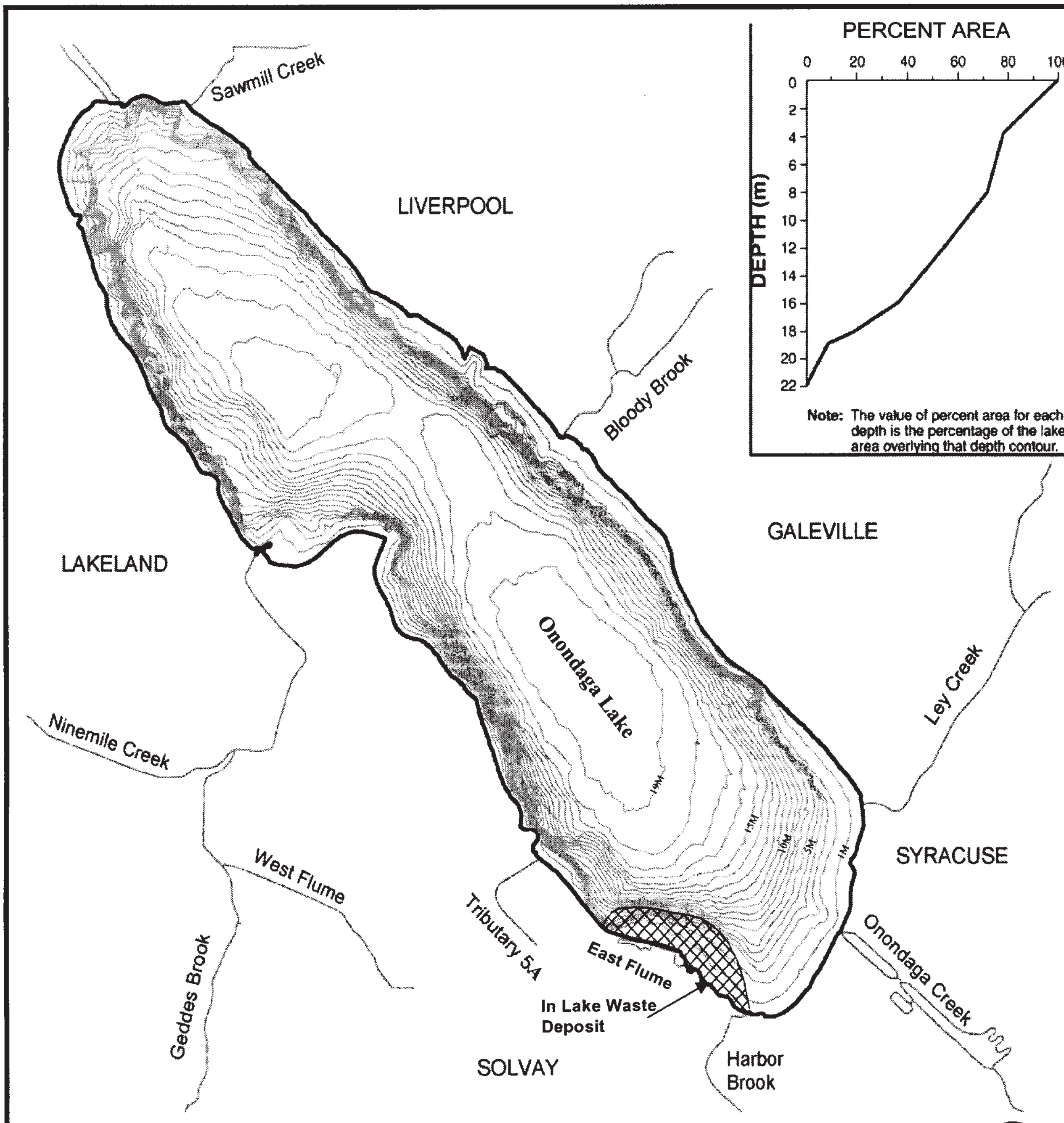


Figure 3 Historical Locations of Solvay Wastebeds



Bathymetry is in 1 meter intervals.

Water surface elevation is 363.39 Feet (110.76 Meters) above mean sea level

Figure 4

ONONDAGA LAKE
SYRACUSE, NEW YORK

Approximate Location of the In-Lake Waste Deposit

FIGURE 5

Honeywell Onondaga Lake Syracuse, New York

SMU Boundaries and Remediation Areas

PARSONS
301 PLAINFIELD RD, SUITE 350, SYRACUSE, NY 13212

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Date Revised: 2/15/2012 11:16:50 AM
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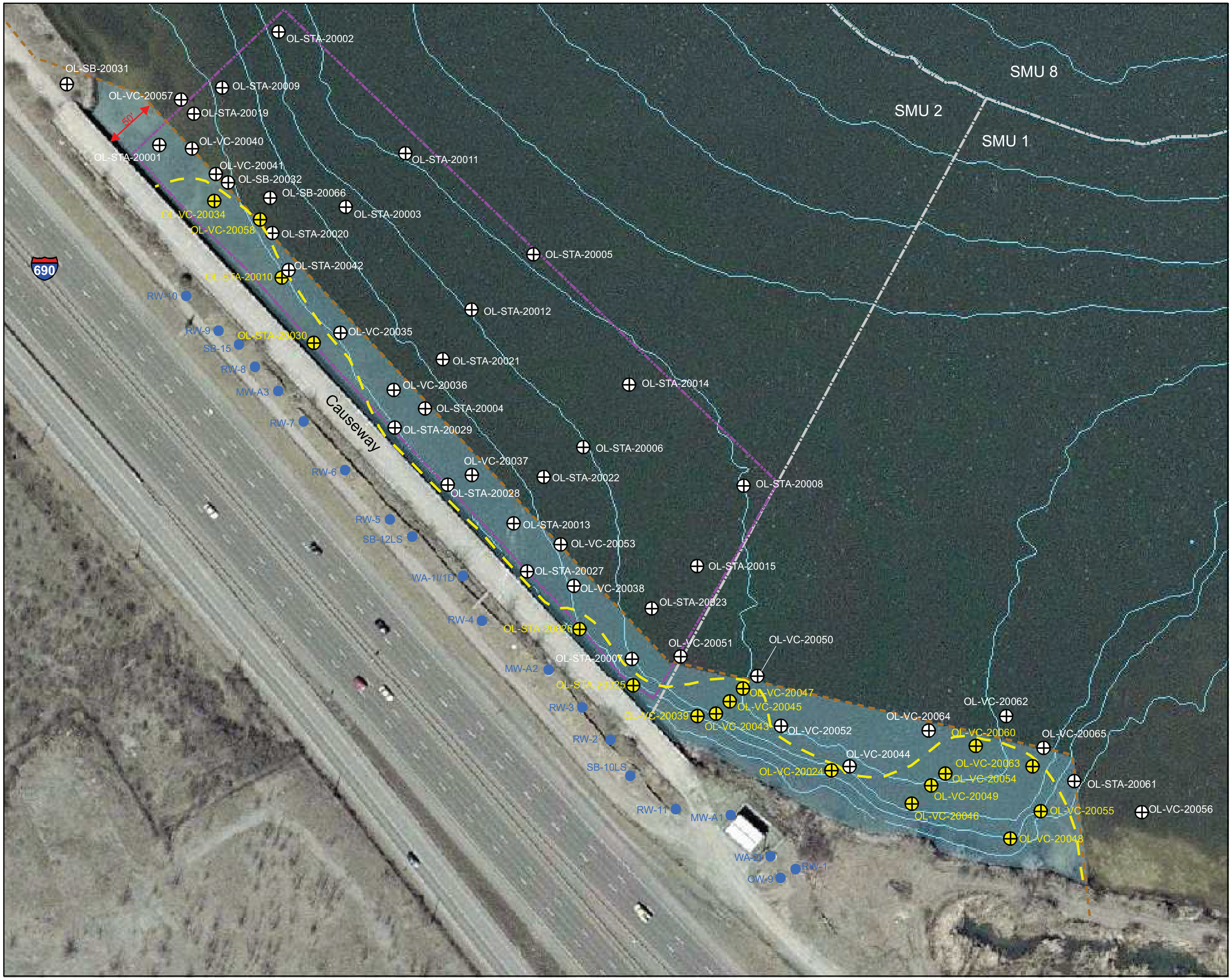

N

- Existing Onshore NAPL Recovery Well
- 2005/2006 Core does not contain pooled NAPL but may contain isolated NAPL stringers, seams and/or globules in Solvay Waste (see text in ESD)
- 2005/2006 Core Contains pooled NAPL (see text in ESD)
- Barrier Wall Alignment (Approximate)
- Extent of Pooled NAPL
- Extent of Pooled NAPL Removal Area Assumed in the FS/ROD

Notes:

1. Bathymetry is shown in 4' intervals.

90 45 0 90

Feet

FIGURE 6

Honeywell

Onondaga Lake
Syracuse, New York

Pooled NAPL Extent and Barrier Wall Alignment

PARSONS

290 ELWOOD DAVIS RD, SUITE 312, LIVERPOOL, NY 13088 Phone:(315)451-9560

Q:\GIS\GIS_Lake\dnapl_invest\pooled_napl_barr_wall_101306.mxd

FIGURE 7

Honeywell Onondaga Lake Syracuse, New York

Remediation Area E Shoreline Offset and Wave Damper

PARSONS
301 PLAINFIELD RD, SUITE 350, SYRACUSE, NY 13212

Path: Q:\GIS\GIS_Lake\CAP\MXD\2014\RemsCDE_Dredge_Cap.mxd
Date Revised: 6/20/2014 1:11:42 PM
User: 40189

FIGURE 8

Honeywell

Onondaga Lake
Syracuse, New York

Shoreline Railroad Lines

PARSONS
301 Plainfield Rd, Suite 350, Syracuse, NY, 13212, Phone 315-451-9560

Remediation Area Boundary

Offset/Buffer Area

Isolation Cap Area

SMU 8 Thin-layer Cap Area

Dredge Area

Sediment Management Unit (SMU) Boundary

Wave Damper (Approximate Location)

Willis/Semet IRM Barrier Wall

West Wall Portion of the WB-B/HB IRM

East Wall Portion of the WB-B/HB IRM

Eastern Shoreline Groundwater Collection Trench

N

New York State Digital Orthoimagery from 2009

650 325 0 650

Feet

FIGURE 9a

Honeywell Onondaga Lake Syracuse, New York

RAs C,D, and E Dredge/Cap & SMU 8 Thin-Layer Cap Areas

PARSONS

301 PLAINFIELD RD, SUITE 350, SYRACUSE, NY 13212

User: 40189

Date Revised: 6/20/2014 1:11:42 PM

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Delineated Wetland Boundaries
Remediation Area Boundary
Isolation Cap Area
Dredge Area
Sediment Management Unit (SMU) Boundary
Groundwater Collection Trench

N

New York State Digital Orthoimagery from 2009

0 295 590 1,180
Feet

FIGURE 9b

Honeywell
Onondaga Lake
Syracuse, New York

Remediation Areas A & B
Dredge and Cap Areas

PARSONS
301 PLAINFIELD RD, SUITE 350, SYRACUSE, NY 13212

Date Revised: 2/15/2012 10:12:36 AM

Path: Q:\GIS\GIS_Lake\CAP\MXD\Final_Design\RemsAB_DredgeCap.mxd

Remediation Area Boundary

Sediment Management Unit (SMU) Boundary

Delineated Wetland Boundaries

Isolation Cap Area

N

New York State Digital Orthoimagery from 2009

750 375 0 750

Feet

FIGURE 9c

Honeywell Onondaga Lake Syracuse, New York

Remediation Area F Cap Area

PARSONS

301 PLAINFIELD RD, SUITE 350, SYRACUSE, NY 13212

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User: p0013927

Date Revised: 3/1/2012 3:10:10 PM

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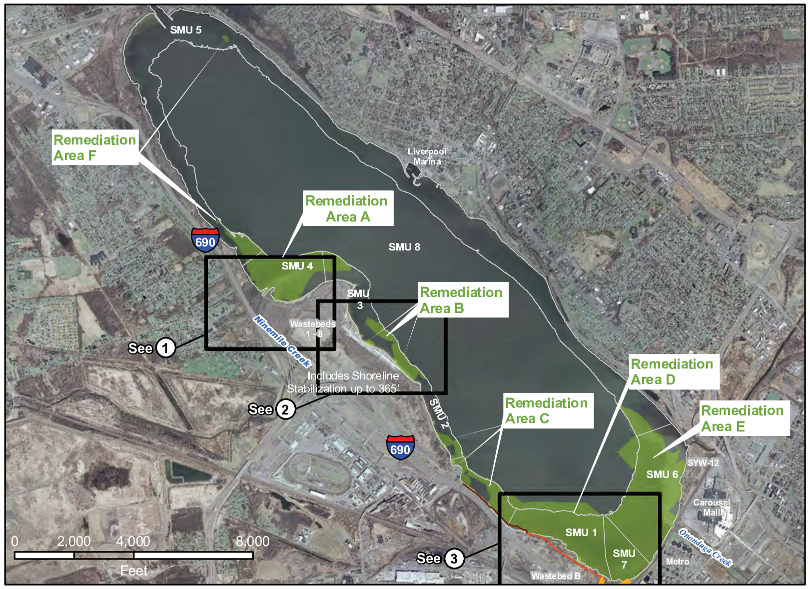
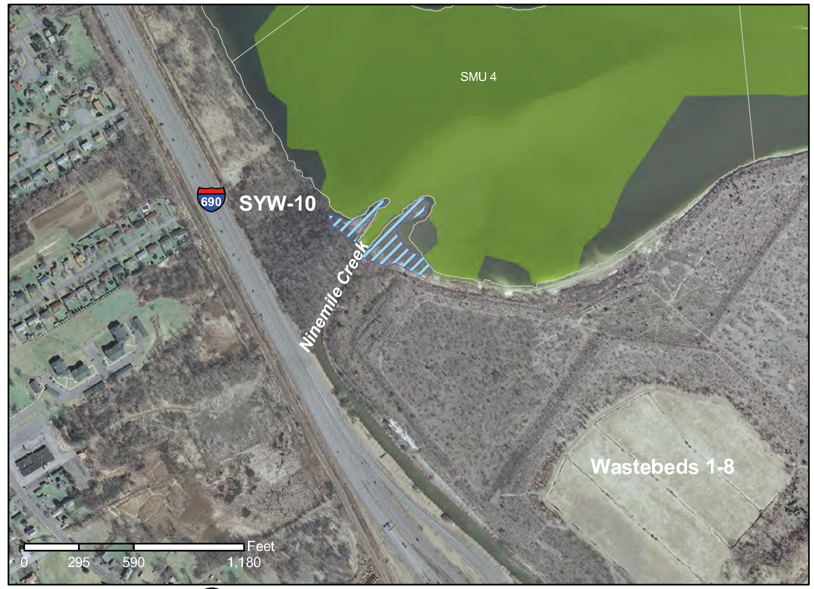


Onondaga Lake Overall Site Plan



1 Ninemile Creek Spits

2 Wastebeds 1-8 Wetlands

3 Wastebed B/ Harbor Brook Outboard Area

Sediment Management Unit (SMU) Boundary

Remediation Area (Parsons, 2010)

Wetland Areas included in the Onondaga Lake Design

Willis/Semet IRM Barrier Wall

West Wall Portion of the WB-B/HB IRM

East Wall Portion of the WB-B/HB IRM

Inland Wetlands included in WB 1-8 IRM Design

N

New York State Digital Orthoimagery from 2009

FIGURE 10

Honeywell Onondaga Lake Syracuse, New York

Adjacent Areas Included in Design

PARSONS

301 Plainfield Road, Suite 350; Syracuse, NY 13212

Path: Q:\GIS\GIS_Lake\Baseline_Monitor\MXDs\2011_NitrateInjectLocs.mxd

Date Revised: 11/12/2013 10:06:07 AM

2014 Nitrate Application Locations

Bathymetry Contours For Water Depth

10 Foot Intervals

30 Foot Water Depth Contour

0 1,200 2,400 4,800 7,200

Feet

Figure 11

Honeywell

Onondaga Lake
Syracuse, New York

2014 Nitrate Application Locations

PARSONS

301 Plainfield Road, Suite 350; Syracuse NY 13212 Phone:(315)451-9560

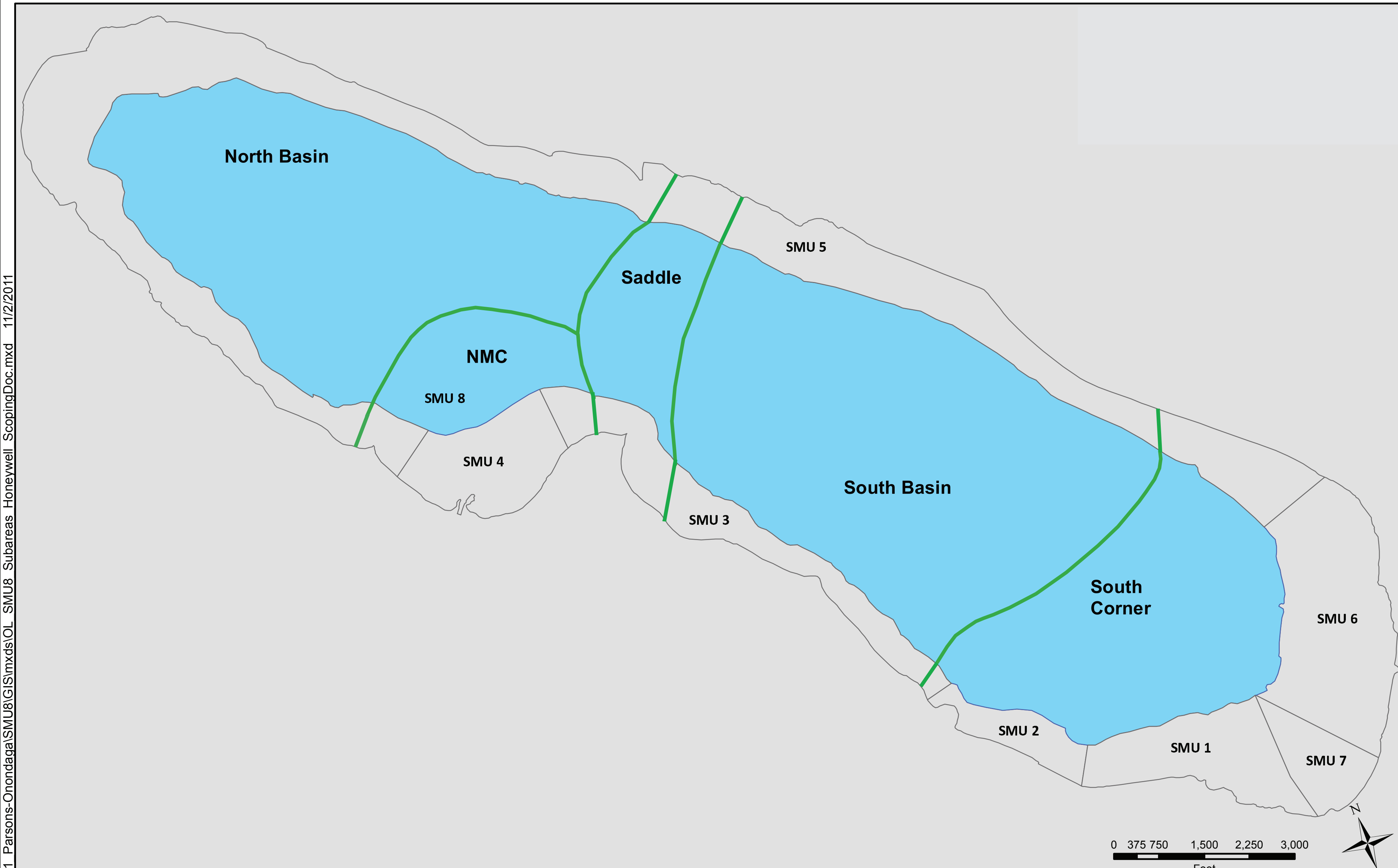


FIGURE 12

Honeywell

Onondaga Lake
Syracuse, New York

Onondaga Lake Subareas for Evaluation of BSQV Compliance

\\helios\aq\d drive\jobs\090139-01 Parsons-Onondaga\SMU8\GIS\mxds\OL_SMU8_Subareas_Honeywell_ScopingDoc.mxd 11/2/2011

Onondaga Lake First Five-Year Review

Attachment 2

Status Update of Upland Operable Units/Subsites

Onondaga Lake First Five-Year Review

Attachment 2

Status Update of Upland Operable Units/Subsites

The control of contamination migrating to Onondaga Lake from the various upland sites is an integral part of the overall cleanup of the Lake. To facilitate coordination of investigation and remedial activities between the upland sites and the Lake, the New York State Department of Environmental Conservation (NYSDEC) and the United States Environmental Protection Agency (EPA) have to date identified eleven subsites, as shown in Figure 1 of the main portion of the Five-Year Review, which comprise the Onondaga Lake National Priorities List (NPL) site. These subsites are also considered to be operable units (OUs) of the NPL site by EPA and actions at these subsites are being performed consistent with the Comprehensive Environmental Response, Compensation, and Liability Act requirements. Remedial activities at the upland subsites have been or are being performed via various means (*e.g.*, as part of the remedy selected in a ROD for the upland area, or as an interim remedial measure [IRM]). In general, these remedial activities have been or are being performed prior to the performance of remedial activities within a respective sediment management unit (SMU), or a portion of a SMU, of Onondaga Lake which may otherwise be recontaminated if the corresponding upland area was not addressed. The status of the each of the upland OUs/subsites is discussed below.

<u>Geddes Brook/Ninemile Creek Operable Unit of the Onondaga Lake Bottom Subsite</u>

Pursuant to an April 2009 decision document issued by NYSDEC and EPA, and an Order on Consent between Honeywell and NYSDEC, an IRM for the Geddes Brook portion of the site began in May 2011 and was substantially completed in February 2013. The IRM included removal of approximately 102,400 CY of contaminated sediments and floodplain soils/sediments over approximately 16 acres from Outfall 019, lower Geddes Brook and the adjacent floodplain. (See Attachment 2, Figure 1.) Contaminated sediments and soils removed from the brook and floodplain were disposed of at the LCP Bridge Street subsite containment system, which was designed and constructed pursuant to the requirements of the ROD for the LCP Bridge Street subsite.

NYSDEC/EPA Records of Decision (RODs) for two portions of the Geddes Brook/Ninemile Creek operable unit of the Onondaga Lake Bottom subsite were issued in April and October 2009. The selected remedies include the dredging/excavation and removal of an estimated 120,000 CY of contaminated channel sediments and floodplain soils/sediments in lower Ninemile Creek over approximately 30 acres. Pursuant to the RODs, remedial activities commenced in June 2012 and were substantially completed in October 2014. Contaminated sediments and soils removed from the creek and floodplain were disposed of at the LCP Bridge Street subsite containment system.

<u>LCP Bridge Street Subsite</u>

With EPA concurrence, NYSDEC issued a ROD for this subsite in 2000. Remedial construction, which commenced in 2004 and was substantially completed in 2007, included removal of contaminated sediments from the West Flume, on-site ditches, and wetlands; restoration of wetlands; installation of a low-permeability cutoff wall around this subsite; installation of an interim low-permeability cap; and capture of contaminated groundwater inside the cutoff wall. Some additional excavation work was performed at this subsite in 2011 and 2012. Remediation of the LCP Bridge Street subsite has controlled discharges of contaminants, mainly mercury, to the West Flume, some of which previously migrated to Onondaga Lake through Geddes Brook and Ninemile Creek. Maintenance and monitoring activities are ongoing. Construction of a final cap for the 20 acre subsite is underway.

Ley Creek PCB Dredgings Subsite

The Ley Creek PCB Dredgings subsite ROD was issued in 1997 and remedial construction activities were completed in 2001. The remedy included the consolidation and covering of PCB-contaminated dredge spoils along a portion of Ley Creek. Approximately 8,400 CY of PCB-contaminated material above 50 mg/kg was excavated and disposed of off-site.

Semet Residue Ponds Subsite

A ROD for the Semet Residue Ponds subsite was issued in 2002. Consistent with this ROD and pursuant to an IRM stipulated in an April 16, 2002 Order on Consent between Honeywell and New York State, construction of a 1,288 linear feet long Lakeshore barrier wall and groundwater collection system for the shallow and intermediate groundwater zones occurred from October 2006 to May 2007. Other than system shut-downs for the periods from October 2009 to December 2009, April 19, 2011 to June 1, 2011, January 2012 to April 2012, and March 3, 2014 to March 10, 2014, the Semet Lakeshore barrier wall collection system has been operating since May 2007. The hydraulic containment system is generally meeting design goals (*i.e.*, groundwater levels are below Lake level, indicating that hydraulic capture and an inward hydraulic gradient are achieved). On occasion, groundwater levels have been above Lake levels, however, these conditions occurred over short periods of time and are not indicative of overall system performance.

Consistent with the ROD and a January 2004 Order on Consent, potential groundwater impacts to an adjacent tributary, Tributary 5A, were mitigated via the operation of a groundwater collection system for shallow groundwater constructed between June 2010 and March 2013. The construction of the groundwater collection system also necessitated sediment removal and liner installation along the length of the tributary, which mitigated the potential for contaminated sediment to migrate and recontaminate the area of the Lake near the tributary. Initial groundwater collection system performance verification data demonstrate hydraulic control for Tributary 5A, therefore the potential for recontamination of the Lake from this source has been mitigated. All groundwater collected by the Semet Lakeshore and Tributary 5A systems, and by the groundwater collection systems discussed below for the Willis Avenue and Wastebed B/Harbor Brook subsites is conveyed to the nearby Willis Avenue Groundwater Treatment facility where it is treated prior to discharge.

Honeywell, NYSDEC and EPA are currently evaluating a potential modification to the portion of the remedy that addresses the pond residue material which is the principal source of contaminated groundwater at the Semet Residue Ponds Subsite.

Willis Avenue Subsite

Pursuant to an IRM stipulated in an April 16, 2002 Order on Consent between Honeywell and New York State, construction of 1,612 linear feet of barrier wall and groundwater collection system for the shallow and intermediate groundwater zones occurred from August 2008 to November 2009. Subsequent to this work and initiation of operation of the collection system, a tie-back anchorage system to mitigate deflection of the barrier wall in areas with deep water present outboard of the wall was constructed. This work was completed in May 2012. Other than system shut-downs for the periods from April 19, 2011 to June 1, 2011, December 2011 to April 2012, and March 3, 2014 to March 10, 2014, the Willis Lakeshore barrier wall collection system has been operating since November 2009. The hydraulic containment system is generally meeting design goals (*i.e.*, groundwater levels are below Lake level, indicating that hydraulic capture and an inward hydraulic gradient are being achieved). On occasion, groundwater levels have been above Lake levels, however, these conditions occurred over short periods of time and are not indicative of overall system performance.

Under this IRM, remediation was also undertaken to address groundwater influences to the eastern and western storm drain systems downgradient of the Willis Avenue and Semet Ponds Subsites. To date, four phases have been completed that have mitigated potential impacts to Onondaga Lake.

An IRM was also implemented to address chlorinated benzene non-aqueous-phase liquid (NAPL) contamination along the Lakeshore. The system was initiated in 1993 and expanded to include additional collection wells in 1995 and 2002. The modifications performed in 2002 were conducted pursuant to an IRM Consent Order between Honeywell and NYSDEC. In 2012, the system was again expanded and the entire system was further upgraded and optimized. To date, over 58,000 gallons of NAPL have been recovered and transported off-site for disposal/ incineration.

A remedial investigation/feasibility study (RI/FS) is underway for the Willis Avenue Subsite.

Wastebed B/Harbor Brook Subsite

Pursuant to an IRM stipulated in a December 2003 Order on Consent between Honeywell and New York State, construction activities associated with a 4,678 linear foot Lakeshore barrier wall and groundwater collection system along the Lake shoreline perimeter of Wastebed B and upstream along the west bank of Harbor Brook, realignment of the lower reach Harbor Brook, and replacement of a culvert for Lower Harbor Brook were conducted from December 2009 to March 2012. The Wastebed B/Harbor Brook Lakeshore barrier wall collection system has been operating since April 2012. The hydraulic containment system is generally meeting design goals (*i.e.*, groundwater levels are below Lake level, indicating that hydraulic capture and an inward hydraulic gradient are achieved). On occasion, groundwater levels have been above Lake levels, however, these conditions occurred over short periods of time and are not indicative of overall system performance.

Potential groundwater impacts to Upper Harbor Brook were mitigated via the operation of a groundwater collection system for shallow groundwater constructed in 2012 through 2013. This work also included sediment removal, isolation layer installation, sealing of leaks in the culverts, and ditch/stream/wetland restoration. Consistent with design goals, groundwater elevations in the Upper Harbor Brook collection trenches have been maintained generally below the surface water elevation in Harbor Brook since January 2014.

Consistent with a March 2012 decision document issued by NYSDEC and EPA and an Order on Consent between Honeywell and New York State, an IRM for a 16-acre strip of land that lies in the outboard area between Wastebed B/Harbor Brook Lakeshore barrier walls and Onondaga Lake (including the mouth of Harbor Brook and areas of wetlands along the shoreline) commenced in 2013. (See Attachment 2, Figure 2.) The Outboard Area IRM includes excavation and/or dredging of approximately 200,000 CY of contaminated soil and sediment located between the Wastebed B/Harbor Brook barrier walls and Onondaga Lake. With the completion of the soil/sediment removal, an isolation cap is being installed to physically isolate the contaminated soil/sediment from the environment. The Outboard Area will be restored and enhanced as a wetland habitat which will include a pike spawning wetland in a portion of the Outboard Area in the vicinity of the mouth of Harbor Brook.

Discharges of storm water from upstream areas to the East Flume via conveyance and sewer pipes have been addressed under an IRM pursuant to an April 2002 Order on Consent between Honeywell and NYSDEC. The Upper East Flume was filled in during the installation of the work platform, Lakeshore barrier wall, and groundwater collection system. The Lower East Flume was addressed under the Outboard Area IRM.

An RI/FS is underway for the Wastebed B/Harbor Brook Subsite.

Town of Salina Landfill Subsite

The Town of Salina Landfill Subsite ROD was issued in 2007. The ROD remedy included consolidation and capping of the landfill, with leachate collection and treatment. In September 2010, NYSDEC and EPA executed a ROD amendment for the excavation and consolidation of municipal waste from the five-acre landfill area into the 50-acre main landfill north of Ley Creek prior to capping. Construction of all of the components of the remedy was completed in 2015.

Niagara Mohawk-Hiawatha Boulevard-Syracuse Former Manufactured Gas Plant (MGP) Subsite

Under an IRM which was conducted in 2001 and 2002 to support the construction of an ammonia removal/phase 2 phosphorus treatment facility associated with the Metropolitan Syracuse Wastewater Treatment Plant, approximately 73,000 CY of impacted soil in the construction zone were removed and disposed of at permitted solid waste facilities. Soils were excavated to a depth of approximately 15 feet throughout the footprint and to a depth of approximately 20 feet in an area where stained soils and NAPL lenses and globules were observed in deeper soil samples.

A ROD for the Niagara Mohawk – Hiawatha Boulevard – Syracuse Former MGP subsite was issued in March 2010. The selected remedy calls for contaminated soil in the northeastern portion of the subsite that could leach contaminants to groundwater to be solidified in place and groundwater along the northern perimeter of the subsite to be treated using enhanced bioremediation. The in-situ soil solidification portion of the remedy was completed in October 2012. A pilot study and remedial design for enhanced bioremediation of groundwater are underway.

Wastebeds 1-8 Subsite

Pursuant to a July 2011 decision document issued by NYSDEC and EPA and an Order on Consent between Honeywell and NYSDEC, an IRM commenced in 2011 and is anticipated to be completed in summer 2015. The IRM includes the collection and treatment of groundwater and seeps along Ninemile Creek and the shoreline of Onondaga Lake, the placement of a vegetative cover over a 14.4-acre area along the eastern Lakeshore, sediment removal from the lower reach of Ditch A, a surface water drainage ditch, rehabilitation of water conveyance pipes at the upper reach of Ditch A, and stabilization of the Lakeshore soils. In addition to the remedial elements of the IRM, mitigation wetlands, a hydraulic groundwater control system along the Wastebeds 1-8 northern shoreline, and restoration and cleaning in the middle reach of Ditch A were incorporated into the IRM design. The IRM actions will prevent the continued migration of contaminants into Ninemile Creek and Onondaga Lake and reduce groundwater upwelling velocities that may impact the isolation cap being placed in SMU 4 (See Attachment 2, Figure 3.)

A ROD which addresses the OU1 portion of the Wastebeds 1-8 Subsite, and which includes Solvay waste and contaminated soil/fill materials, was issued in December 2014. A FS for the OU2 portion of the Wastebeds 1-8 subsite, which will consider additional measures to address contaminated groundwater and impacted media in Ditch A, is underway.

General Motors – Inland Fisher Guide Subsite

The General Motors (GM)-Inland Fisher Guide subsite includes two operable units. OU1 of this subsite is the former General Motors – Inland Fisher Guide Syracuse Plant property that is located south of Ley Creek on Town Line Road in the Town of Salina. An RI/FS is underway for OU1.

Between 2002 and 2004, three large-scale IRMs were performed at OU1 pursuant to Orders on Consent between GM and the State of New York to mitigate contaminant migration from the subsite to Ley Creek. Under the Former Landfill IRM, hot spots in an on-site industrial landfill that contains chromium- and PCB-contaminated material were excavated and the landfill was capped to prevent contaminants from leaching into the groundwater. A second IRM, the Former Drainage Swale IRM, involved the removal of highly-contaminated soil from a former discharge swale which was used in the 1950s and 1960s as a conduit for the discharge of liquid process waste to Ley Creek. The swale was subsequently filled in, but the contaminated soil remained until the performance of this IRM. Over 26,000 tons of soils containing hazardous waste levels of PCBs were removed as part of the IRM. The third IRM, the State Pollutant Discharge Elimination System (SPDES) Treatment System IRM, included the construction of a retention pond and associated water treatment system. This pond collects all water that accumulates on the GM-Inland Fisher Guide property in any of the storm sewers or abandoned process sewers. The pond water is then sent through the treatment plant in order to meet permitted discharge limits, prior to discharge to Ley Creek. The purpose of this IRM was to stop the intermittent discharge of PCBs and other contaminants that occur during storm events.

OU2 of this subsite includes Ley Creek channel sediments; surface water; and floodplain soils/sediments in the reach from Townline Road to the Route 11 Bridge. OU2 also includes an adjacent wetland and roadway shoulders near the facility and on the northern side of Factory Avenue in the vicinity of LeMoyne Avenue. A remedy for OU2, which includes excavating approximately 25,000 CY of PCB-contaminated sediment and soil from impacted media, was documented in a ROD issued in March 2015.

Lower Ley Creek Subsite

The Lower Ley Creek subsite consists of the sediments and floodplain soils along the lower two-miles of Ley Creek beginning at and including the Route 11 bridge and ending downstream at Onondaga Lake, as well as the sediments and floodplain soils associated with the "Old Ley Creek Channel". A ROD for this subsite was issued in September 2014. The selected remedy includes excavation and capping of contaminated soil and excavation of contaminated sediment in Lower Ley Creek and disposal of the excavated soil and sediment.

Coordination of Remediation of Upland Subsites with Implementation of the Lake Bottom Subsite Remedy

As noted above, remedial activities at the upland subsites have been or are being performed prior to the performance of remedial activities within a respective SMU, or a portion of a SMU, of Onondaga Lake which may otherwise be recontaminated if the corresponding upland area was not addressed. The coordination between remediation at the upland subsites and the Lake is further discussed below.

Remedial activities associated with the Semet, Willis, Wastebed B/Harbor Brook hydraulic control systems; LCP Bridge Street; Geddes Brook; and Ninemile Creek were sufficiently completed prior to cap placement in areas of the Lake downstream of the subsites and/or adjacent to areas undergoing hydraulic control of groundwater, consistent with NYSDEC-approved designs, such that the potential for recontamination of the Lake from these sources has been mitigated. Initial groundwater collection system performance verification data demonstrate hydraulic control for Tributary 5A, therefore the potential for recontamination of the Lake from this source has been mitigated. Groundwater elevations in the collection trenches along upper Harbor Brook have been maintained below the surface water elevation in the adjacent open water area. Therefore the potential for recontamination of the Lake from this source has been mitigated.

Cap placement adjacent to Wastebeds 1-8 is underway in areas where hydraulic control of shallow and intermediate groundwater is being achieved. Final cap placement in other areas adjacent to Wastebeds 1-8 will not be initiated until potential source areas have been sufficiently addressed to prevent recontamination of capped areas.

The principal COCs for Ley Creek are PCBs. External sources of PCBs to the Lake via Ley Creek have decreased substantially as a result of the institution of environmental controls, the closure of facilities, and subsequent remedial activities so that there are currently no significant impacts to Lake sediments due to current loads from Ley Creek. This is supported by total PCB and TSS data from Ley Creek storm-event samples which suggest that PCBs from Ley Creek might produce sediments with concentrations of, at most, 80 to 160 micrograms per kilogram (μg/kg) as a reasonable maximum concentration in depositional areas of the Lake. This estimate is consistent with detected PCB concentrations in profundal surficial sediment samples collected in 2010 off of SMU 6 which indicate PCB concentrations below the total PCBs PEC of 295 μg/kg (which is the cap effectiveness criterion for PCBs). Operational controls and monitoring to be conducted during the remediation of Lower Ley Creek would be expected to prevent any increase in the loading to the Lake during the dredging/excavation of creek sediments and soils. Consequently, the potential for recontamination of the Lake from Ley Creek, and the subsites which have impacted the Creek, has been mitigated.

Potential migration of site-related contaminants (*e.g.*, BTEX, naphthalene) from the Niagara Mohawk Hiawatha Boulevard Former MGP facility has been reduced as a result of the in-situ soil solidification portion of the remedy which was implemented and completed in October 2012. BTEX concentrations in about half of the groundwater monitoring wells where one or more BTEX compounds were identified at levels above standards were generally less in 2013 groundwater samples than for samples collected from the same wells during the previous sampling events. BTEX concentrations in the remaining wells appear to be generally consistent with concentrations identified in the same wells during the previous sampling events. Naphthalene concentrations in 2013 groundwater samples are generally consistent with or less than the concentrations identified in the same wells during the previous sampling events. Three on-site monitoring wells closest to

Onondaga Lake do not show impacts from select MGP-related contaminants (*i.e.*, BTEX, naphthalene). While some of the wells with elevated levels of the select MGP-related contaminants are near the Barge Canal, sediment samples collected in 2009 from the section of the Canal adjacent to and downstream of the former MGP facility were non-detect for BTEX. Naphthalene was non-detect in the sediment sample located adjacent to the former MGP facility and detected at low-levels downstream of the facility. The detection limits for BTEX and napthalene and the detected levels of naphthalene in the downstream samples were significantly below cap performance criteria for BTEX and naphthalene established for the Lake Bottom Subsite. The adjacent and downstream sediment sample results for BTEX and naphthalene were also generally consistent with the upstream results in Barge Canal sediment. Based on the above, the migration of contaminants from the former MGP facility has been mitigated and would not be expected to result in the recontamination of capped areas in the Lake.

Onondaga Lake First-Five Year Review

Attachment 2

Figures

Figure 1

Honeywell — Ninemile Creek, Syracuse, New York

Geddes Brook IRM Area

PARSONS

290 Elwood Davis Rd, Suite 312, Liverpool, NY 13088, Phone 315-451-9560


SMU 1
SMU 6
SMU 7
Outboard Area
Wastebed B
690
Lower Harbor Brook
Upper Harbor Brook
Willis/Semet IRM Barrier Wall
West Wall Portion of the WBB/HB IRM
East Wall Portion of the WBB/HB IRM
Sediment Management Unit (SMU) Boundary
Wastebed B/Harbor Brook Site Boundary
Note: The East Flume has subsequently been filled in to elevation 365 (NAVD 88).
N
400
200
0
400
Feet
FIGURE 2
Honeywell
Onondaga Lake Syracuse, New York
Wastebed B/Harbor Brook Site and Outboard Area
PARSONS
301 Plainfield Road, Suite 350; Syracuse, NY 13212 Phone:(315)451-9560
Date Revised: 5/19/2011 4:34:50 PM
Path: Q:\GIS\GIS_Lake\WBB_HB\MXDs\EECA\WBB-HB_Site.mxd

FIGURE 3

N

LEGEND

- SEEP COLLECTION TRENCH
- GROUNDWATER COLLECTION TRENCH
- DITCH A IRM
- ACCESS PATHWAYS
- REVETMENT
- SEEP APRON
- VEGETATIVE COVER / RESTORED AREA / SHORELINE STABILIZATION / WET SWALE
- MITIGATION WETLAND
- BIOSOLIDS AREA
- WASTEBEDS 1-8 SITE

HONEYWELL INTERNATIONAL INC.
OU-1 FEASIBILITY STUDY
WASTEBEDS 1- 8
GEDDES, NEW YORK

INTEGRATED IRM COMPONENTS

0 350 700 1,400
Feet

SEPTEMBER 2014
1163.45176

O'BRIEN & GERE

Onondaga Lake First-Five Year Review

Attachment 3

Data Summary Tables and Figures

Onondaga Lake First Five-Year Review

Attachment 3a

Surface Water/Mercury Methylation in Hypolimnion Summary Tables and Figures

TABLE SW-1

DISSOLVED MERCURY CONCENTRATION MEASURED SINCE 2008 IN WATER FROM THE SOUTH DEEP AREA OF ONONDAGA LAKE

Year	South Deep Location					
	2-meter water depth			14 or 16-meter water depth		
	Number of Samples Exceeding 0.7 ng/L	Maximum Detected Concentrations, ng/L	Sample Collection Period	Number of Samples Exceeding 0.7 ng/L	Maximum Detected Concentrations, ng/L	Sample Collection Period
2008	7 of 27	1.35	April-November	No samples collected	No samples collected	No samples collected
2009	1 of 17	1.20	April-November	No samples collected	No samples collected	No samples collected
2010	6 of 17	1.07	May-November	No samples collected	No samples collected	No samples collected
2011	3 of 19	0.88	May–November	No samples collected	No samples collected	No samples collected
2012	2 of 11	1.4	June–November	0 of 3 (14-meter depth water)	0.36J	September–October
2013	7 of 13	2.0	May–October	0 of 4 (14-meter depth water)	0.26J	September - October
2014	3 of 10	0.98	May–October	0 of 4 (16-meter water depth)	0.62	September - October

Notes: 2.6 nanograms per liter (ng/L) is the State of New York Surface Water Quality Standard for dissolved mercury based on protection of wildlife.
0.7 ng/L is the lowest State of New York Surface Water Quality Standard for dissolved mercury based on human consumption of fish.
J – Estimated value

Table SW-2: Hg and MeHg Levels in Zooplankton - Years 1992, 2008, and 2014

Year	THg in Zooplankton (mg/kg ww)	MeHg in Zooplankton (mg/kg ww)
1992	0.023 – 0.247	0.021 – 0.184
2008	0.016 – 0.076	ND – 0.028
2014	ND – 0.068	ND – 0.011

Notes: 1992 Results based on zooplankton assemblages. Concentrations of THg and MeHg in daphnia in 1992 ranged up to 0.994 mg/kg ww and 0.390 mg/kg ww, respectively (as per the BERA).

ND = non detect

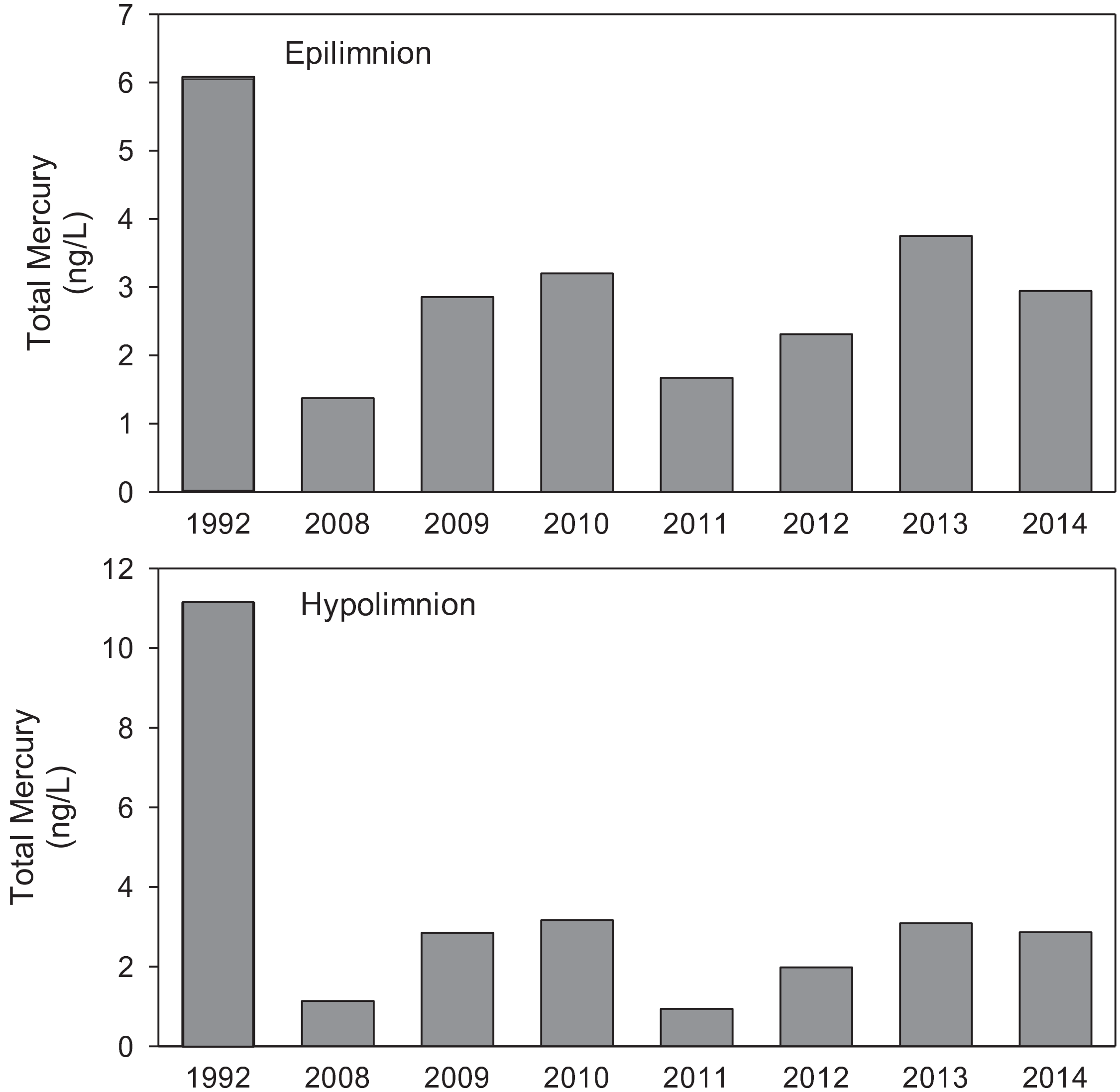


Figure SW-1

1992-2014 Annual Average Volume-Weighted Concentrations of Total Mercury in the Epilimnion and Hypolimnion of Onondaga Lake

Note: Although data were collected in 1999, annual average concentrations are not shown for 1999 as samples were only collected during the fall turnover period (see Figure SW-2).

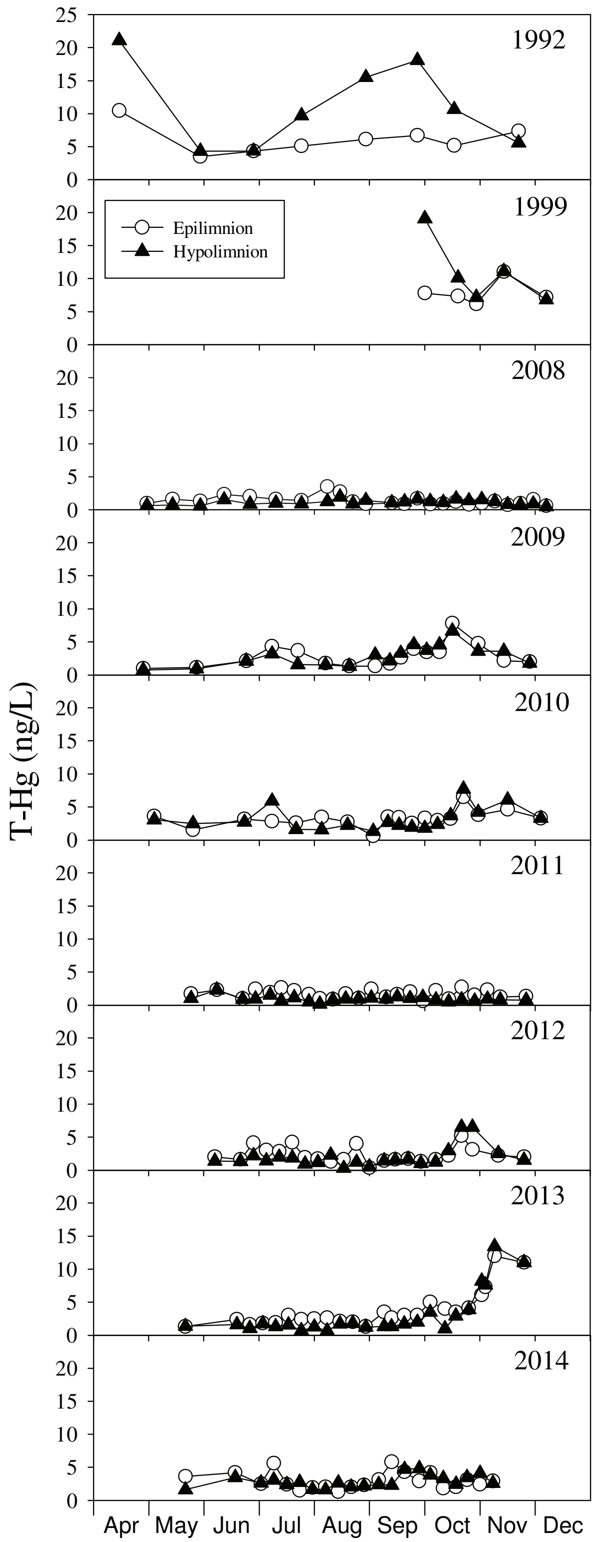


Figure SW-2 1992-2014 Volume-Weighted Concentrations of Total Mercury from the Epilimnion and Hypolimnion of Onondaga Lake.

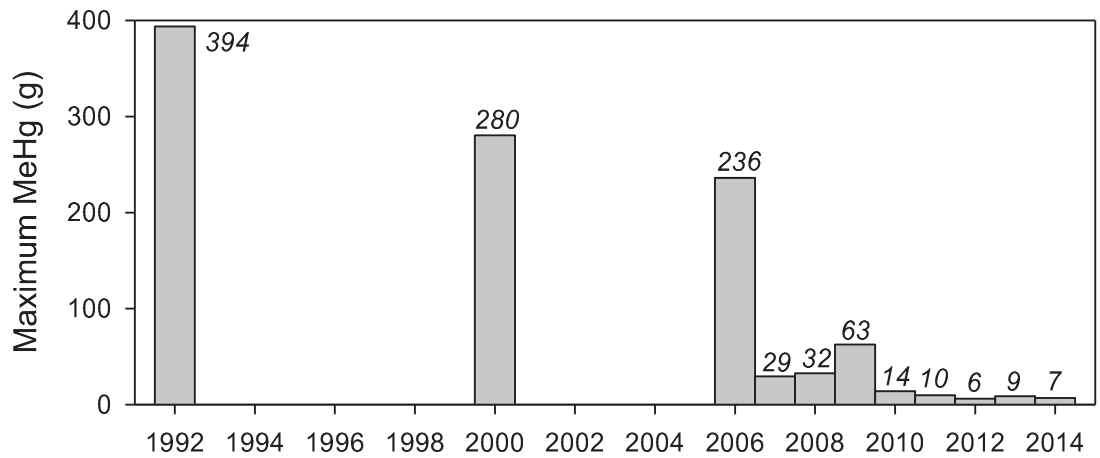
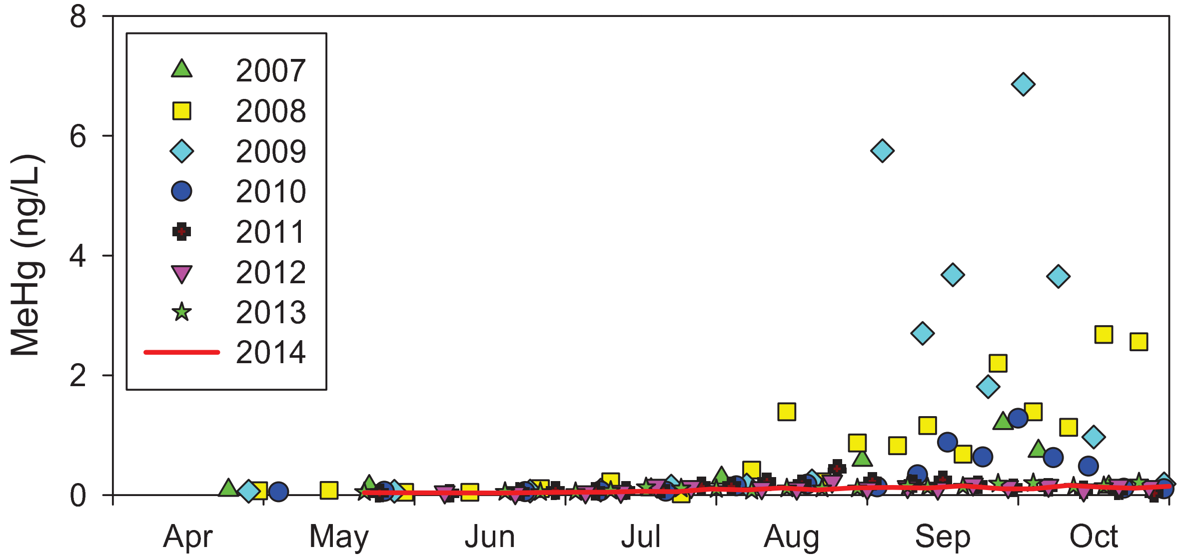


Figure SW-3

Annual Maximum Mass (in grams - g) of Methylmercury (MeHg) in the Hypolimnion (10 to 19-meter water depth) of Onondaga Lake from 1992 through 2014.



ng/L – nanograms per liter

Figure SW-4

2007-2014 Time Series of Methylmercury (MeHg) Concentrations for the 18-Meter Water Depth at the South Deep Location

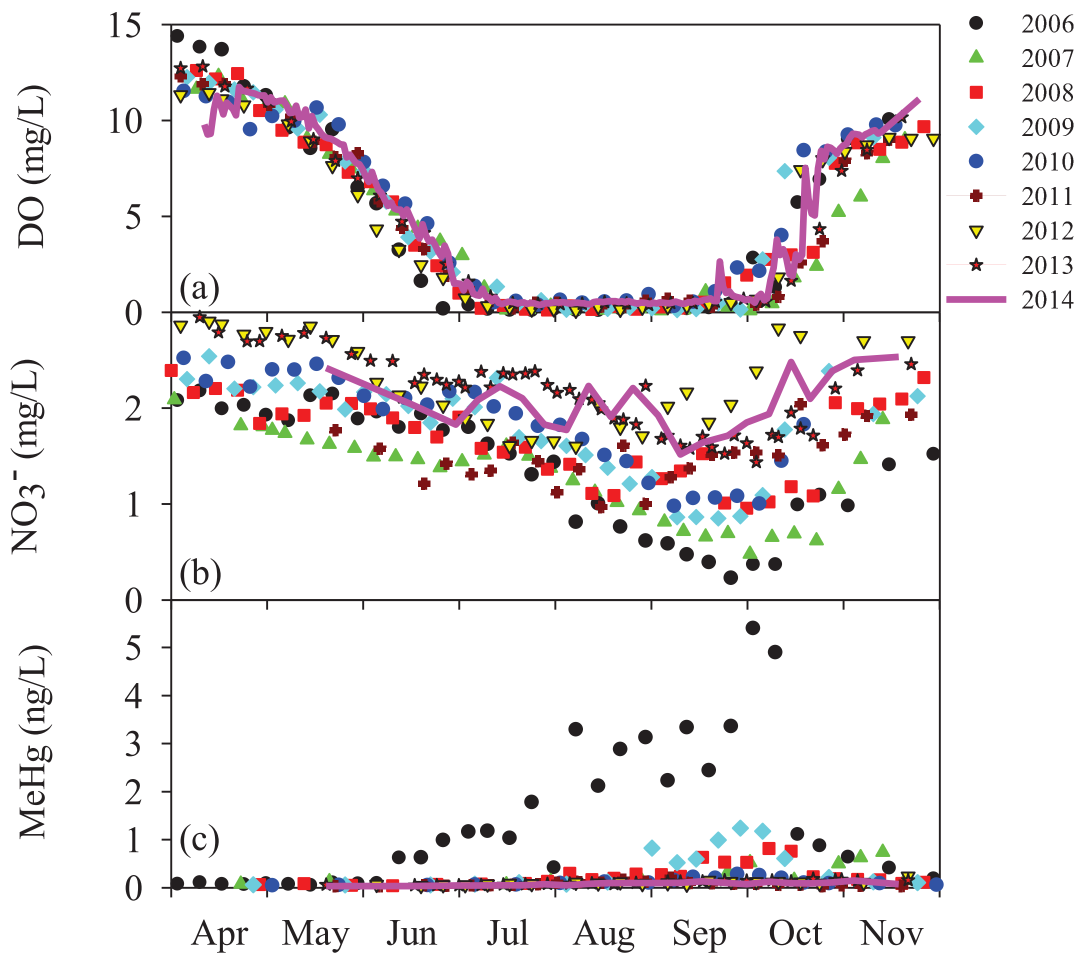


Figure SW-5

2006-2014 Volume-Weighted Concentrations of (a) Dissolved Oxygen (DO), (b) Nitrate ($NO3^-$), and (c) Methylmercury (MeHg) in the Hypolimnion of Onondaga Lake (10-19 meter water depths)

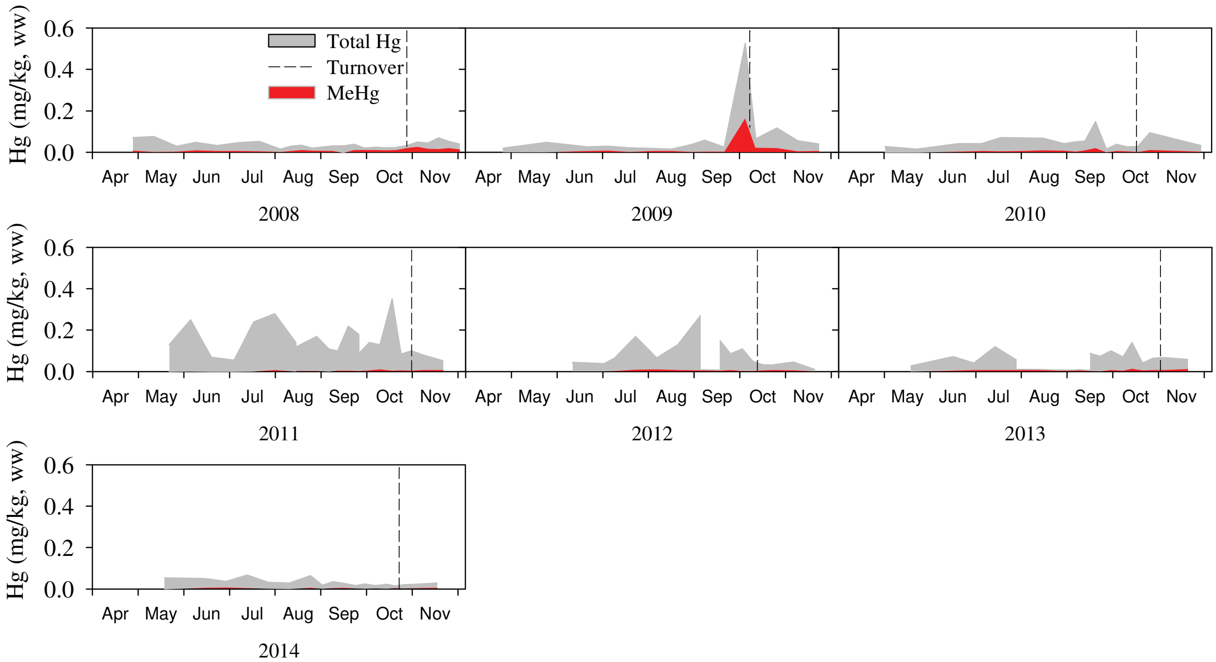


Figure SW-6

Total Mercury and Methylmercury Concentrations from 2008 through 2014 in Zooplankton from Onondaga Lake

Notes: Total mercury results are presented in gray shading, and methylmercury results are presented in red shading.

Units for total mercury and methylmercury are milligrams per kilogram on a wet-weight basis (ww).

Dashed vertical lines denote the fall turnover date in the lake. Zooplankton samples were collected at the South Deep location.

Onondaga Lake First Five-Year Review

Attachment 3b

Natural Recovery Data Summary Tables and Figures

TABLE SED-1

COMPARISON OF PREDICTED AND ACTUAL 2014 SMU 8 SURFACE (0 to 4 cm) SEDIMENT MERCURY CONCENTRATIONS

Location ID (North to South)	Predicted (Modeled) 2014 Sediment Concentration	Actual 2014 Sediment Concentration
North Basin		
OL-STA-80068	0.9 – 0.95	0.71
OL-STA-80069	1.1 – 1.2	0.71
OL-VC-80157	1.15 – 1.25	0.66
Ninemile Creek Outlet Area		
OL-STA-80073	1.3 – 1.35	0.87
Saddle		
OL-STA-80103	1.4	0.96
OL-STA-80075	1.5 – 1.6	0.69
South Basin		
OL-STA-80076	1.45	0.93
OL-STA-80078	1.45 – 1.55	1.0
OL-STA-80080	1.4 – 1.5	0.80
OL-STA-80082	1.5 – 1.6	0.94
OL-STA-80084	1.6 – 1.7	1.15
South Corner		
OL-STA-80085	1.9	1.26
OL- VC-80172	1.6 – 1.7	1.2
OL-STA-80088	2.0 – 2.1	1.2
OL- VC-80177	1.7 – 1.8	1.25

NOTES:

1. Sediment concentrations are in milligrams per kilogram (parts per million) and are averages of data from the 0 to 2 cm and 2 to 4 cm intervals.

2. The MNR model in the design simulates surface sediment mercury concentrations at specific SMU8 locations.

3. Predicted concentration ranges are based on the MNR model applied in the design for two different sedimentation rates and a four-centimeter mixing depth.

TABLE SED-2

2014 WEIGHTED-AVERAGE SURFACE SEDIMENT MERCURY CONCENTRATIONS

Portion of SMU 8	Reduction of Profundal Surface Sediment Mercury Concentration Since Design (based on 2014 results)	2014 (Existing) Profundal Zone Surface-Weighted Average Mercury Concentration (Updated from Table N.1 based on reductions presented in Column 2)	Profundal Zone Surface Area, acres	Littoral Zone Weighted Average Mercury Concentration Following Dredging and Capping (from Design, Table N.1)	Littoral Zone Surface Area, acres	Total Weighted Average for the Profundal Zone (Existing) and the Littoral Zone Following Dredging and Capping
North Basin	29%	0.76	626	0.86	245	0.79
Ninemile Creek Outlet Area	30%	1.27	113	0.24	109	0.77
Saddle	43%	0.82	162	0.44	77	0.70
South Basin	24%	2.32	658	0.41	173	1.92
South Corner	30%	1.51	402	0.12	389	0.83

NOTES:

1. Sediment concentrations are in milligrams per kilogram (mg/kg or parts per million).

2. Percent reductions in Column 2 are based on a ratio of results from 2014 to results at the same location from the most recent sampling event prior to completion of the final design for those locations where predictions of natural recovery were included in the final design. A total of 13 locations (from the 15 locations presented in Table SED-1) were included in this analysis.

TABLE SED-3

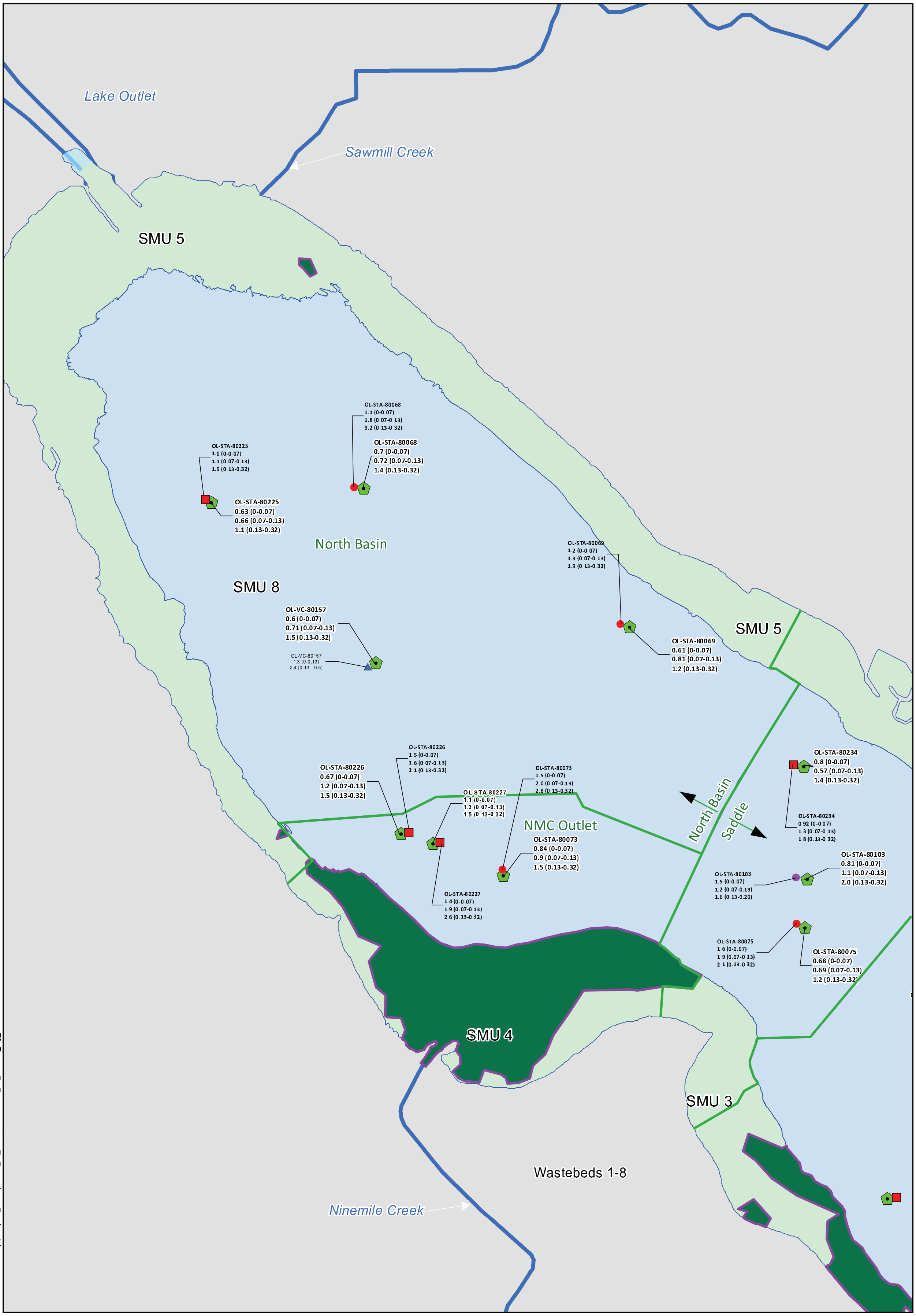
SUMMARY OF SMU 8 FROZEN CORE OBSERVATIONS TO DATE

	Water Depth (ft)		Year	Depth to First Varve / Layer (cm) Based on Observations of Frozen Cores	Depth to Sand Microbead Marker (cm)	Approximate Sedimentation Rate based on microbead depth (cm per year)
NORTH HALF OF SMU 8						
North Basin						
West side mid-way between Ninemile Creek Outlet and Lake Outlet	35		2011	2	Not cored in microbead plot	Not cored in microbead plot
West side mid-way between Ninemile Creek Outlet and Lake Outlet	45		2011	2	Not cored in microbead plot	Not cored in microbead plot
Near north end (80101)	45		2012	1.5 and 6 (2 cores)	Not cored in microbead plot	Not cored in microbead plot
Microbead plot 80095 (central)	60 (approx.)		2012	1 (1 core)	0.5 and 1 to 1.5 (2 cores)	0.3 average
At and off Microbead plot 80094 (east end)	51, 54		2014	0.5 and 7 (2 cores 300 ft apart)	7	1.3
Ninemile Creek Outlet						
None to date						
Saddle						
None to date						
SOUTH HALF OF SMU 8						
South Basin						
Off Wastebeds 1-8 and Remediation Area B (WB 1-8)	38		2012	7 and 13 (2 cores)	Not cored in microbead plot	Not cored in microbead plot
Off east end near Microbead plot 80099	60 (approx.)		2012	2	Not cored in microbead plot	Not cored in microbead plot
Off Wastebeds 1-8 near Microbead plot 80098	62		2014	1.75	Not cored in microbead plot	Not cored in microbead plot
South Corner						
Off Boundary of Remediation Areas C and D	35		2011	3	Not cored in microbead plot	Not cored in microbead plot
Off Boundary of Remediation Areas C and D	45		2011	3	Not cored in microbead plot	Not cored in microbead plot
Off Boundary of Remediation Areas C and D	55		2011	1.5 to 2	Not cored in microbead plot	Not cored in microbead plot
Off Remediation Area D (80102)	40		2012	2 and 2.5 (2 cores)	Not cored in microbead plot	Not cored in microbead plot
Microbead plot 80101 (east end)	49		2014	1	Not cored in microbead plot	Not cored in microbead plot

Notes: (1) 1 centimeter = 0.033 ft.
(2) The sand microbead marker was placed at nine localized SMU 8 plots in late June 2009.

Table SED-4: Summary of Benthic Macroinvertebrate Collections in SMU 8

Month/Year	Number of Locations and Replicate Samples	Average Number of Individual Benthic Macroinvertebrates Observed Per Sample
July-August 1992	10 locations and 5 replicates each from 30 to 65 feet water depths	Less than one
August 2000	3 locations and 2 to 4 replicates each from 54 to 56 feet water depths	1.5 to 2.0
August 2008	2 locations and 5 replicates each from 44 to 47 feet water depths	6.2 and 6.8
June 2012	3 locations and 3 replicates each from 38 to 45 feet water depths	27, 30, and 185
August 2012	3 locations and 3 replicates each from 35 to 42 feet water depths	18, 30, and 34



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Legend

- Remediation Areas
- SMU 8 Zone
- Littoral zone
- 2014 Sample Locations
- PDI Phase 7 (2011)
- PDI Phase 3 (2007)
- PDI Phase 4 (2008)
- PDI Phase 6 (2010)

NOTES

1. The 30-foot water depth contour is the boundary between the littoral zone (SMUs 1-7) and SMU 8.
2. 0.X is total mercury concentration in mg/kg (ppm). (0.Y to 0.Z) is the sample depth in feet.

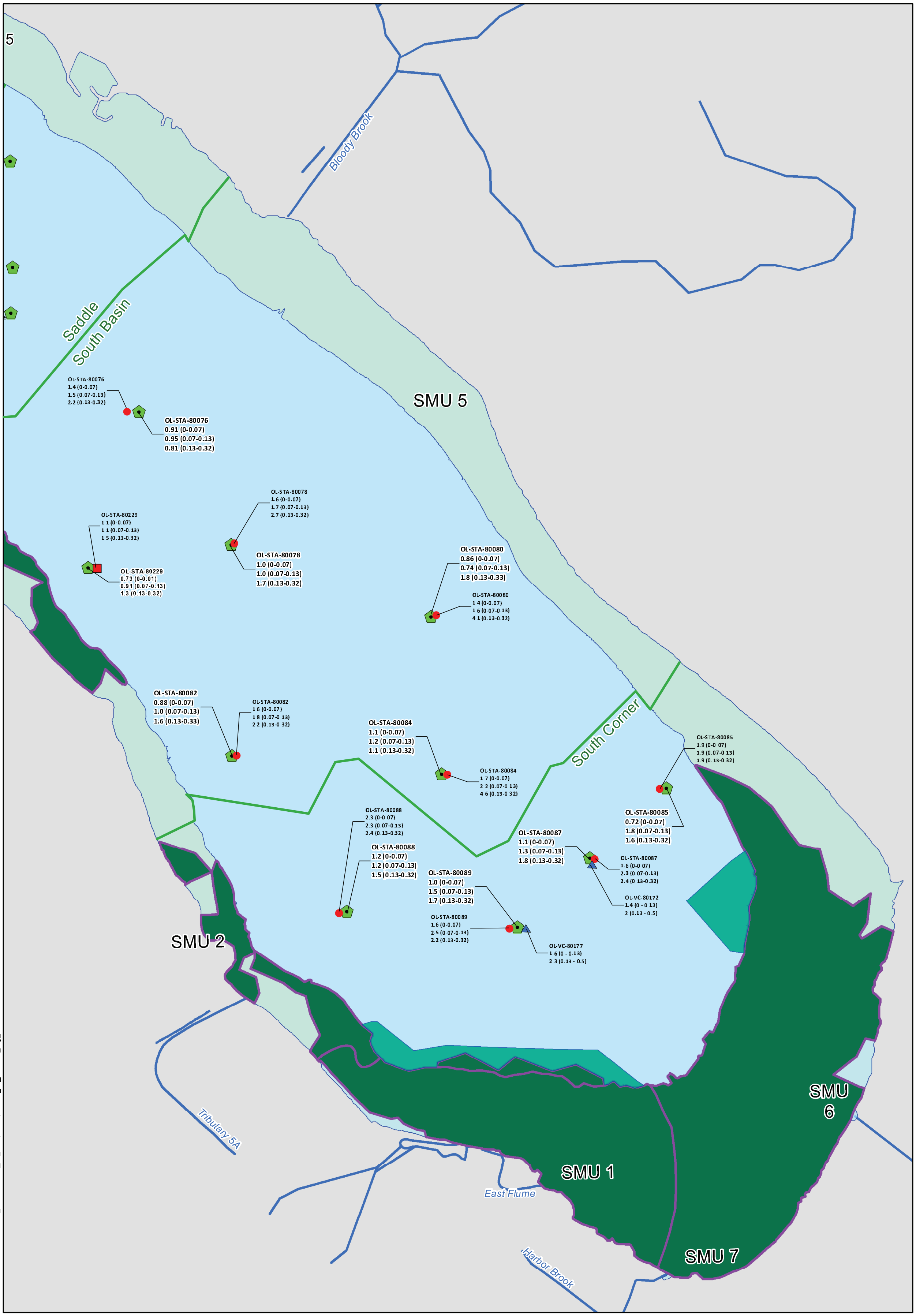
0 240 480 960 1,440 1,920 2,400
Feet

FIGURE SED-1A

Honeywell
Onondaga Lake
Syracuse, New York

Mercury in Top Six Inches of SMU 8 Sediment in North Half of Onondaga Lake (mg/kg) at Locations Sampled in 2014

PARSONS
301 PLAINFIELD RD, SUITE 350, SYRACUSE, NY 13212 Phone:(315)451-9560



Date Saved: 5/27/2015 10:54:20 AM
Document Path: Q:\GIS\GIS_Lake\Phase_VI_PDI\2014\Phase_VI_8south_Hg_2014v2.mxd

Legend

- Remediation Areas
- Thin Layer Cap
- SMU 8 Zone
- Littoral zone
- 2014 Sample Locations
- PDI Phase 7 (2011)
- PDI Phase 3 (2007)
- PDI Phase 4 (2008)
- PDI Phase 6 (2010)

NOTES

1. The 30-foot water depth contour is the boundary between the littoral zone (SMUs 1-7) and SMU 8.
2. 0.X is total mercury concentration in mg/kg (ppm). (0.Y to 0.Z) is the sample depth in feet.

0 260 520 1,040 1,560 2,080 2,600
Feet

N

FIGURE SED-1B

Honeywell
Onondaga Lake
Syracuse, New York

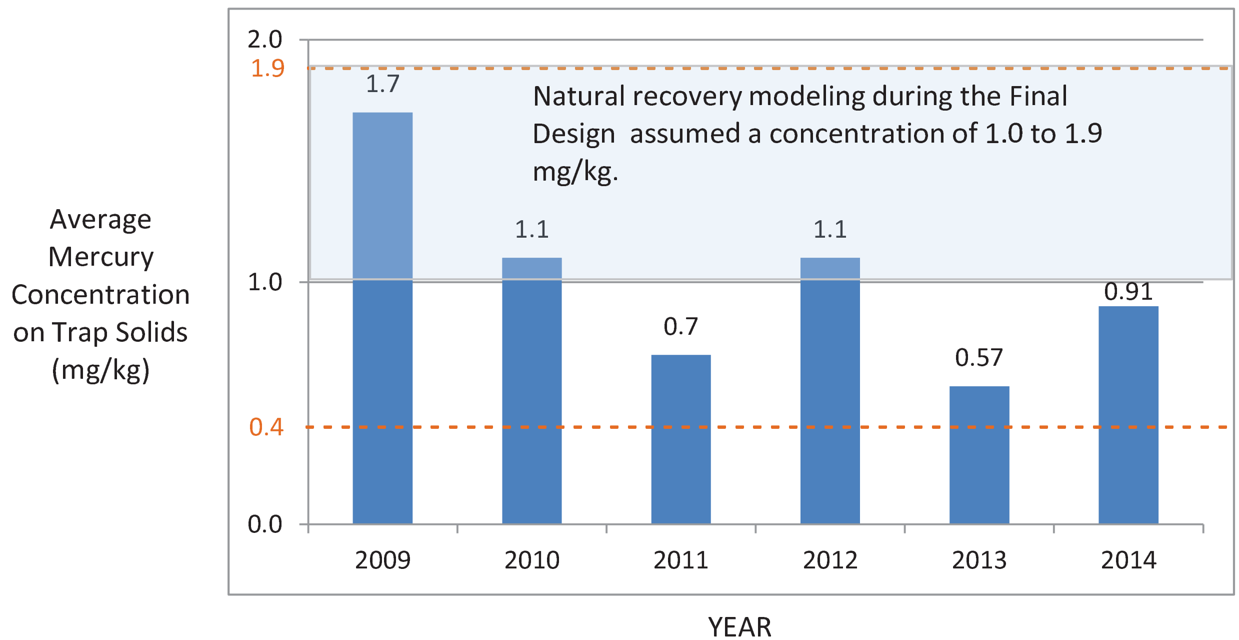
Mercury in Top Six Inches of SMU 8 Sediment in South Half of Onondaga Lake (mg/kg) at Locations Sampled in 2014

PARSONS
301 PLAINFIELD RD, SUITE 350, SYRACUSE, NY 13212 Phone:(315)451-9560

FIGURE SED-2

AVERAGE ANNUAL ONONDAGA LAKE SMU 8 MERCURY CONCENTRATIONS ON SEDIMENT TRAP SOLIDS

(in units of milligrams per kilogram (mg/kg) or parts per million)



Notes:

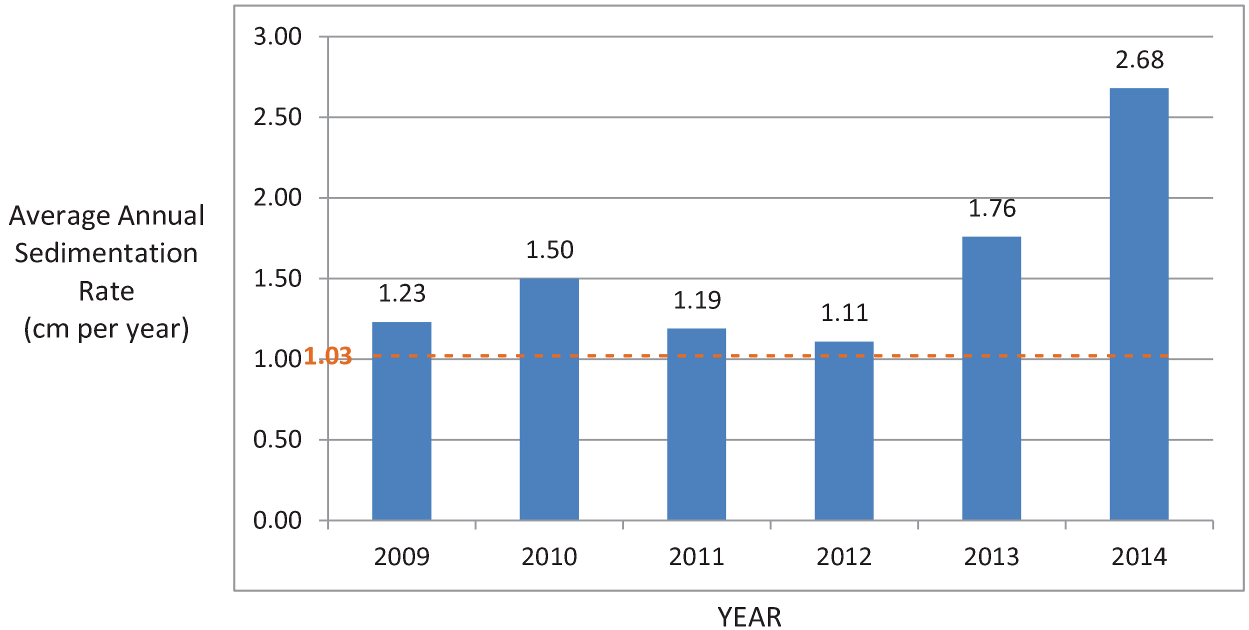
1. The range of settling sediment mercury concentrations in SMU 8 from 1.0 mg/kg in the North Basin to 1.9 mg/kg in the South Corner (shaded area above) was applied in the design of the SMU 8 remedy for the period of time prior to completion of remediation of the upland sites and lake.

2. 0.4 mg/kg is the future settling sediment mercury concentration assumed in the MNR model to represent concentrations after remediation of the Lake is completed.

FIGURE SED-3

AVERAGE ANNUAL ONONDAGA LAKE SMU 8 SEDIMENTATION RATES FROM SEDIMENT TRAP SOLIDS MEASUREMENTS

(in centimeters per year)



Notes:

1. 1.03 cm per year (equivalent to 6,850 milligrams per square meter per day or 0.25 grams per square centimeter per year) is the annual average sedimentation rate assumed in the MNR model as part of the design.

2. Annual sedimentation rates in milligrams per square meter per day reported previously from sediment trap results are as follows: 8,150 in 2009; 10,000 in 2010; 7,840 in 2011; 7,370 in 2012; 11,700 in 2013; and 17,800 in 2014.

3. Sedimentation rates are measured at the South Deep location in SMU 8 at a water depth that is below the thermocline.

Onondaga Lake First Five-Year Review

Attachment 3c

Fish Tissue Data Tables and Figures

Onondaga Lake Bottom Site
First Five-Year Review Report
Attachment 3c
Fish Tissue Data Tables and Figures

Introduction

The following includes a summary of the fish tissue data tables and figures presented in this Five-Year Review and a general description of the fish tissue monitoring program since 2008. As the statistical metrics to demonstrate whether the concentration for each target fish species is statistically below the stated goals have not yet been formalized, the information presented here and the assessments in main portion of the Five-Year Review reflect the general distribution of the bulk of the data (i.e., a large percentage of the data is reflected in the assessment rather than a specific metric, and the full range of concentrations can be seen in the box-and-whisker plots, as defined below). It is expected that the metrics to assess achievement of fish tissue goals and the statistical methods will be formalized as part of the completion of the Onondaga Lake Monitoring and Maintenance Scoping Document in 2015 and used in subsequent Five-Year Reviews.

The Onondaga Lake Record of Decision (ROD) (NYSDEC and USEPA, 2005) indicated that mercury is a primary concern in the lake and is a part of all five remedial action objectives (RAOs), and therefore the ROD specified the following remedial goals for mercury in fish tissue for protection of human health and ecological exposure:

- 0.2 mg/kg (fish tissue fillet) for protection of human health based on the reasonable maximum exposure scenario assumptions from the Onondaga Lake Human Health Risk Assessment (HHRA) (TAMS, 2002a).
- 0.3 mg/kg (fish tissue fillet) based on EPA's methylmercury National Recommended Water Quality criterion for the protection of human health for the consumption of organisms.
- 0.14 mg/kg (whole fish) for protection of ecological receptors (wildlife) based on the exposure assumptions from the Onondaga Lake Baseline Ecological Risk Assessment (BERA) (TAMS, 2002b). This ecological goal was based on the lowest-observed-adverse-effect level (LOAEL) for the river otter.

In addition to the remedial goals for mercury in fish tissue, cited above, ecological target tissue concentrations for mercury based on the no-observed-adverse-effect levels (NOAELs) as well as target tissue concentrations for bioaccumulative organic contaminants, corresponding to various risk levels (including both the 10^{-4} and 10^{-5} cancer risk levels for human health exposure and both the LOAELs and NOAELs for ecological exposure), were developed in the Onondaga Lake Feasibility Study (Parsons, 2004) based on exposure parameters from the Onondaga Lake HHRA and BERA and were included in the ROD (Table 7). These targets are not remedial goals, as presented in the ROD, but will be used as points of reference for future evaluations of reduction of risk for human and wildlife consumers of fish.

As indicated in the ROD, these other contaminants, including PCBs, hexachlorobenzene, and PCDD/PCDFs, are not as widespread in sediments in the lake (as compared to mercury) and are found primarily in a few specific areas of the lake (e.g., sediment management units [SMUs] 1, 2, 6, and 7), which are undergoing aggressive active remediation (dredging and/or capping).

As the areas of the lake with elevated concentrations of these bioaccumulative organic contaminants for which target tissue concentrations were developed are generally within the remedial areas based on exceedance of the cleanup criteria of the mean PECQ of 1 (which addresses multiple contaminants) plus the mercury PEC, the exposures to these compounds would be reduced to the same or greater extent as that of mercury. It was therefore expected that if the remedial goals for mercury in fish tissue are met in the future (e.g., during the 10-year monitored natural recovery [MNR] period after completion of the dredging and capping), that the future fish tissue concentrations for the contaminants listed in ROD Table 7 would fall within the concentration ranges shown in that table for each contaminant and receptor. For this reason, target tissue concentrations other than the remedial goals for mercury in fish are not shown on the Sets 1, 2, and 3 figures below and contaminants other than mercury are not included in the discussion of results for the Sets 1, 2, and 3 figures in the main portion of the Five-Year Review. (Contaminants other than mercury are included in the discussion of the Set 4 figures.) If the above noted expectation is proven not to be the case in the future, based on ongoing fish tissue monitoring, then an evaluation will take place to determine why this expectation may no longer be valid.

As the remediation of the lake is in progress, it is premature in this First Five-Year Review to determine whether the remediation has achieved the goals stated in the ROD. The Onondaga Lake ROD envisioned a long-term monitoring program to assess the effectiveness of the remedy, since changes in the contaminant concentrations in biota typically take at least several years to fully manifest. This concept is reflected in the ten-year MNR period discussed in the ROD, and is consistent with the results seen following remediation at other sediment sites (e.g., Cumberland Bay in New York State). Future Five-Year Reviews will continue to assess the data trends as they are established as well as attainment of the fish tissue goals.

Fish Data Reporting

For the fish tissue data reporting, both the Honeywell data sets from 2008 to 2014 (fillets of smallmouth bass, walleye, brown bullhead and pumpkinseed [and carp in 2014] and whole-body small prey fish [and whole-body large prey fish in 2014]) and NYSDEC data sets from 2008 to 2014 (largemouth bass, carp, yellow perch, white perch, and channel catfish) are used. Data were obtained from the September 2014 version of the NYSDEC Onondaga Lake Database (AECOM/YEC) and working updates incorporating data received since September 2014 (i.e., the Honeywell data from 2014 and NYSDEC data from 2013 and 2014). Honeywell data from 2008 through 2011 were collected under the Baseline Monitoring Program and data collected from 2012 through 2014 were collected under the Monitoring and Maintenance Program during remedial action (dredging and capping)[1].

1 Adult sport fish and alewife prey fish were collected by Honeywell in June 2012 just prior to the commencement of dredging in late July 2012. Minnow prey fish were collected in August 2012.

For the Honeywell Baseline Monitoring Program, adult sport fish species were selected by Honeywell to cover a range of trophic levels including top level piscivores (smallmouth bass, walleye), benthic invertivores (brown bullhead), and invertivores (pumpkinseed). The NYSDEC monitoring program is independent of the Honeywell program. NYSDEC instituted a long-term sampling program in 1970, initially concentrating on smallmouth bass and later largemouth bass. Other species were analyzed by NYSDEC if collected in certain years to provide information on other trophic levels such as carp (benthic herbivore), yellow and white perch (invertivores), and channel catfish (benthic omnivore).

Based on prior discussions with Honeywell related to data usability, the Honeywell organics data from 2010 are not used and the mercury data from 2010 are qualified as estimated due to incorrect filleting procedures and potential problems with extractions resulting in very low concentrations of organic contaminants in sport fish and prey fish in 2010. In addition, four of the revised lipids results from 2011 were rejected and the lipids results for these samples are not used.

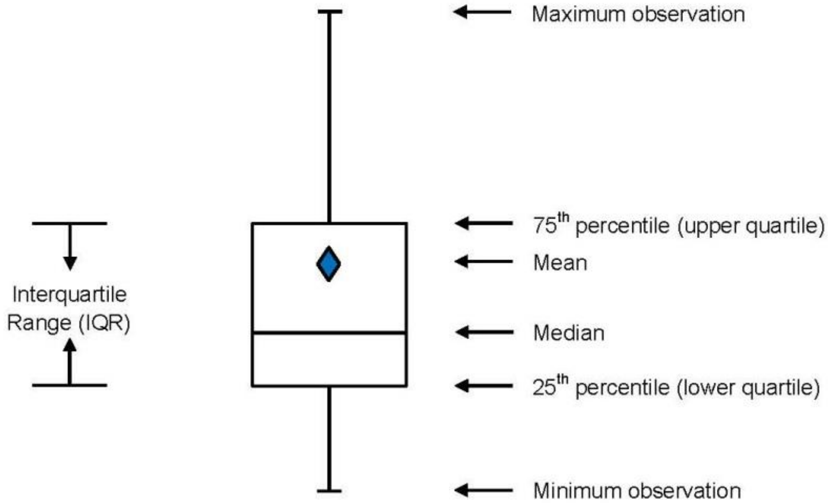
Calculations of total PCBs, sum of DDT and metabolites, and dioxin/furan toxic equivalence (TEQs) (based on the World Health Organization human health and mammalian based toxicity equivalence factors [TEFs] from van den Berg et al., 2006) were performed by AECOM (on behalf of NYSDEC) for those data sets where totals were not included in the source files.

For ecological exposure, the fish were grouped into two size classes: small (3 to 18 cm) and large (18 to 60 cm) consistent with the Onondaga Lake BERA (TAMS, 2002b). Data for small whole-body prey fish are available in the Honeywell data set. As large whole-body prey fish were not collected from 2008 to 2013, the whole-body concentrations were estimated based on the fillet samples from that size class and the fillet to whole-body conversion factors (0.7 for mercury, 2.5 for PCBs, and 2.3 for DDTs and HCB) from the Onondaga Lake BERA (Section 8.2.6.4). These conversion factors will be reassessed with new data in the future, if appropriate. In 2014, Honeywell collected large (18 to 60 cm) prey fish for whole-body analysis, consisting exclusively of white suckers.

Tables 1 and 2 below provide a summary of the number of samples used in the analyses for each species and analyte for the Honeywell and NYSDEC data sets, respectively.

The data are presented in the figures as box-and-whisker plots, as defined below, or as means +/- one standard deviation. For non-detects, statistics incorporate one-half of the reported detection limit. Refinements to these methods may be incorporated in future Five-Year Reviews.

Legend for Box-and-Whisker Plots (Sets 1, 2, and 3 Figures):



Honeywell Labs for Fish Analyses (2008 to 2014):

- 2008. Test America, Vermont (all analytes)
- 2009. Accutest, New Jersey (mercury in prey fish); Test America, Pittsburgh (other analytes, mercury in sport fish)
- 2010. SGS, North Carolina (dioxins/furans); Accutest, NJ (other analytes)
- 2011, 2012, 2013. Test America, Pittsburgh PA and Knoxville TN
- 2014. Pace Analytical (all analytes)

NYSDEC Lab for Fish Analyses (2008 to 2014):

- Hale Creek Field Station, Analytical Services Unit

LIST OF FISH MONITORING SUMMARY TABLES

LIST OF FISH MONITORING SUMMARY FIGURES

- Total PCBs – White Perch (Fillet)
- Total PCBs – Channel Catfish (Fillet)
- DDTs – Largemouth Bass (Fillet)
- DDTs – Carp (Fillet)
- DDTs – Yellow Perch (Fillet)
- DDTs – White Perch (Fillet)
- DDTs – Channel Catfish (Fillet)
- Hexachlorobenzene – Largemouth Bass (Fillet)
- Hexachlorobenzene – Carp (Fillet)
- Hexachlorobenzene – Yellow Perch (Fillet)
- Hexachlorobenzene – White Perch (Fillet)
- Hexachlorobenzene – Channel Catfish (Fillet)

Set 2: Small (3 to 18 cm) Prey Fish Whole-Body Concentrations for Ecological Goal

Honeywell Data (2008-2014)

- Mercury – Small Prey Fish (Whole Body)
- Total PCBs – Small Prey Fish (Whole Body)
- DDTs – Small Prey Fish (Whole Body)
- Hexachlorobenzene – Small Prey Fish (Whole Body)

Note, all species of small prey fish (whole body) collected by Honeywell are included in this data set (primarily banded killifish, but also alewife, golden shiner, brook silverside, bluntnose minnow, and gizzard shad).

Set 3: Large (18 to 60 cm) Prey Fish Whole-Body Concentrations for Ecological Goal

Honeywell Data (2008-2014)

- Calculated Mercury (Whole Body) in Large Fish (18-60 cm), Smallmouth Bass
- Calculated Mercury (Whole Body) in Large Fish (18-60 cm), Walleye
- Calculated Mercury (Whole Body) in Large Fish (18-60 cm), Pumpkinseed
- Calculated Mercury (Whole Body) in Large Fish (18-60 cm), Brown Bullhead
- Analyzed Mercury (Whole Body) in Large Fish (18-60 cm), White Sucker (2014 Data Only)
- Calculated Total PCBs (Whole Body) in Large Fish (18-60 cm), Smallmouth Bass
- Calculated Total PCBs (Whole Body) in Large Fish (18-60 cm), Walleye
- Calculated Total PCBs (Whole Body) in Large Fish (18-60 cm), Pumpkinseed
- Calculated Total PCBs (Whole Body) in Large Fish (18-60 cm), Brown Bullhead
- Analyzed Total PCBs (Whole Body) in Large Fish (18-60 cm), White Sucker (2014 Data Only)
- Calculated DDTs (Whole Body) in Large Fish (18-60 cm), Smallmouth Bass
- Calculated DDTs (Whole Body) in Large Fish (18-60 cm), Walleye
- Calculated DDTs (Whole Body) in Large Fish (18-60 cm), Pumpkinseed
- Calculated DDTs (Whole Body) in Large Fish (18-60 cm), Brown Bullhead

- Analyzed DDTs (Whole Body) in Large Fish (18-60 cm), White Sucker (2014 Data Only)
- Calculated Hexachlorobenzene (Whole Body) in Large Fish (18-60 cm), Smallmouth Bass
- Calculated Hexachlorobenzene (Whole Body) in Large Fish (18-60 cm), Walleye
- Calculated Hexachlorobenzene (Whole Body) in Large Fish (18-60 cm), Pumpkinseed
- Calculated Hexachlorobenzene (Whole Body) in Large Fish (18-60 cm), Brown Bullhead
- Analyzed Hexachlorobenzene (Whole Body) in Large Fish (18-60 cm), White Sucker (2014 Data Only)

NYSDEC Data (2008-2014)

- Calculated Mercury (Whole Body) in Large Fish (18-60 cm), Largemouth Bass
- Calculated Total PCBs (Whole Body) in Large Fish (18-60 cm), Largemouth Bass
- Calculated DDTs (Whole Body) in Large Fish (18-60 cm), Largemouth Bass
- Calculated Hexachlorobenzene (Whole Body) in Large Fish (18-60 cm), Largemouth Bass

Note, as largemouth bass was the predominant species analyzed by NYSDEC during this period with significantly fewer numbers of samples of the other species (carp, yellow perch, white perch, channel catfish) as shown in Table 2, figures for calculated whole-body concentrations based on the fillet data for these other species (see Set 1 figures) are not included herein.

Set 4: Additional Reporting to Assess Potential Impacts of Remediation

For information on the potential impact of the implementation of the remediation on contaminant concentrations in fish tissue (as opposed to the risk to consumers of fish), the changes in concentration over time are reported. In these Set 4 figures, the data are presented in a way that controls factors which may influence the wet-weight concentrations, but are independent of any exposure to the site-related contamination. This reduces the variability (e.g., noise) in the data.

For mercury, the variability due to fish age is corrected by using length as a surrogate for age. The wet-weight mercury concentration of each individual fish is adjusted by dividing the concentration (in mg/kg) by its length (in millimeters [mm]), providing a concentration as mg/kg per mm. For the organic contaminants, the amount of lipid in the fish has a major influence on the wet-weight concentrations (Sloan et al., 2002). For PCBs, dioxin/furans, DDTs, and hexachlorobenzene, the wet-weight concentrations for each individual fish are adjusted by dividing the concentration by its lipid content, providing a lipid-normalized concentration (e.g., mg PCBs/kg lipid). In future reviews, more sophisticated data analysis techniques may be used.

The first subset of figures presents mercury data normalized to fish length and organic contaminants normalized to lipids for both sport fish and prey fish. As the normalized data are not compared to the goals (which are on a wet-weight basis) and all sport fish species for each contaminant are shown on one figure, the data are presented as mean +/- one standard deviation rather than box-and-whisker plots to provide a simpler image.

The second subset of figures presents the normalized data by sample location for localized small prey fish species collected by Honeywell (note, whole-body prey fish were not collected by NYSDEC). These figures show normalized concentrations for the sediment management units (SMUs) from which the prey fish samples were collected. Note, Honeywell's fish sampling program did not include stations in SMUs 1 and 8. For these figures, only localized small prey fish are used (i.e., all small prey fish species except for alewife and gizzard shad). Both alewife and gizzard shad tend to be pelagic, inhabiting deeper waters in the lakes where they are found, and plankton feeders. They have distinctly different habits than most of the prey fish in Onondaga Lake. In particular, they will tend to have large home ranges, and are not localized. Therefore, these fish are not included in the location-specific reporting for prey fish.

As pumpkinseed and brown bullhead tend to be more localized and feed more heavily in the littoral zone than the other adult sport fish collected, figures for these species are also included in this subset.

Honeywell Data (2008-2014)

Subset 1

- Mercury – All Sport Fish Species (Fillet), Length Normalized
- Mercury – Prey Fish Species (Whole Body), Length Normalized
- Total PCBs – All Sport Fish Species (Fillet), Lipid Normalized
- Total PCBs – Prey Fish Species (Whole Body), Lipid Normalized
- Dioxins/Furans TEQ (Half DL) – All Sport Fish Species (Fillet), Lipid Normalized
- DDTs – All Sport Fish Species (Fillet), Lipid Normalized
- DDTs – Prey Fish Species (Whole Body), Lipid Normalized
- Hexachlorobenzene – All Sport Fish Species (Fillet), Lipid Normalized
- Hexachlorobenzene – Prey Fish Species (Whole Body), Lipid Normalized

Subset 2

- Mercury – Localized Small Prey Fish, Length Normalized by SMU
- Total PCBs – Localized Small Prey Fish, Lipid Normalized by SMU
- DDTs – Localized Small Prey Fish, Lipid Normalized by SMU
- Hexachlorobenzene – Localized Small Prey Fish, Lipid Normalized by SMU
- Mercury – Pumpkinseed, Length Normalized by SMU
- Total PCBs – Pumpkinseed, Lipid Normalized by SMU
- DDTs – Pumpkinseed, Lipid Normalized by SMU
- Hexachlorobenzene – Pumpkinseed, Lipid Normalized by SMU
- Mercury – Brown Bullhead, Length Normalized by SMU
- Total PCBs – Brown Bullhead, Lipid Normalized by SMU
- DDTs – Brown Bullhead, Lipid Normalized by SMU
- Hexachlorobenzene – Brown Bullhead, Lipid Normalized by SMU

NYSDEC Data (2008-2014)

Subset 1

- Mercury – All Sport Fish Species (Fillet), Length Normalized
- Total PCBs – All Sport Fish Species (Fillet), Lipid Normalized
- DDTs – All Sport Fish Species (Fillet), Lipid Normalized
- Hexachlorobenzene – All Sport Fish Species (Fillet), Lipid Normalized

References

NYSDEC and USEPA Region 2. 2005. Record of Decision. Onondaga Lake Bottom Subsite of the Onondaga Lake Superfund Site. July.

Parsons. 2004. Onondaga Lake Feasibility Study Report. Draft Final. Prepared by Parsons, Liverpool, NY in association with Anchor Environmental and Exponent for Honeywell. November.

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TAMS. 2002a. Onondaga Lake Human Health Risk Assessment. Original document prepared by Exponent, Bellevue, Washington, for Honeywell, East Syracuse, New York. Revision prepared by TAMS, New York, New York and YEC, Valley Cottage, New York, for New York State Department of Environmental Conservation, Albany, New York. December.

TAMS. 2002b. Onondaga Lake Baseline Ecological Risk Assessment. Original document prepared by Exponent, Bellevue, Washington, for Honeywell, East Syracuse, New York. Revision prepared by TAMS, New York, New York and YEC, Valley Cottage, New York, for New York State Department of Environmental Conservation, Albany, New York. December.

Van den Berg, M., L.S. Birnbaum, M. Denison, et al. 2006. The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds. Toxicol Sci 93(2):223−241.

TABLES

TABLE 1

HONEYWELL FISH DATA USED IN THE ANALYSES (NUMBER OF SAMPLES)

	Baseline Monitoring																			
	2008					**2009**					**2010 (2)**					**2011**				
Analyte	SMB	WEYE	BB	PKSD	Small Prey Fish	SMB	WEYE	BB	PKSD	Small Prey Fish	SMB	WEYE	BB	PKSD	Small Prey Fish	SMB	WEYE	BB	PKSD	Small Prey Fish
Mercury (1)	18	50	50	50	40	42	50	50	50	40	41	50	51	50	40	25	25	25	25	40
Total PCBs	12	12	12	12	10	12	12	0	0	0	12	12	12	12	10	12	12	12	12	0
PCDDs/PCDFs	5	5	5	5	0	0	0	0	0	0	5	5	5	5	0	5	5	5	5	0
Hexachlorobenzene	12	12	12	12	10	0	0	0	0	0	12	12	12	11	10	11	12	9	10	0
Total DDTs	12	12	12	12	10	12	12	0	0	0	12	12	12	12	10	12	12	12	12	0
Lipid	12	12	12	12	10	12	12	0	0	0	12	12	12	12	10	10	12	11	11	0

	Monitoring During Remedial Action																
	2012 (3)					**2013**					**2014**						
Analyte	SMB	WEYE	BB	PKSD	Small Prey Fish	SMB	WEYE	BB	PKSD	Small Prey Fish	SMB	WEYE	BB	PKSD	CP	Small Prey Fish	Large Prey Fish
Mercury (1)	25	25	25	0	40	25	25	24	25	40	25	25	25	25	25	24	24
Total PCBs	12	12	12	0	10	25	25	25	25	40	25	25	25	25	25	24	24
PCDDs/PCDFs	5	5	5	0	0	0	0	0	0	0	12	13	6	1	9	0	0
Hexachlorobenzene	12	12	12	0	10	25	25	25	25	40	25	25	25	12	25	24	24
Total DDTs	12	12	12	0	10	25	25	25	25	40	0	0	0	0	0	24	24
Lipid	12	12	12	0	10	25	25	25	25	40	25	25	25	25	25	24	24

SMB - Smallmouth Bass
WEYE - Walleye
BB - Brown Bullhead
PKSD - Pumpkinseed
CP - Carp

Notes:
1. Sample counts do not include fish plug samples collected in 2008 and 2009.
2. Results for organics and lipids from 2010 are not used in analysis. See text for discussion.
3. Adult sport fish and alewife prey fish were collected by Honeywell in June 2012 just prior to the commencement of dredging in late July 2012. Minnow prey fish were collected in August 2012.
4. Sport fish analyzed as fillet samples. Small prey fish (various species) and large prey fish (white sucker in 2014 only) analyzed as whole-body samples.

TABLE 2
NYSDEC FISH DATA USED IN THE ANALYSES (NUMBER OF SAMPLES)

Analyte	Baseline Monitoring																			
	2008					**2009**					**2010**					**2011**				
	LMB	CP	YP	WP	CHC	LMB	CP	YP	WP	CHC	LMB	CP	YP	WP	CHC	LMB	CP	YP	WP	CHC
Mercury	45	0	0	0	0	50	0	0	0	0	50	16	15	15	10	53	0	15	14	1
Total PCBs	10	0	0	0	0	49	0	0	0	0	50	16	15	15	10	53	0	15	14	1
Total DDTs	10	0	0	0	0	49	0	0	0	0	50	16	15	15	10	53	0	15	14	1
Hexachlorobenzene	10	0	0	0	0	49	0	0	0	0	50	16	15	15	10	53	0	15	14	1
Lipid	10	0	0	0	0	50	0	0	0	0	50	16	15	15	10	53	0	15	14	1

Analyte	Monitoring During Remedial Action														
	2012 (1)					**2013**					**2014**				
	LMB	CP	YP	WP	CHC	LMB	CP	YP	WP	CHC	LMB	CP	YP	WP	CHC
Mercury	50	0	15	15	5	50	10	0	0	0	41	0	0	0	0
Total PCBs	50	0	15	15	5	50	10	0	0	0	41	0	0	0	0
Total DDTs	50	0	15	15	5	50	10	0	0	0	41	0	0	0	0
Hexachlorobenzene	50	0	15	15	5	50	10	0	0	0	41	0	0	0	0
Lipid	50	0	15	15	5	50	10	0	0	0	41	0	0	0	0

LMB - Largemouth Bass
CP - Carp
YP - Yellow Perch
WP - White Perch
CHC - Channel Catfish

Notes:
1. Fish were collected by NYSDEC in May 2012 prior to the commencement of dredging in late July 2012.
2. Fish analyzed as fillet samples.

FIGURES

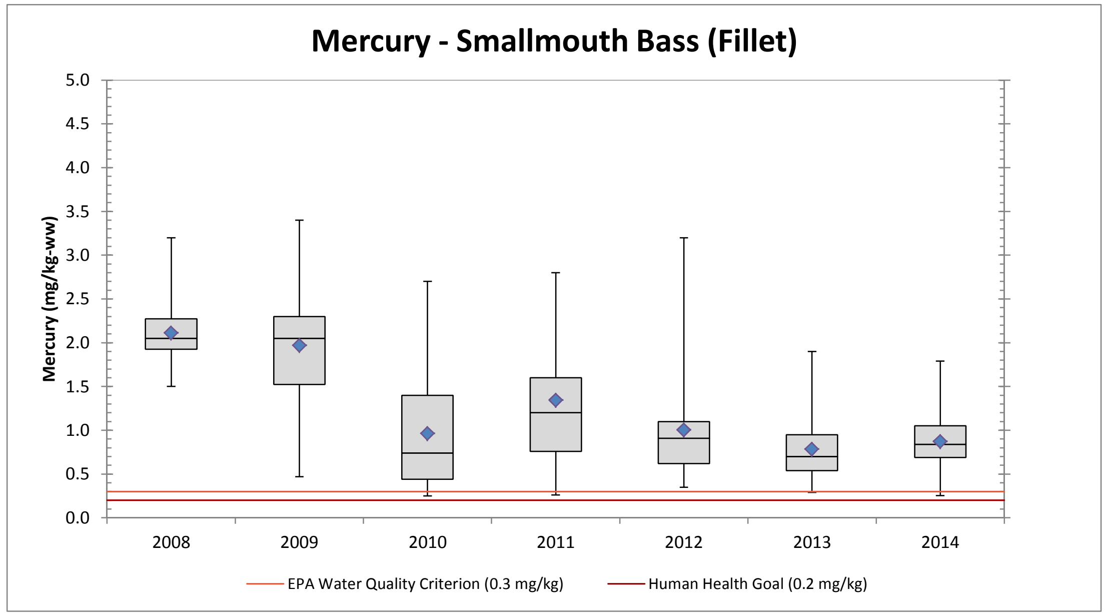
Set 1:
Sport Fish Fillet Concentrations for Human Health Goals

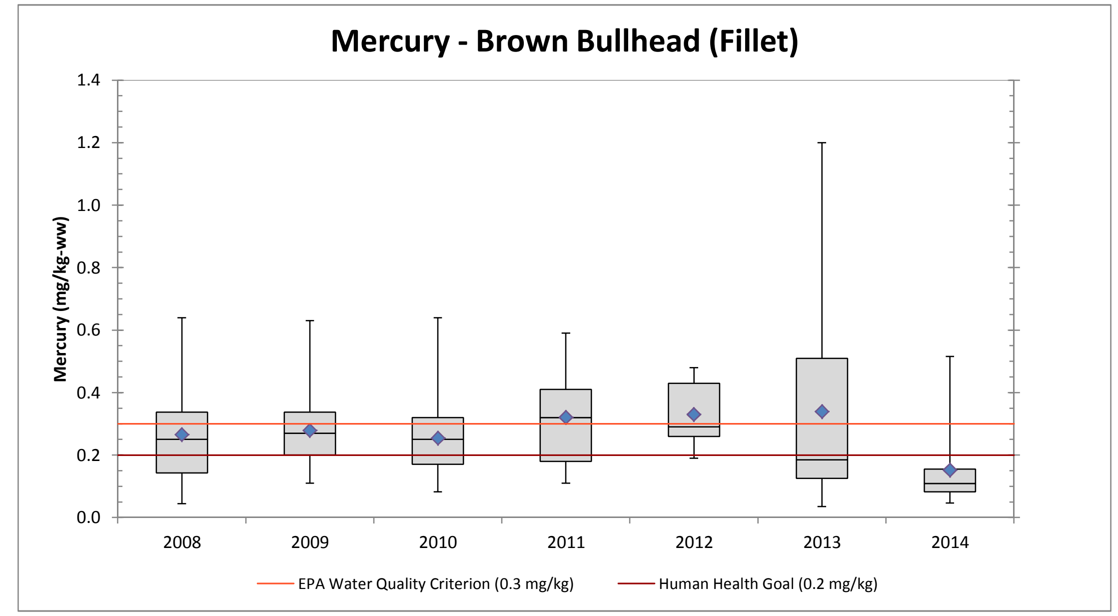
Honeywell Data (2008-2014)

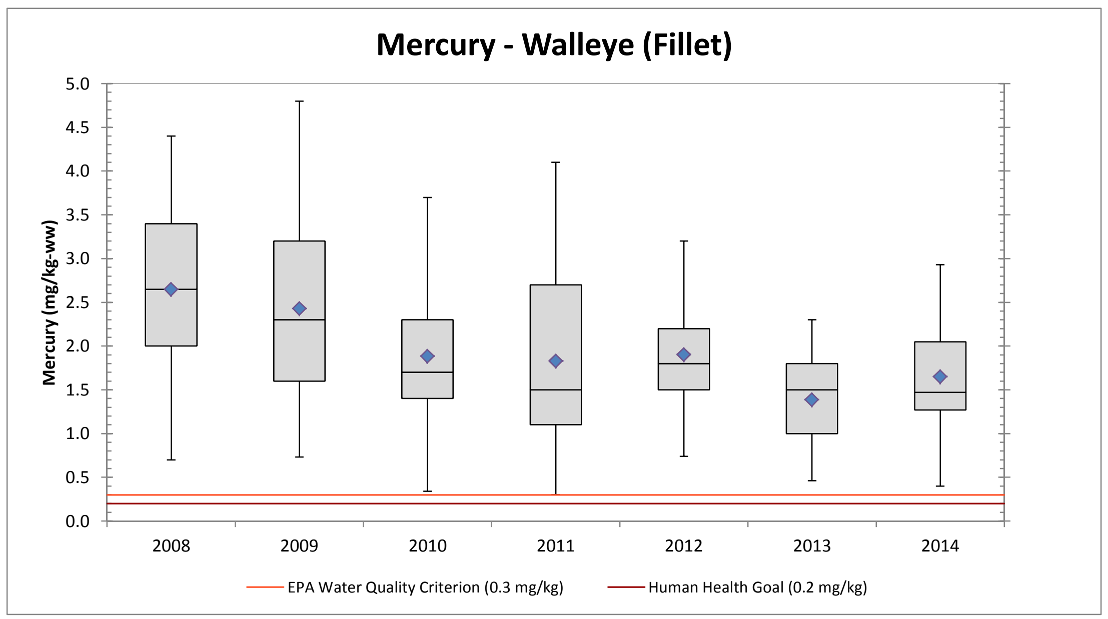
AECOM

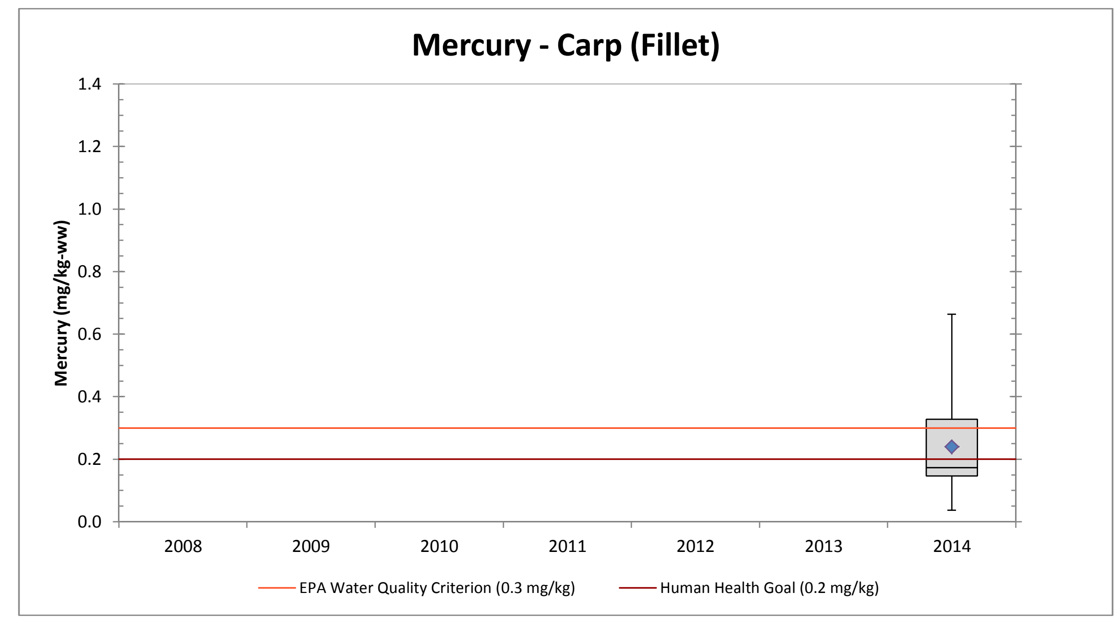
June 2015

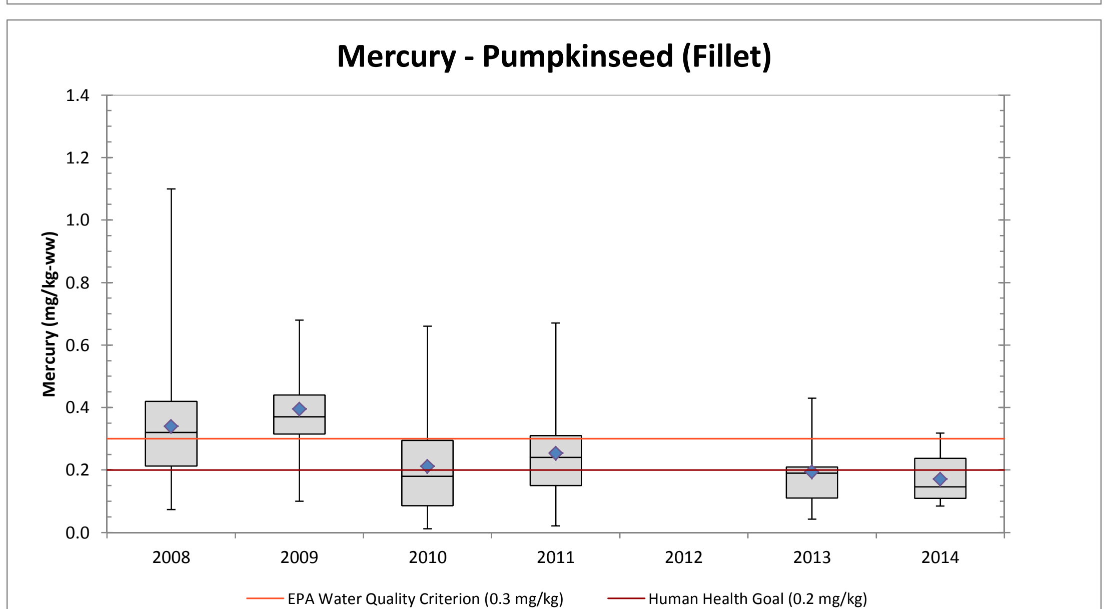
Honeywell Mercury Data - Set 1



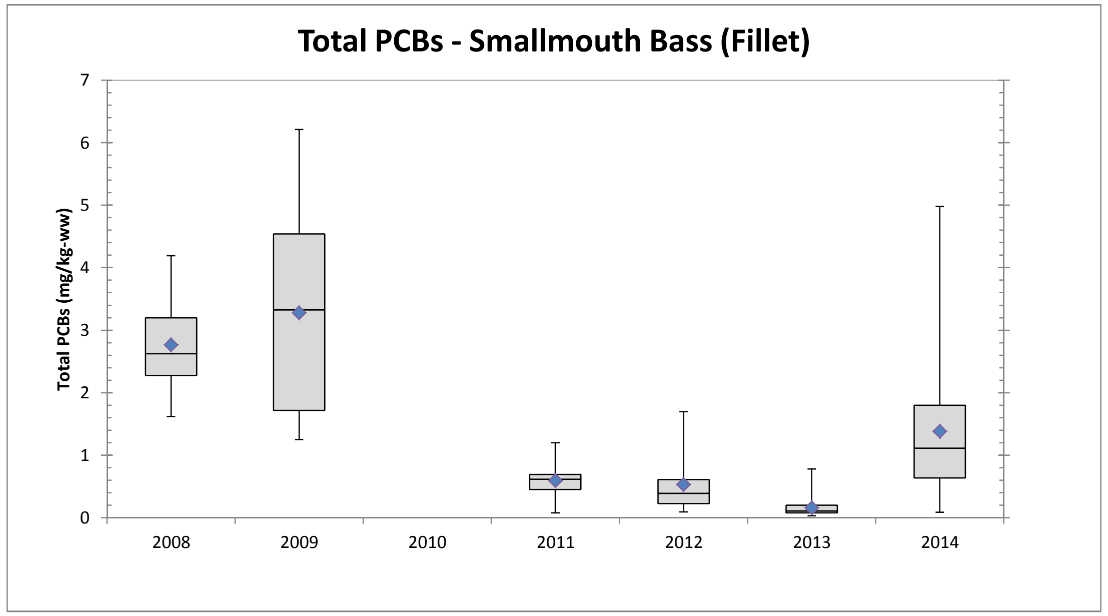


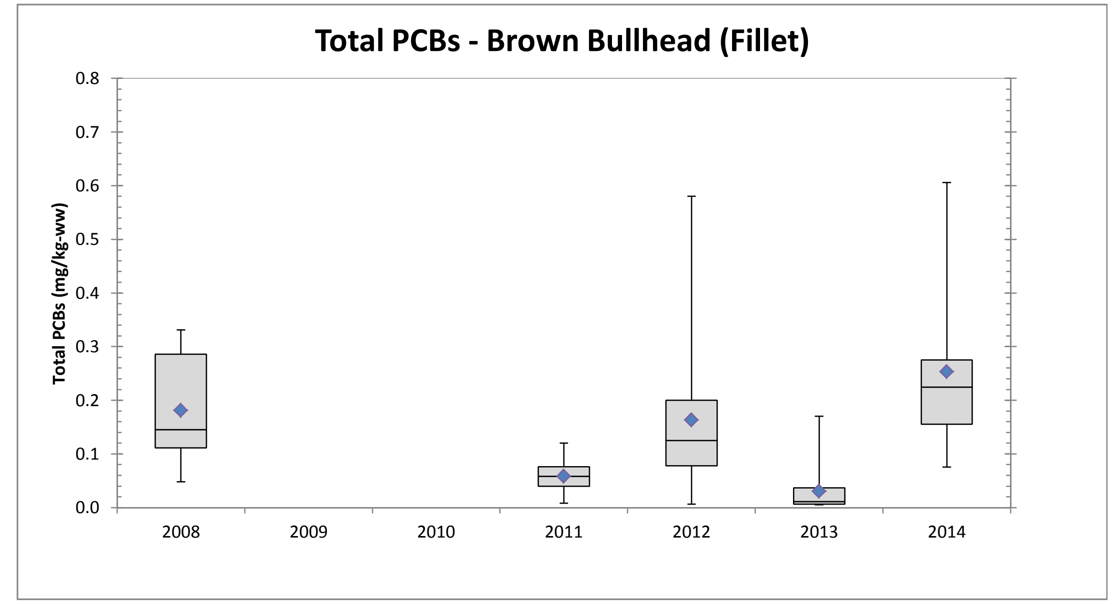


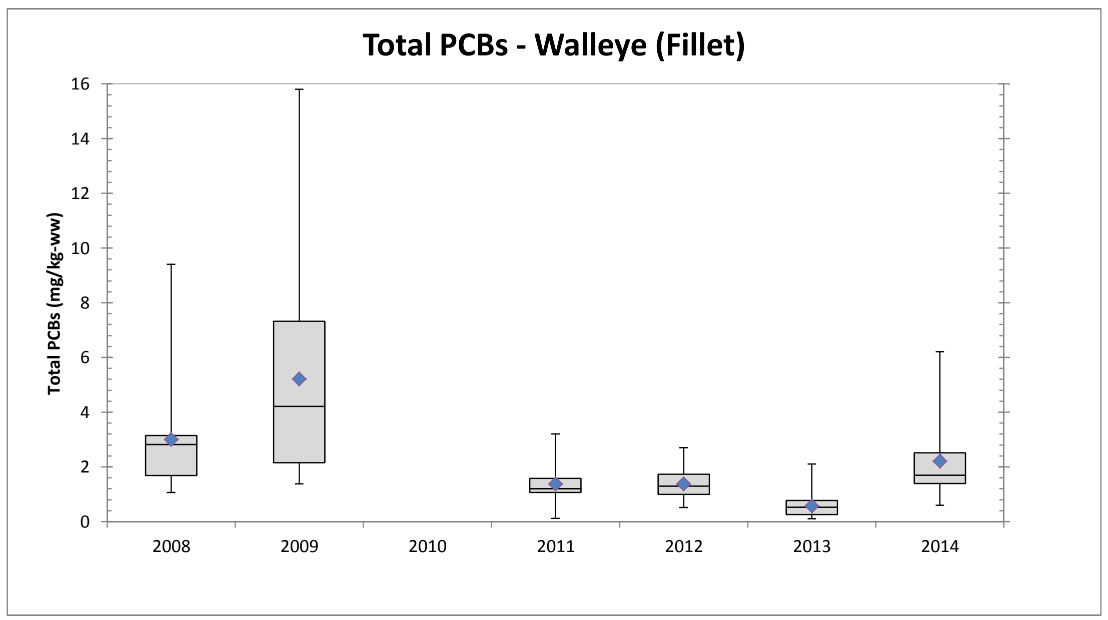


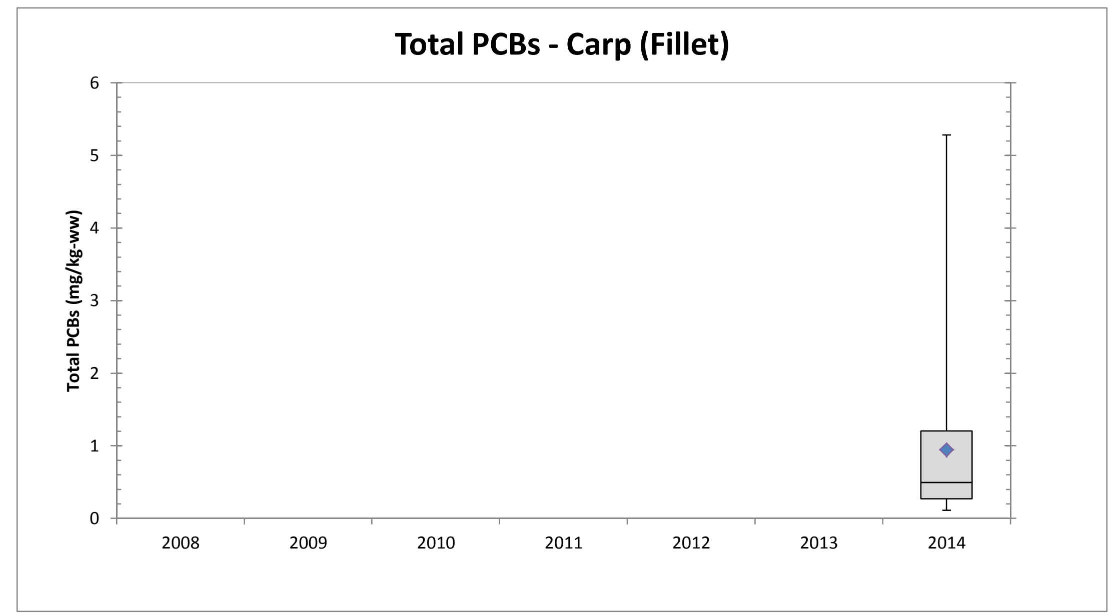


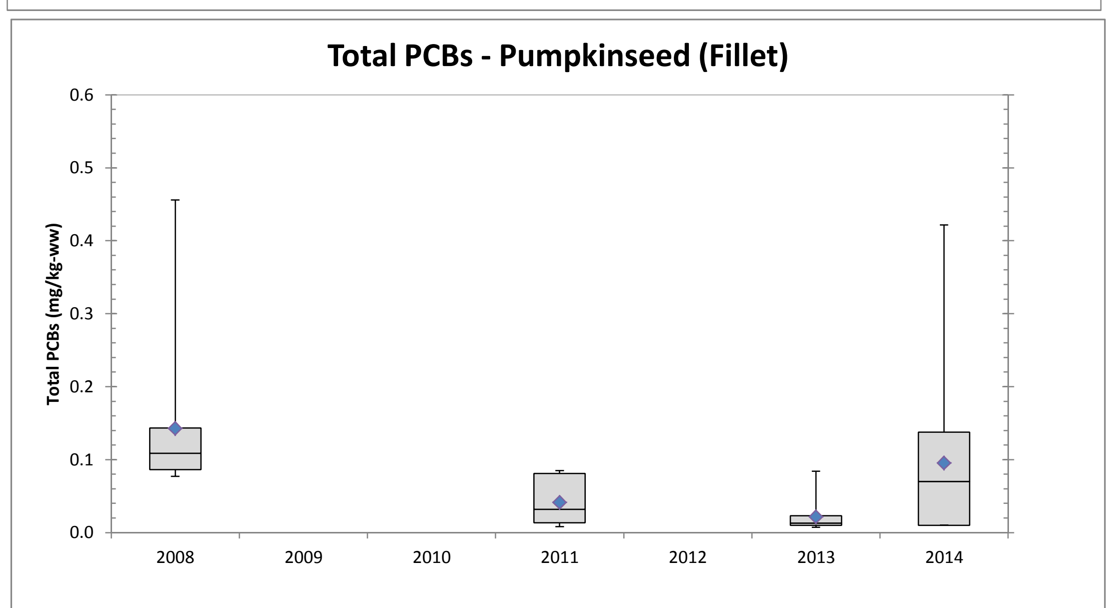
Honeywell Total PCBs Data - Set 1



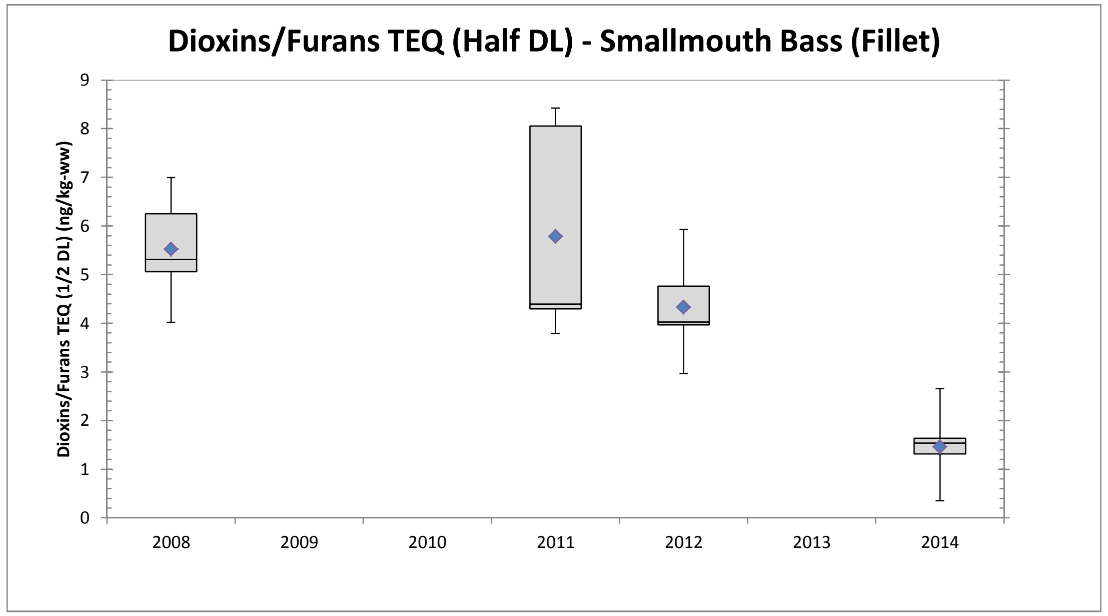


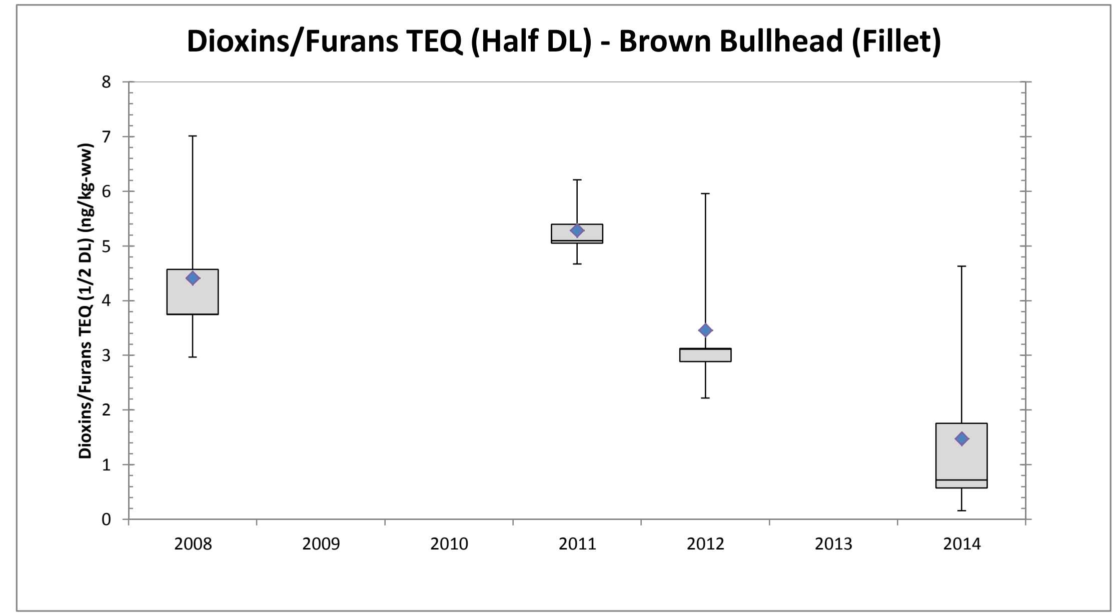


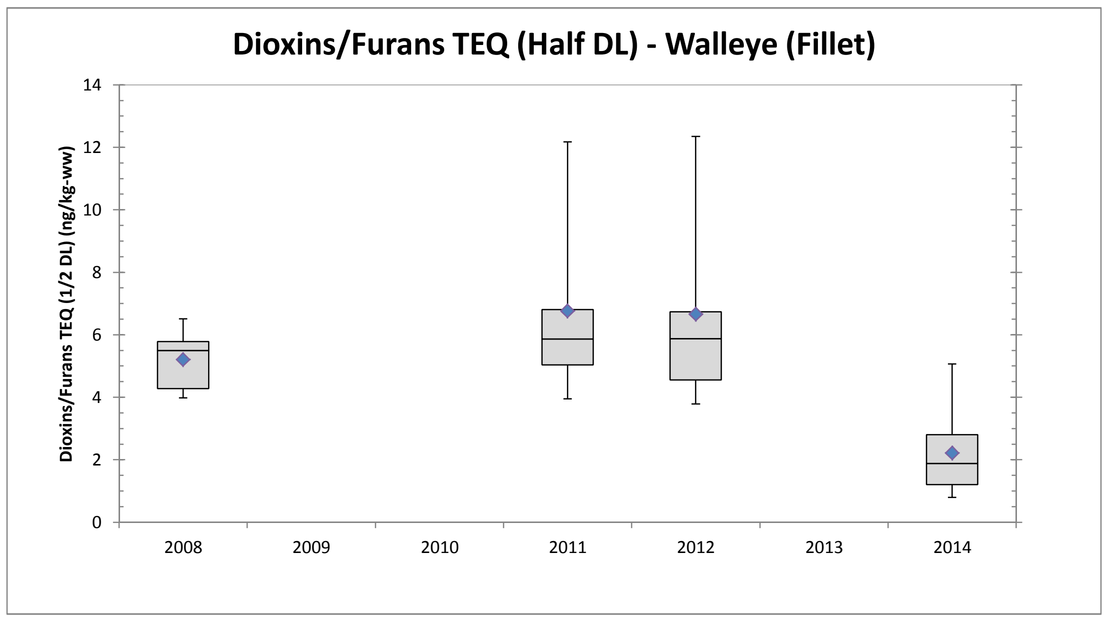


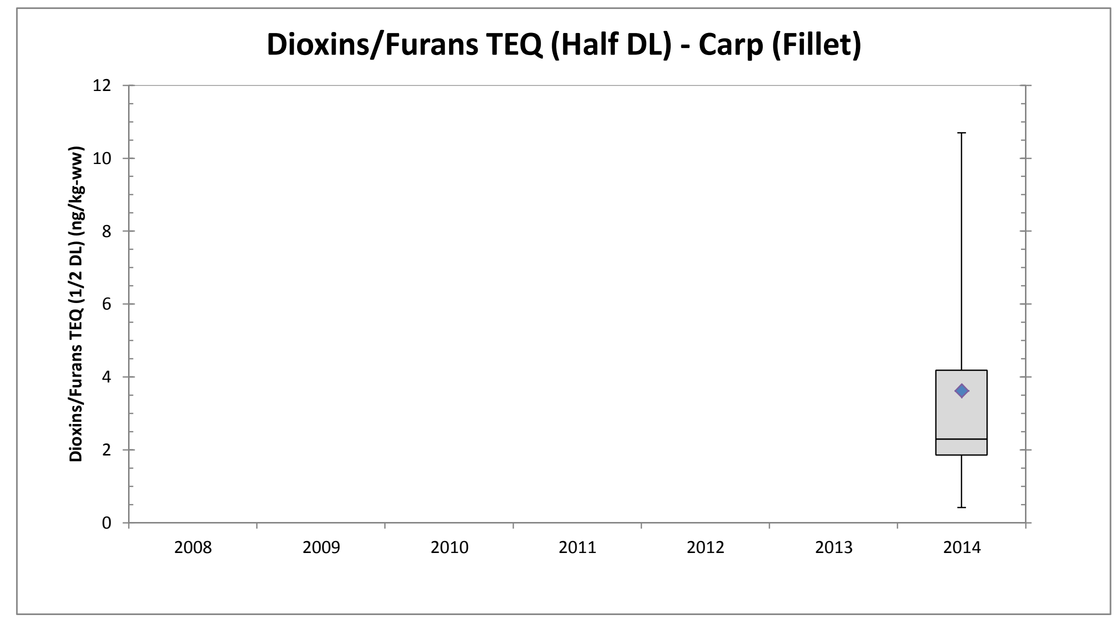


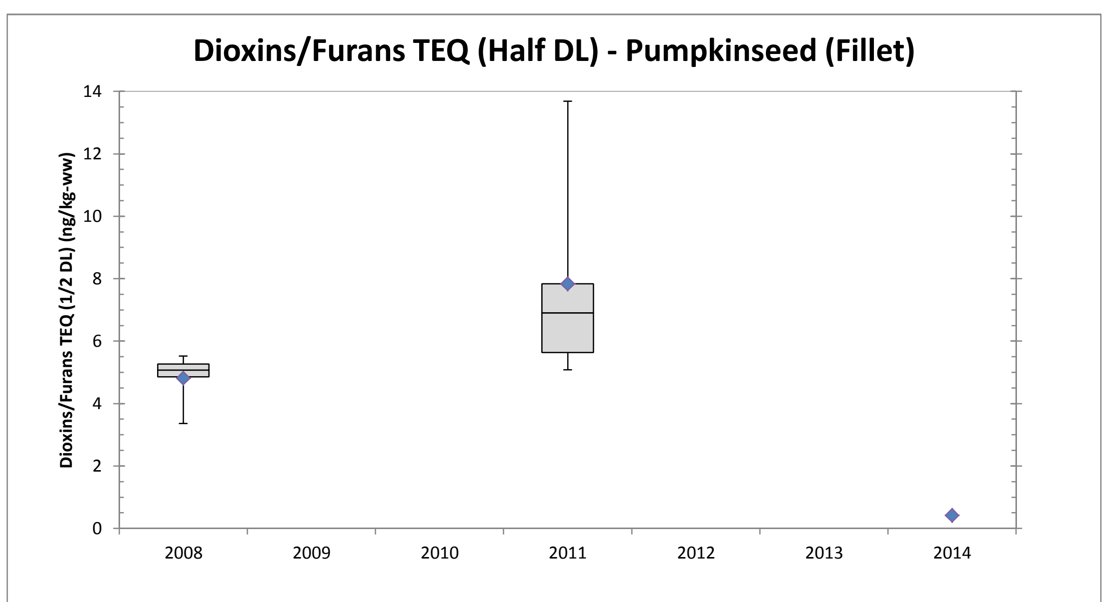
Honeywell Dioxins/Furans Data - Set 1



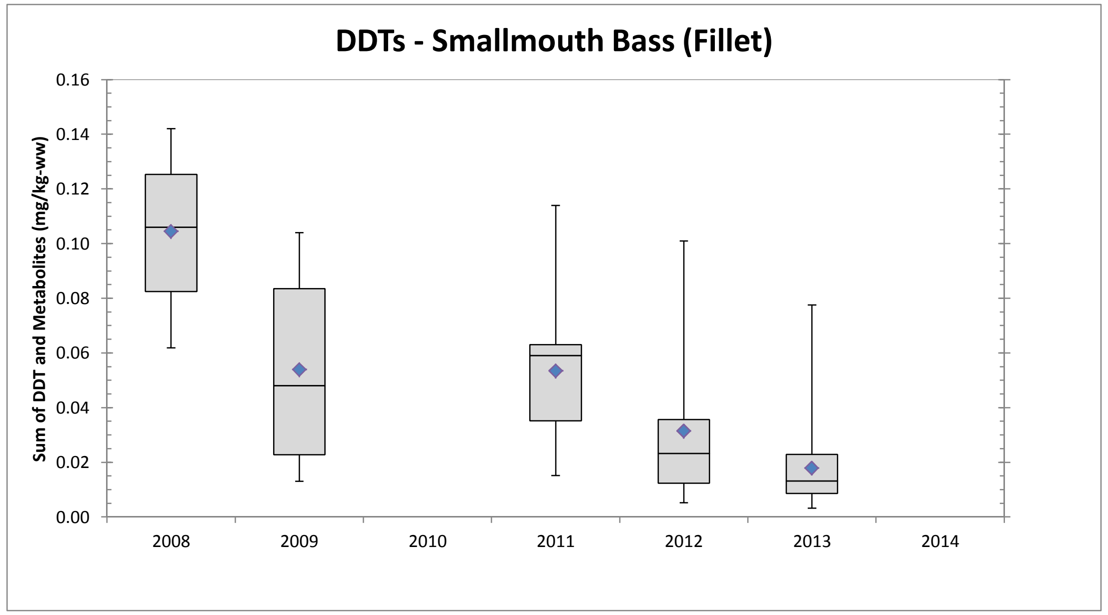


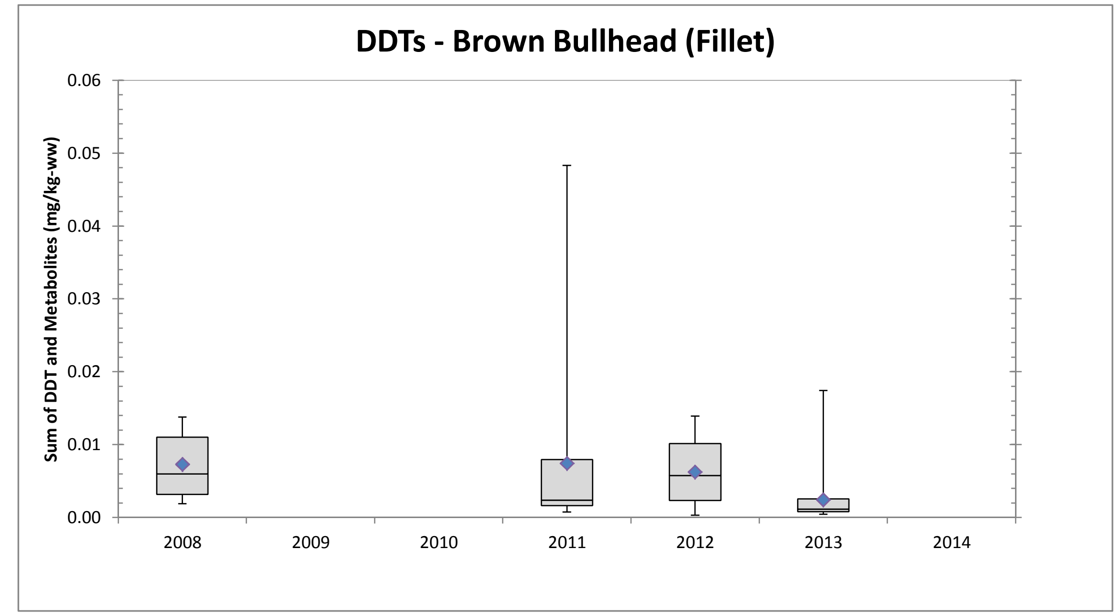


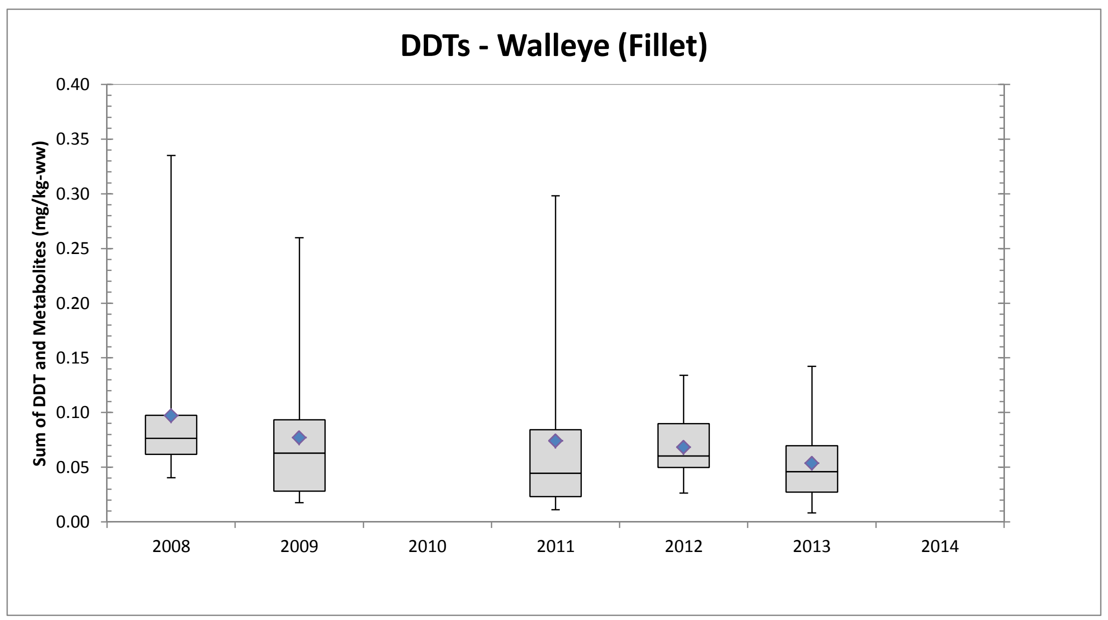


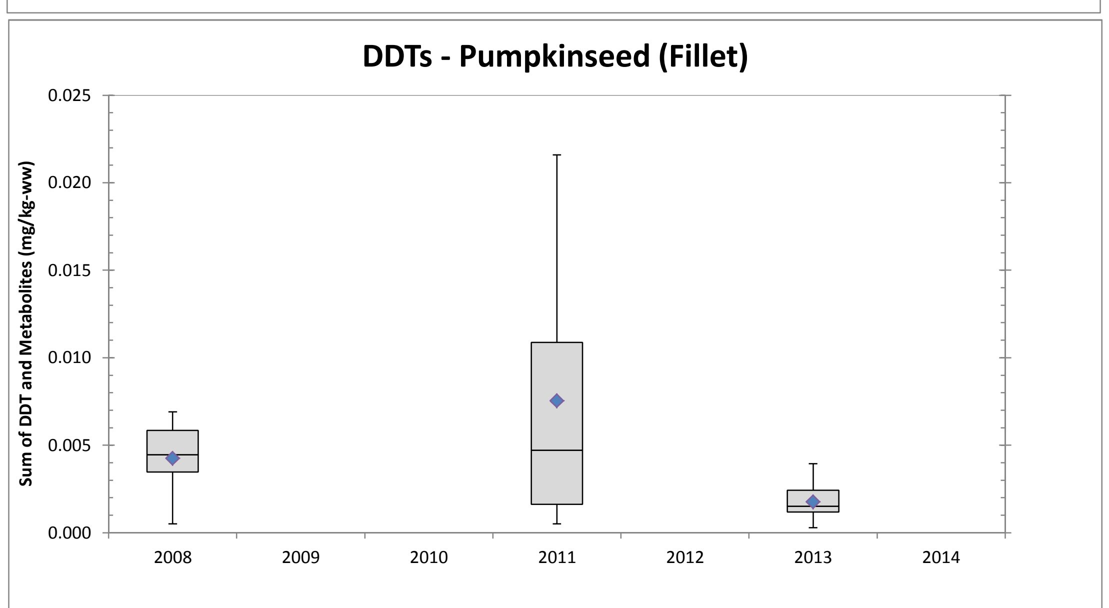


Honeywell DDTs Data - Set 1

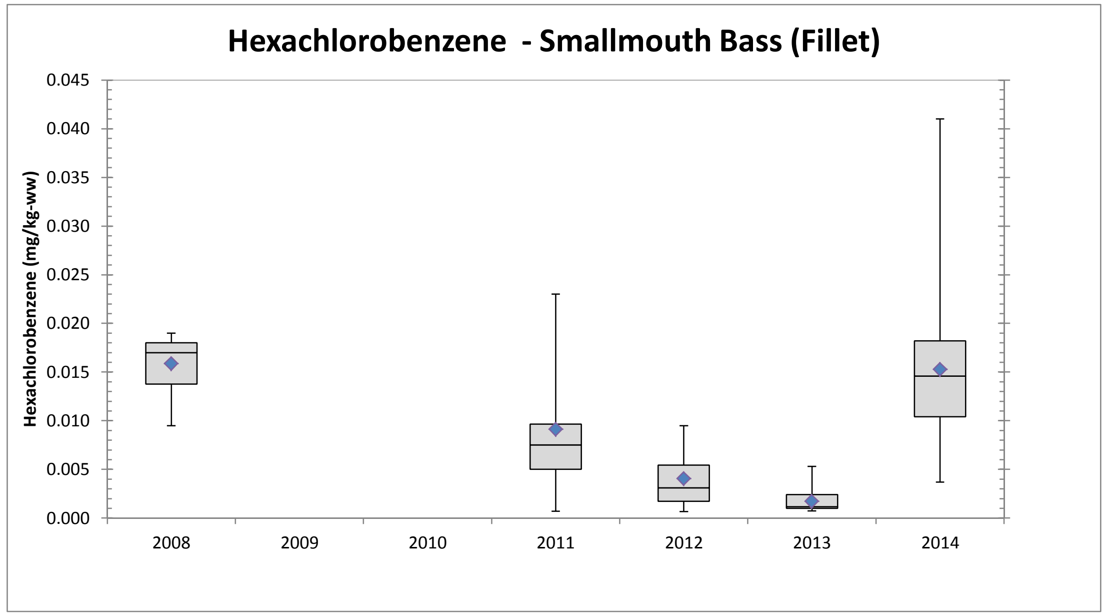


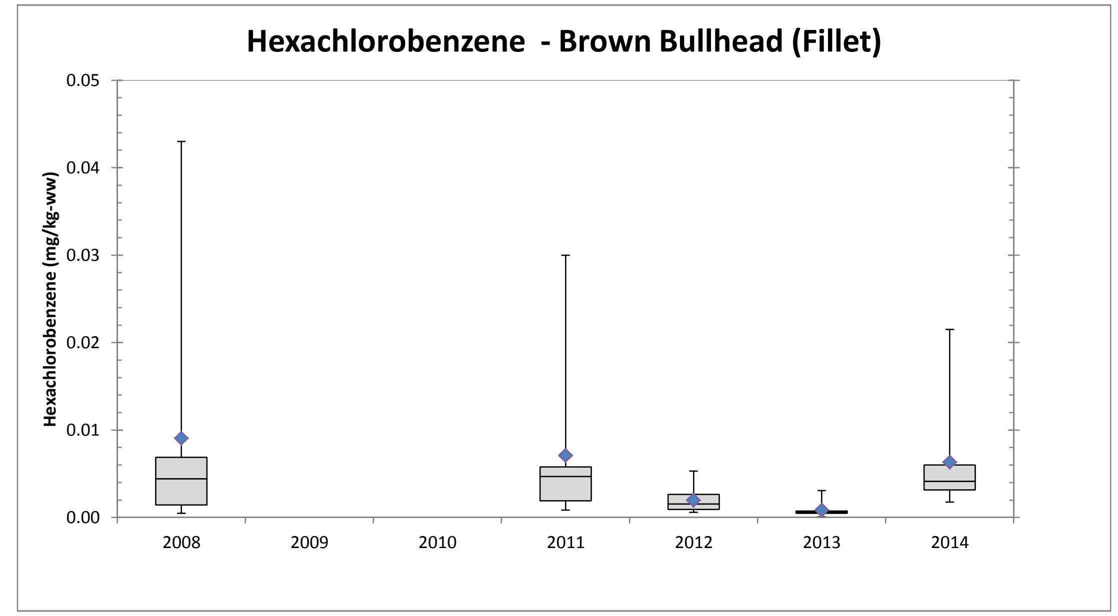


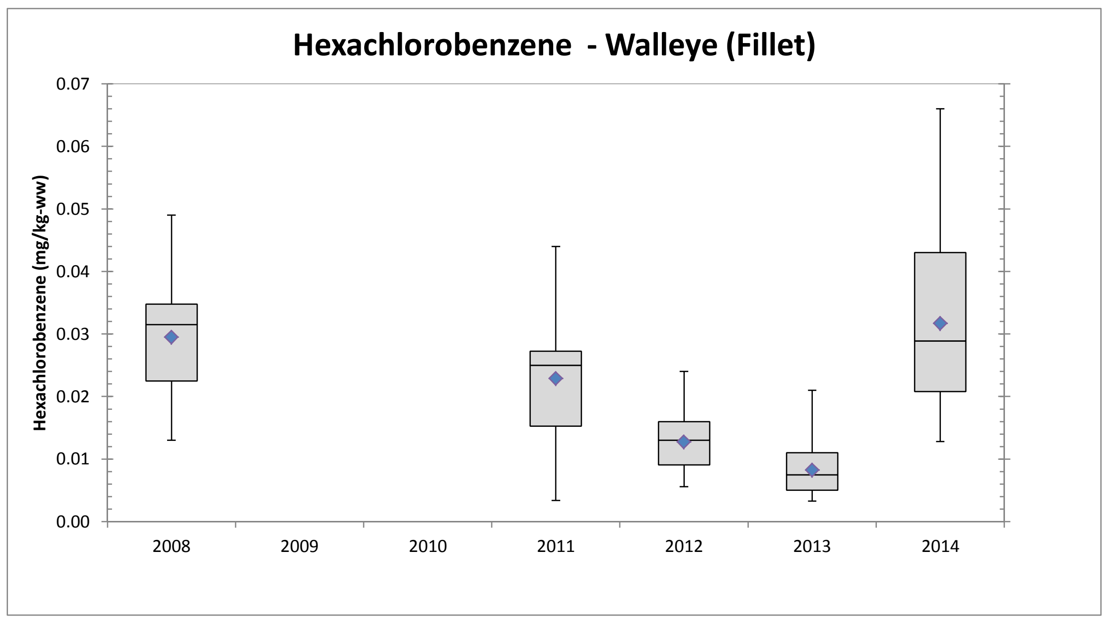


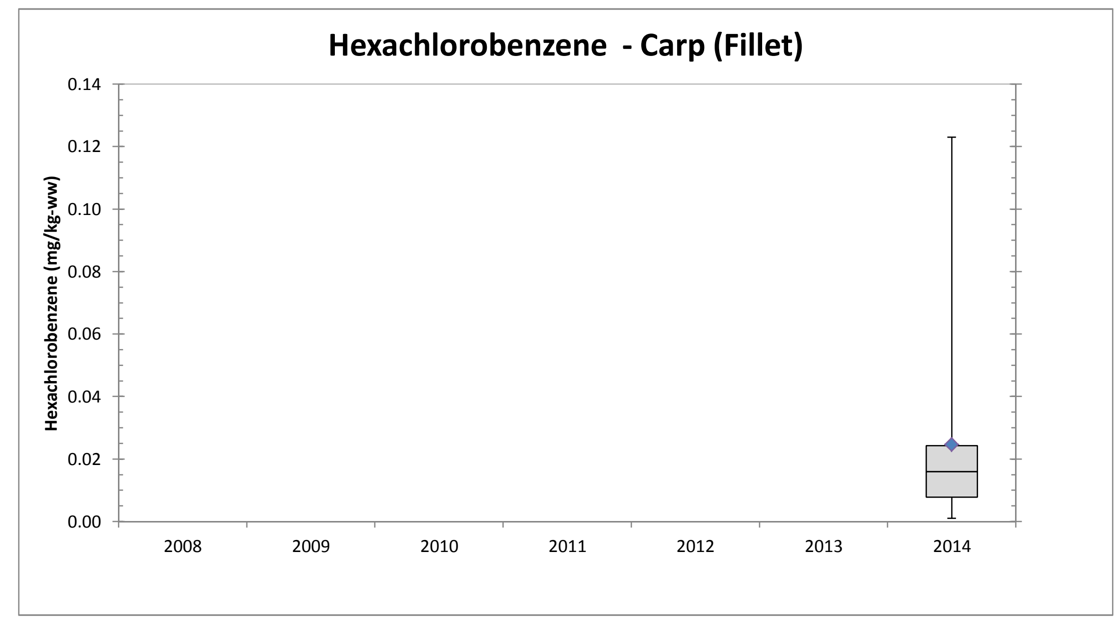


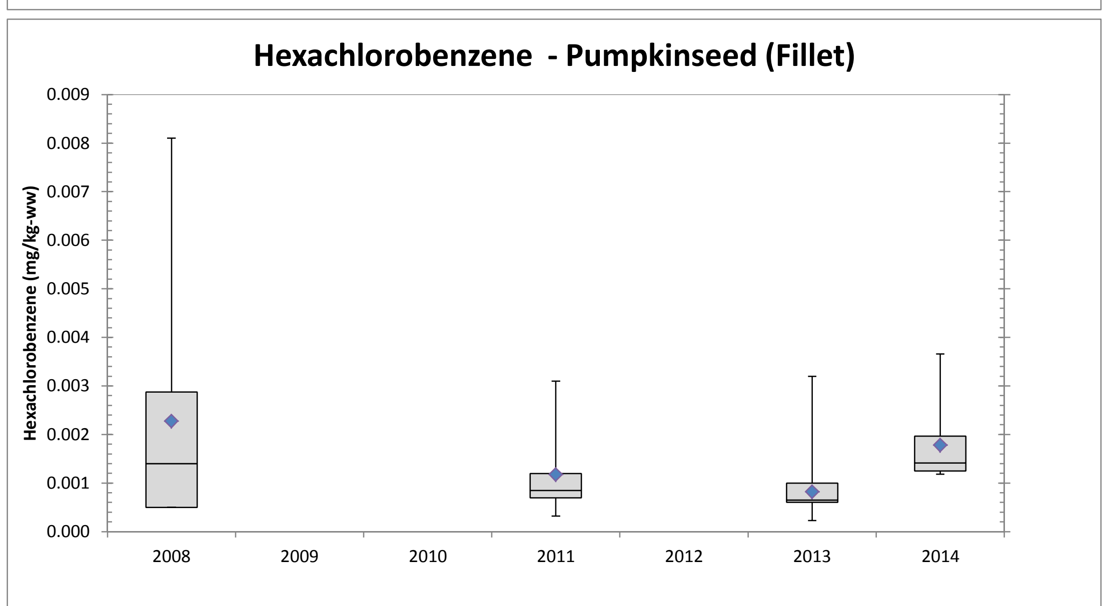
Honeywell Hexachlorobenzene Data - Set 1









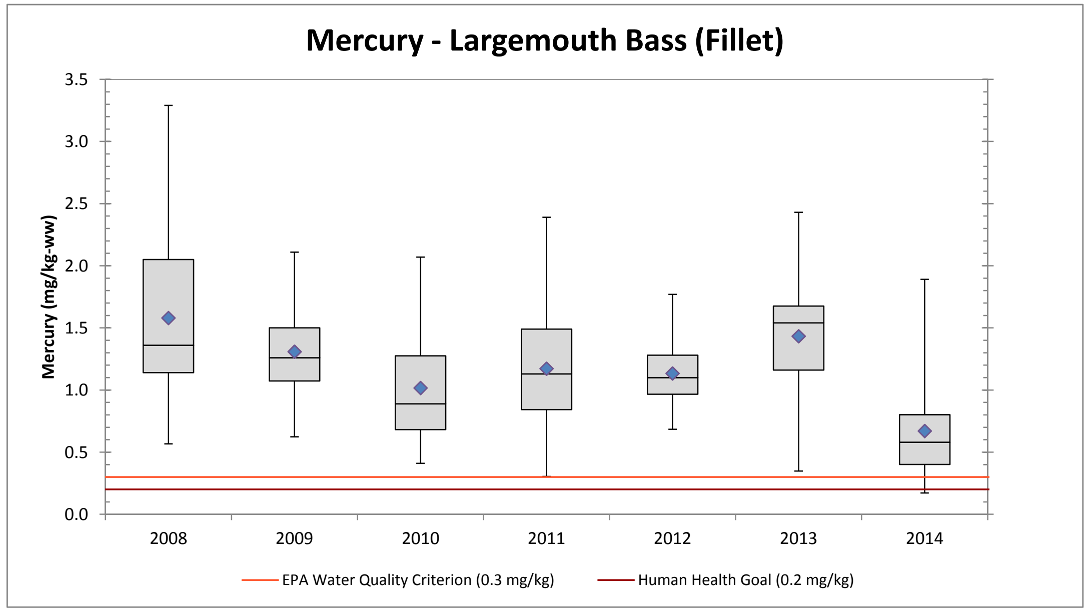


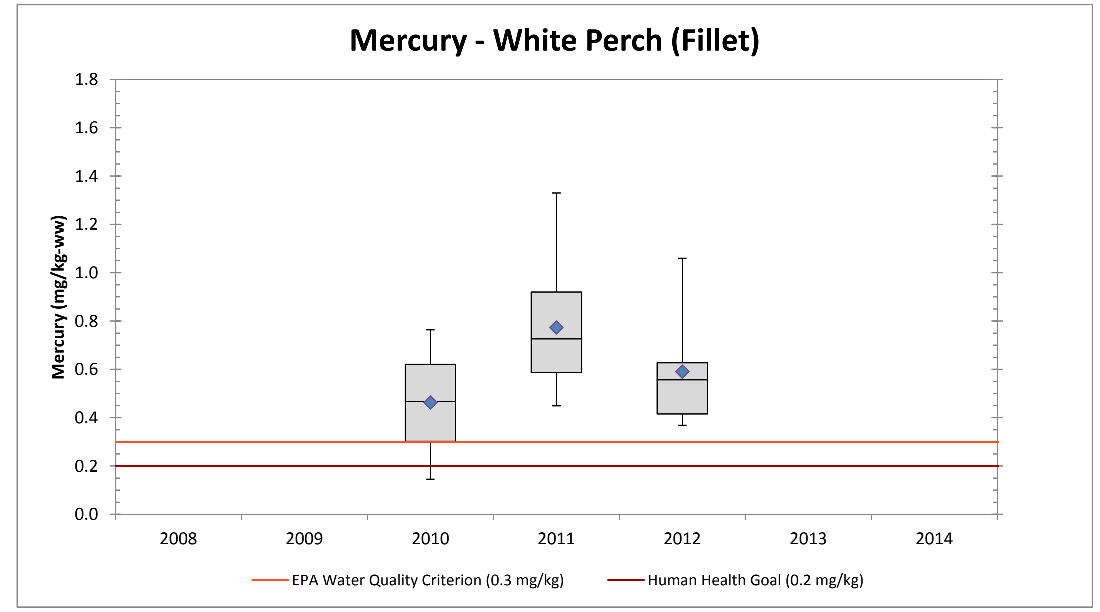
NYSDEC Data (2008-2014)

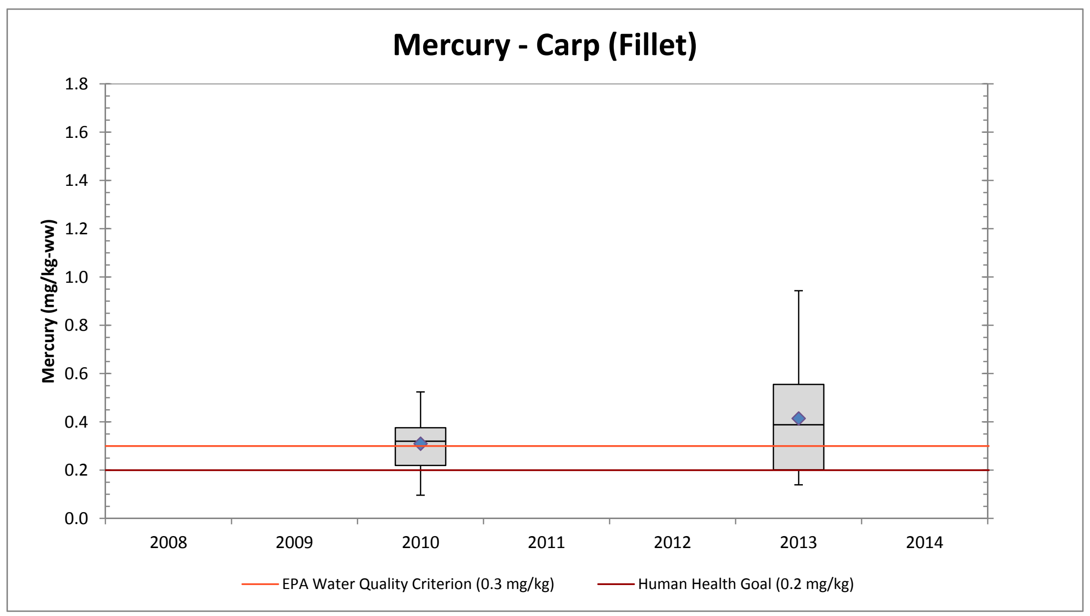
AECOM

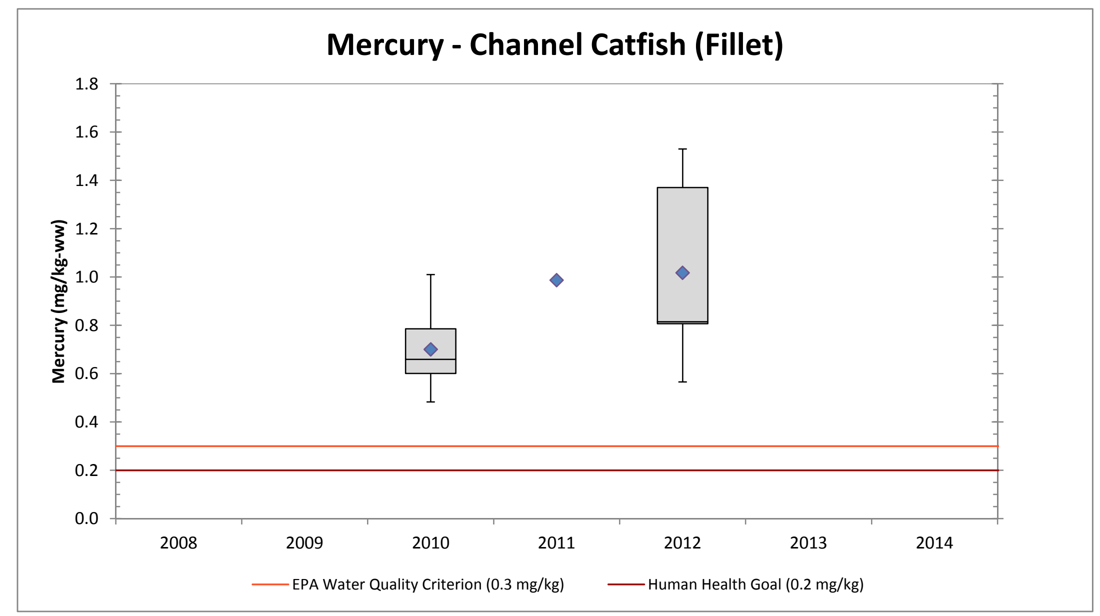
June 2015

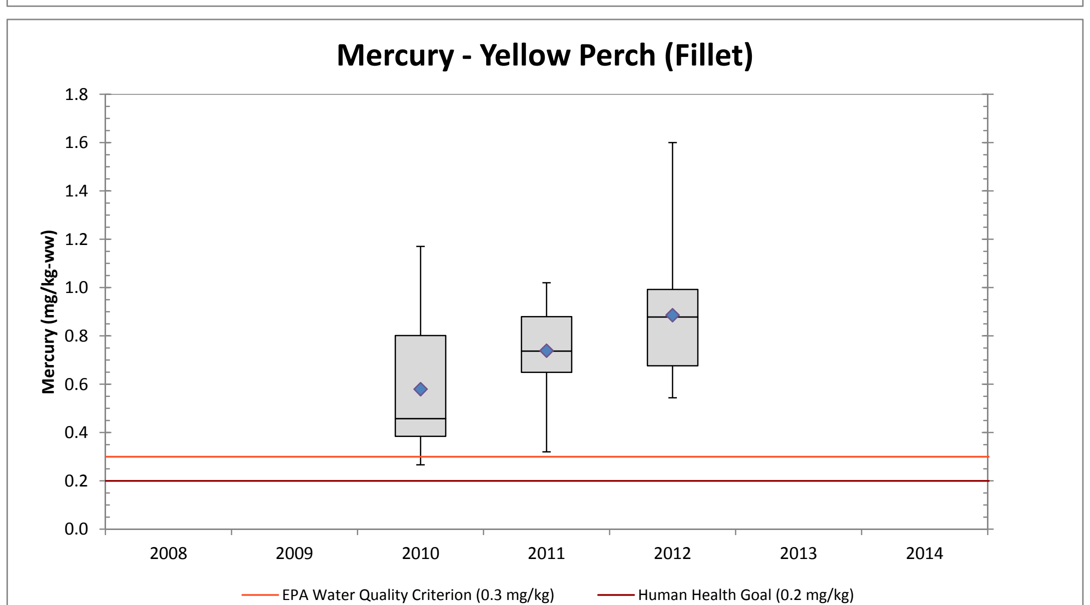
NYSDEC Mercury Data - Set 1



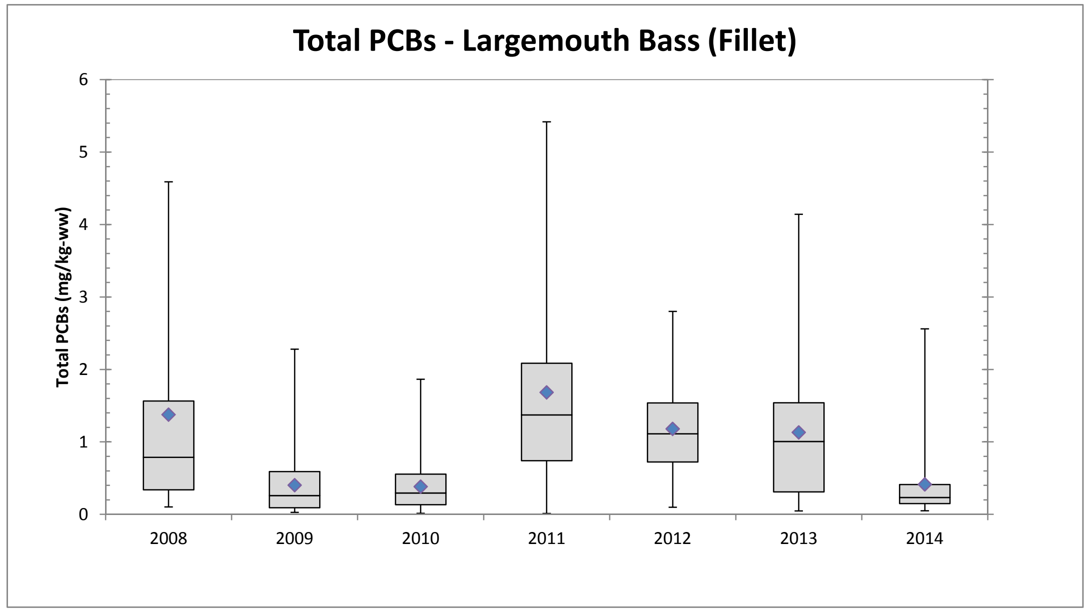


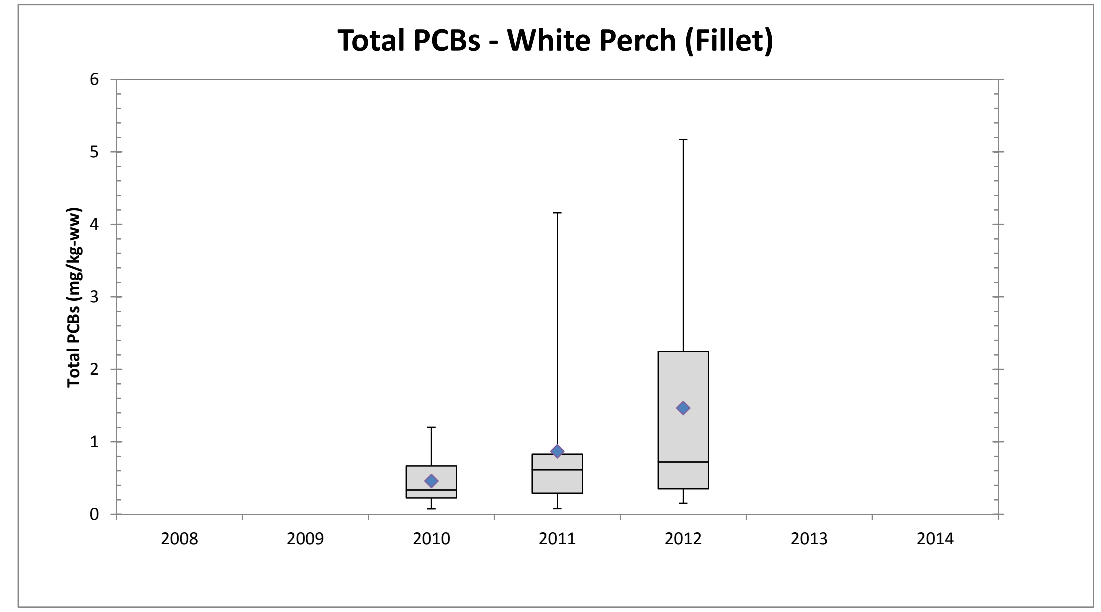


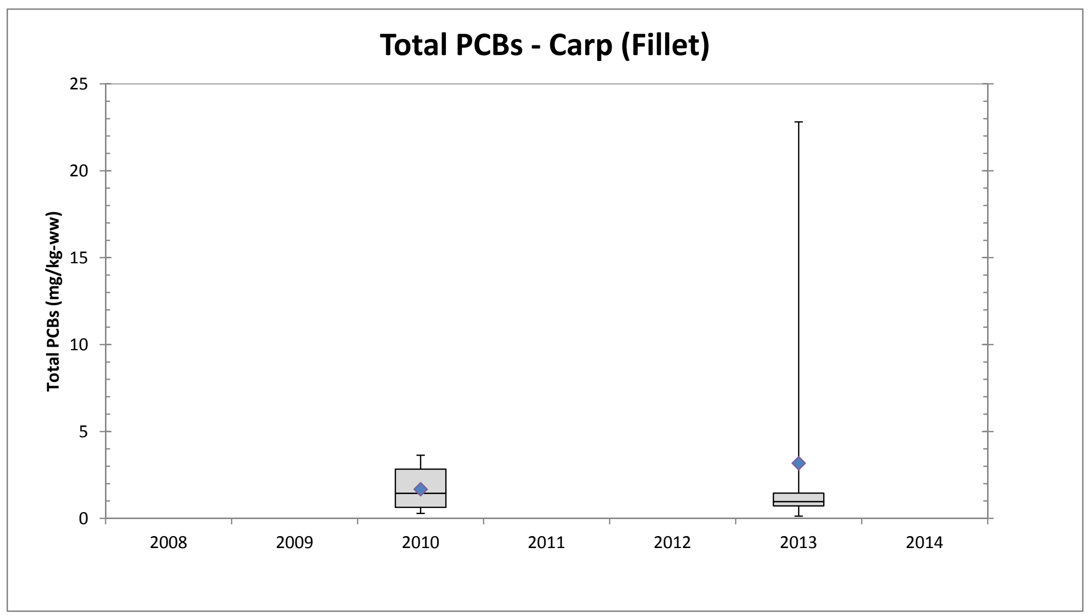


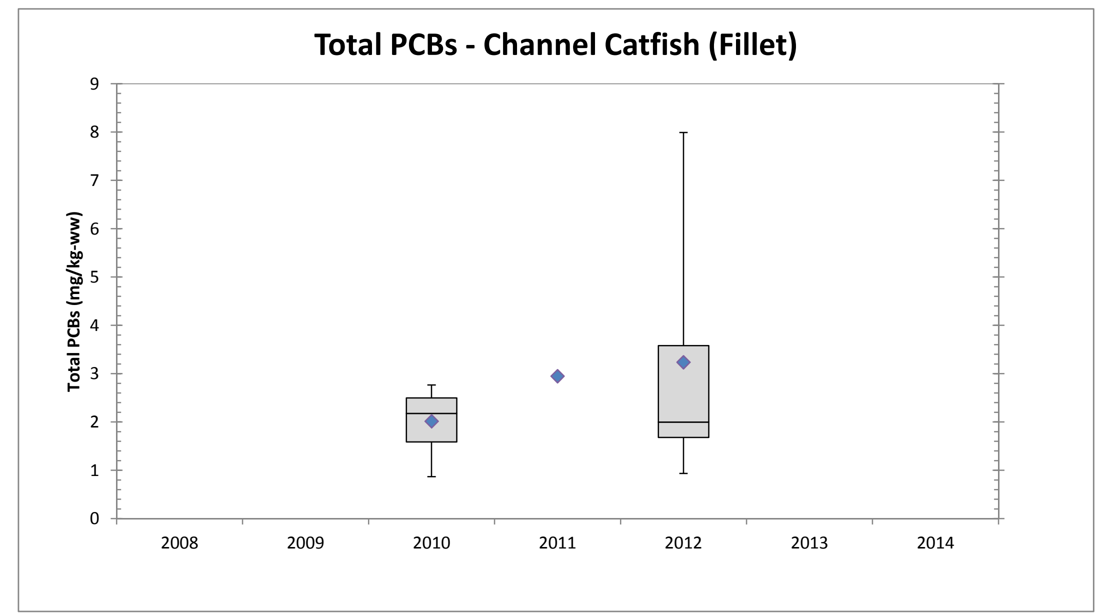


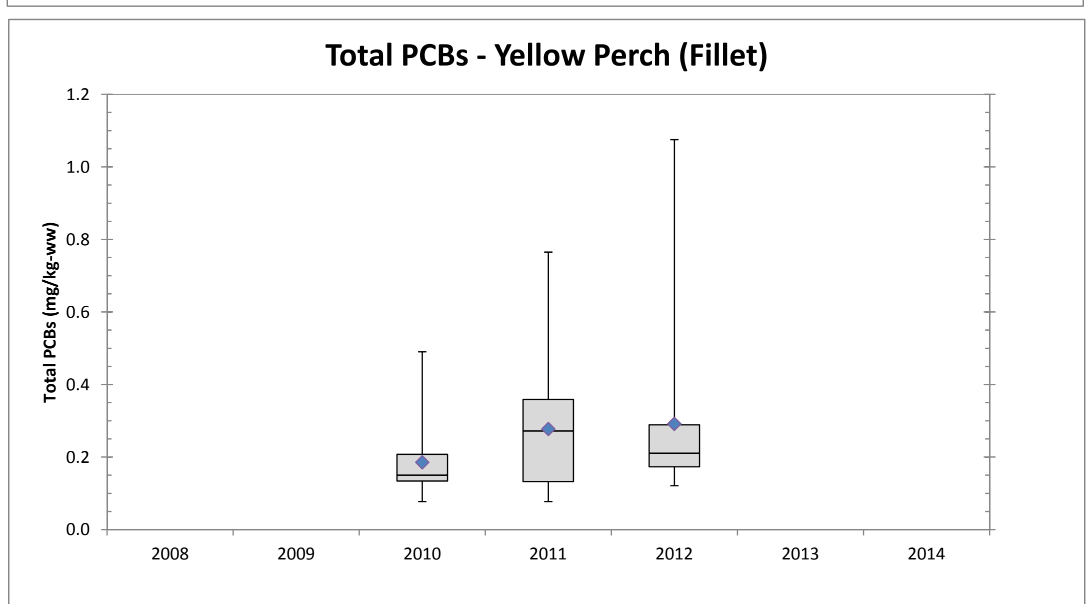
NYSDEC Total PCBs Data - Set 1



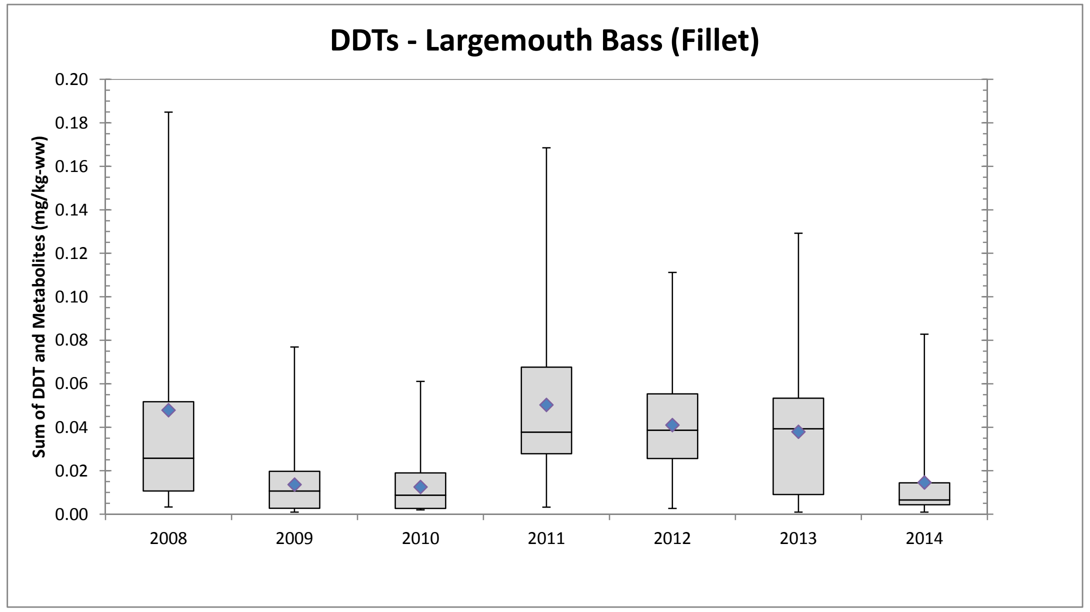


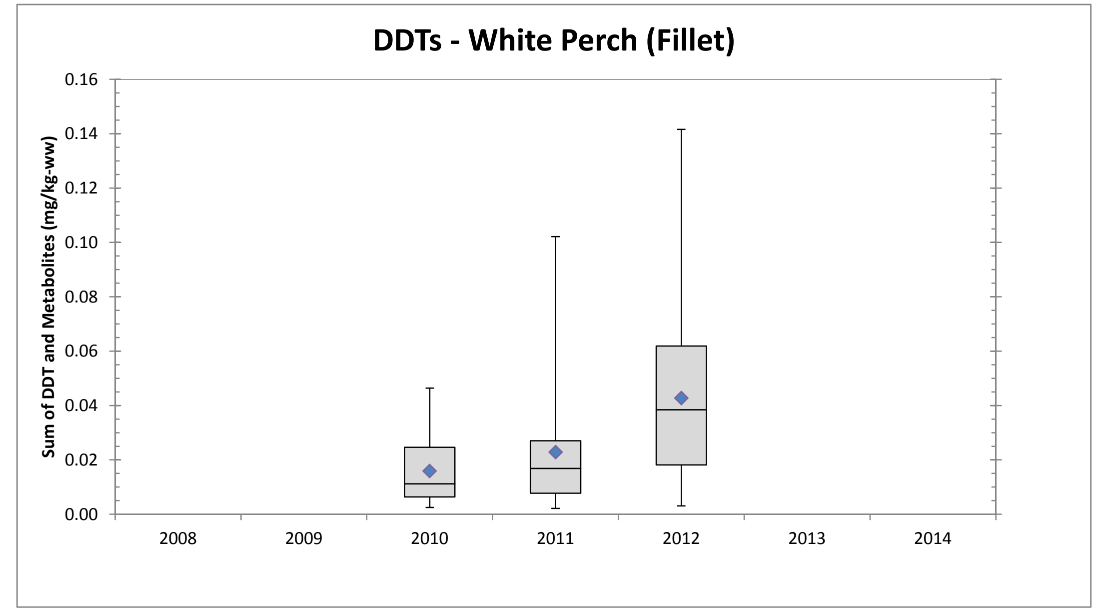


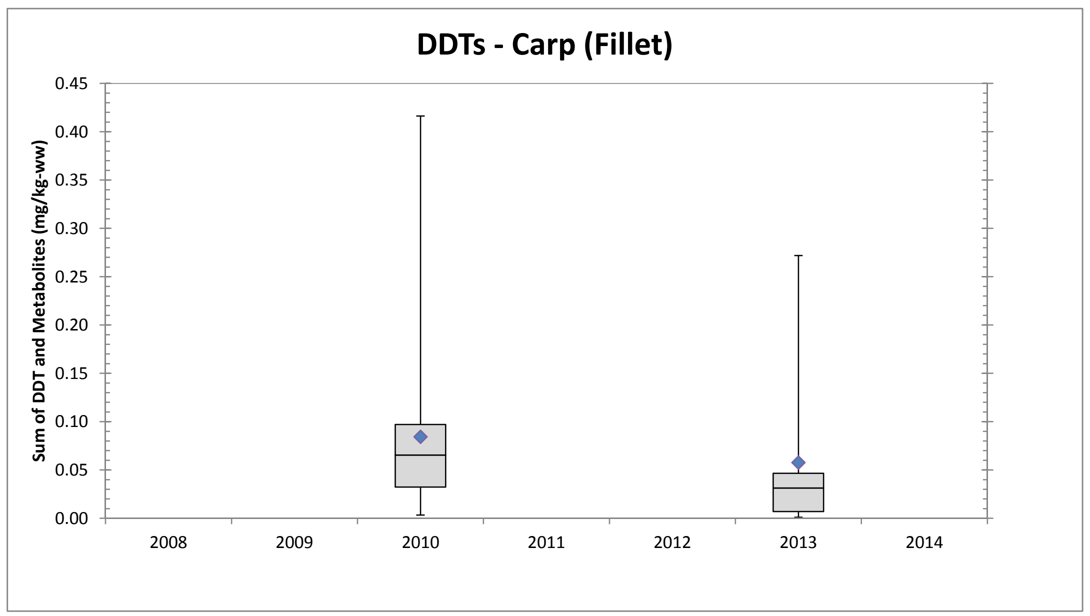


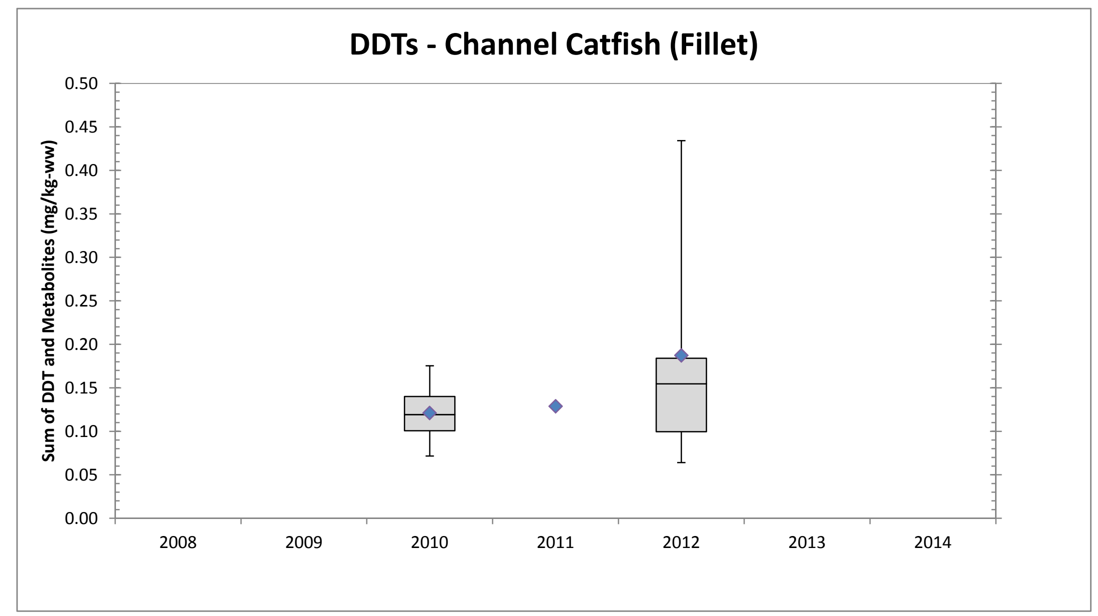


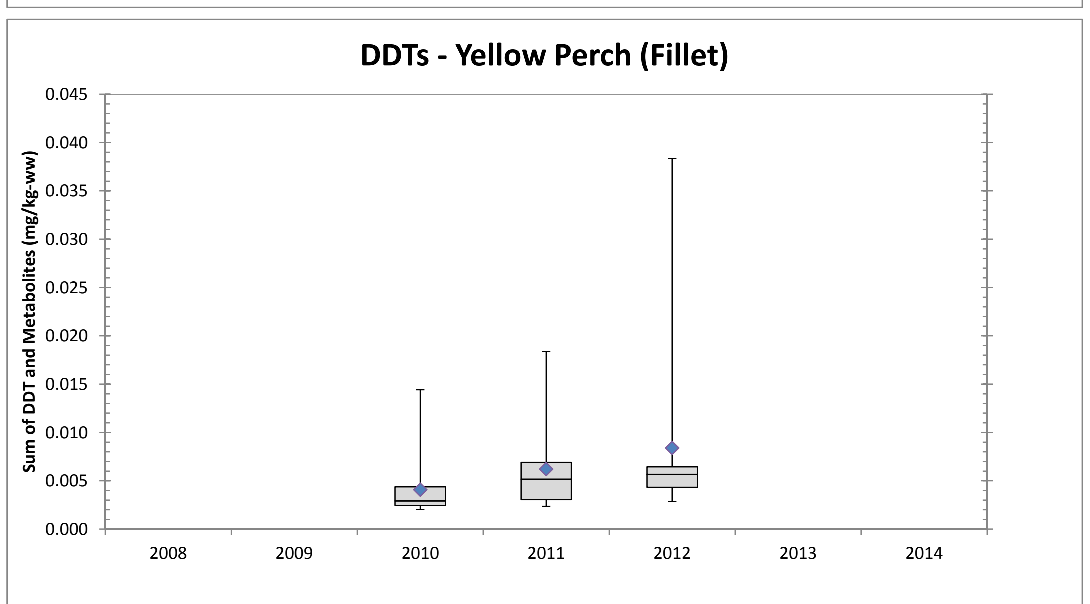
NYSDEC DDTs Data - Set 1



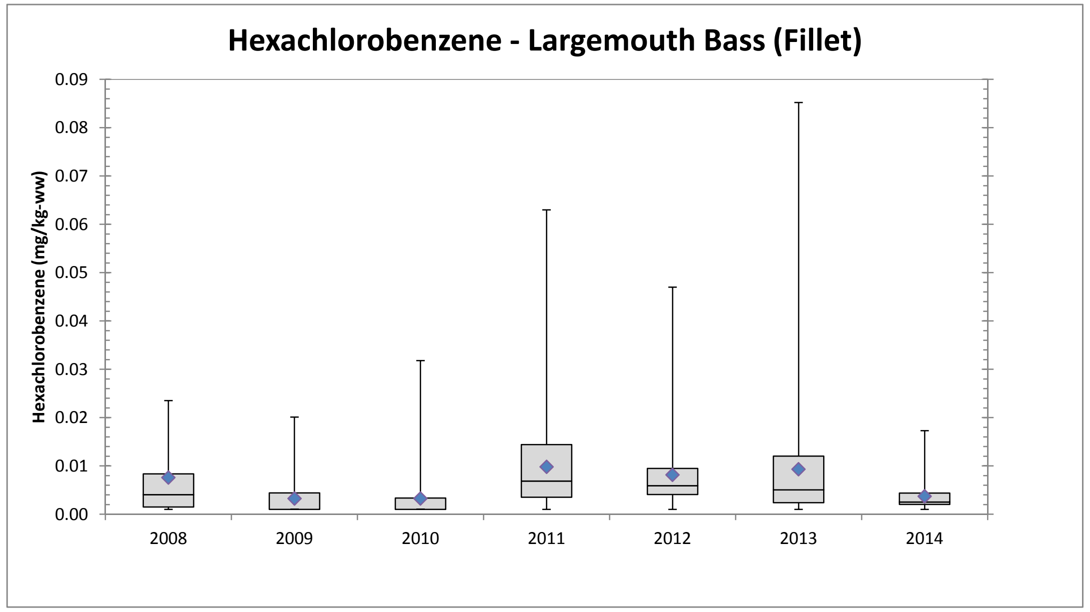


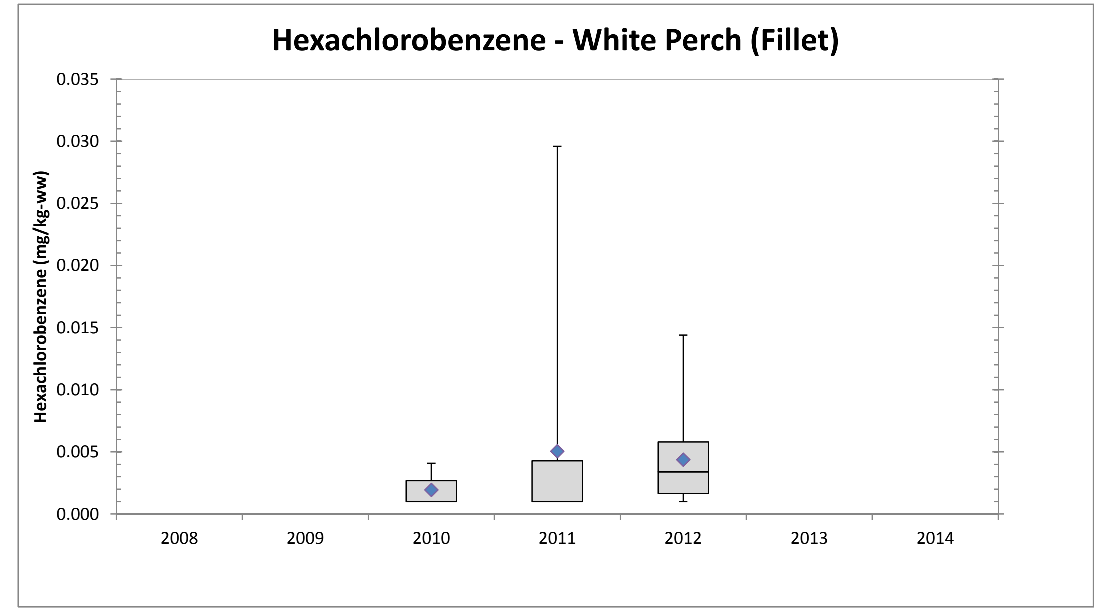


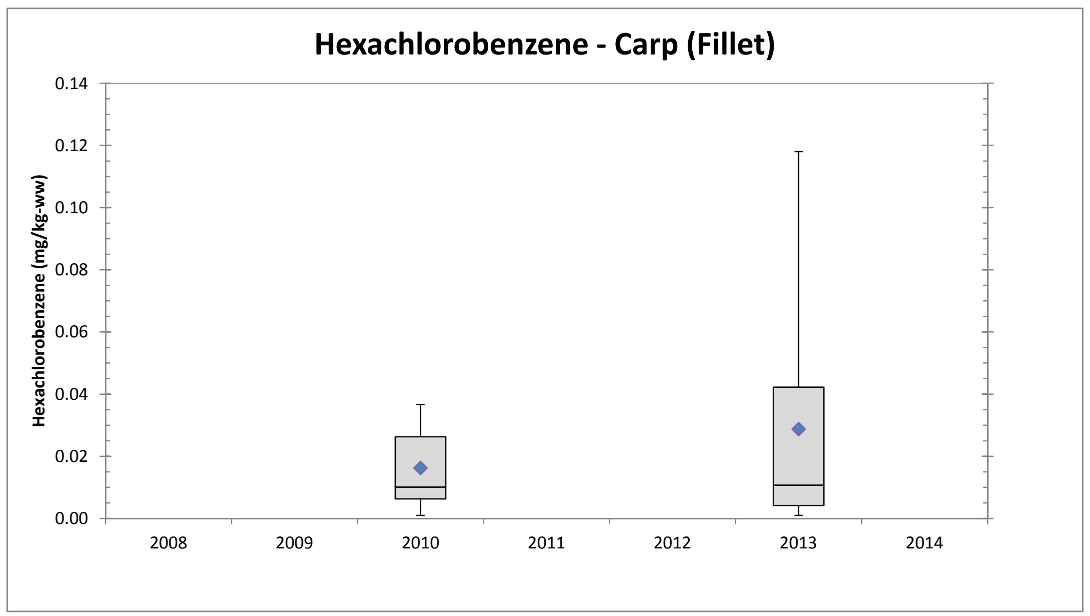


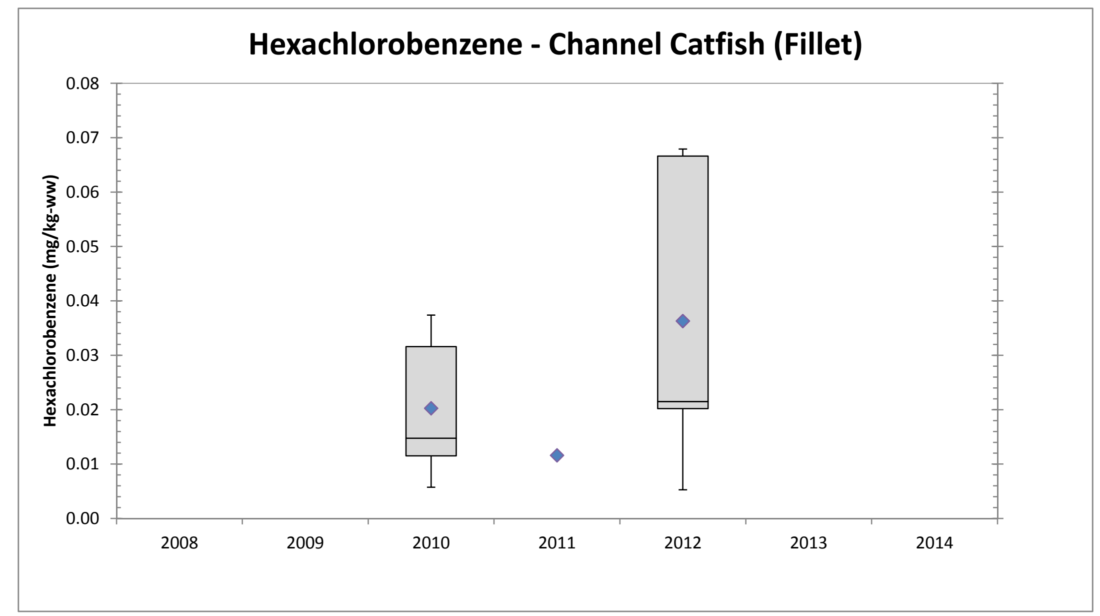


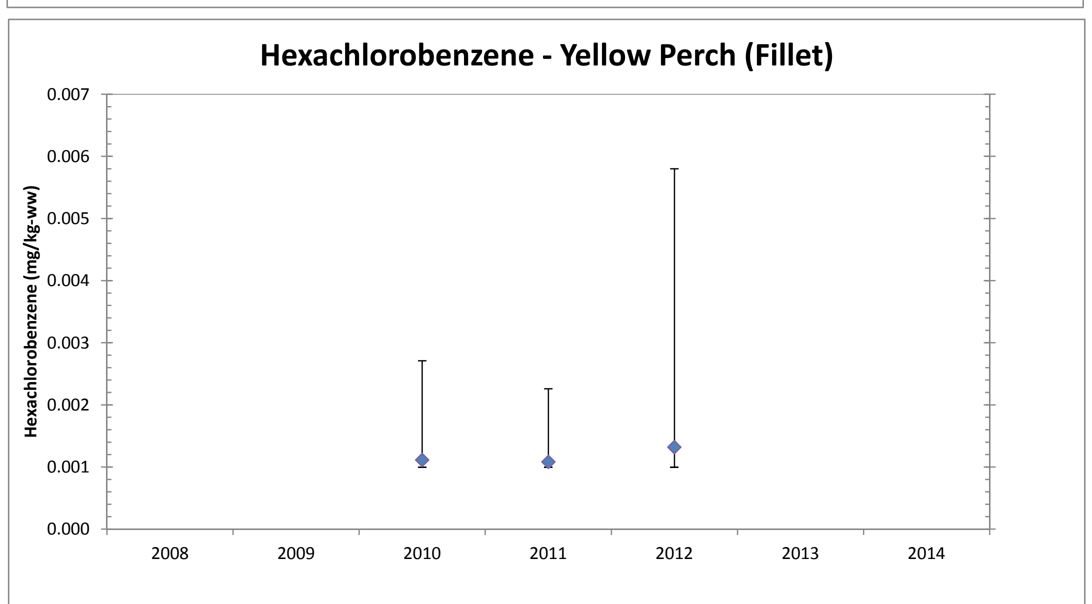
NYSDEC Hexachlorobenzene Data - Set 1











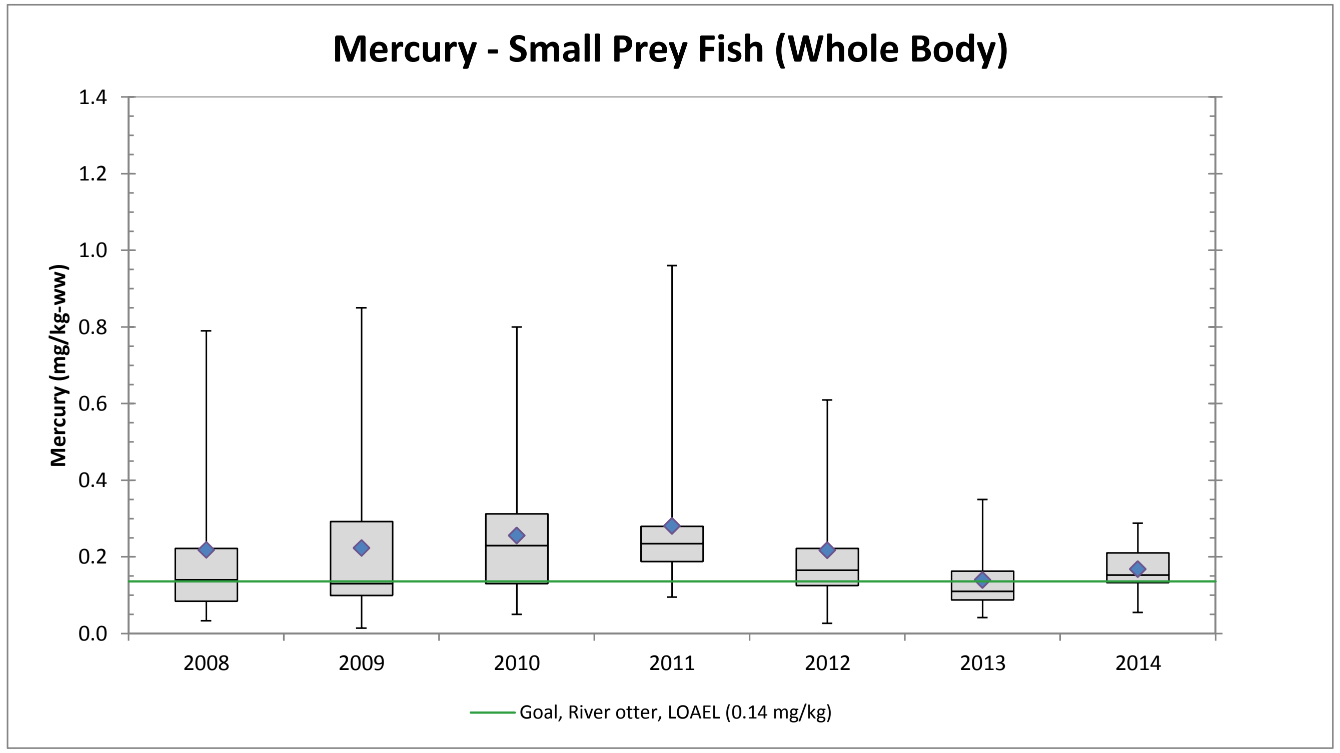
Set 2:
Small (3 to 18 cm) Prey Fish Whole-Body Concentrations for Ecological Goal

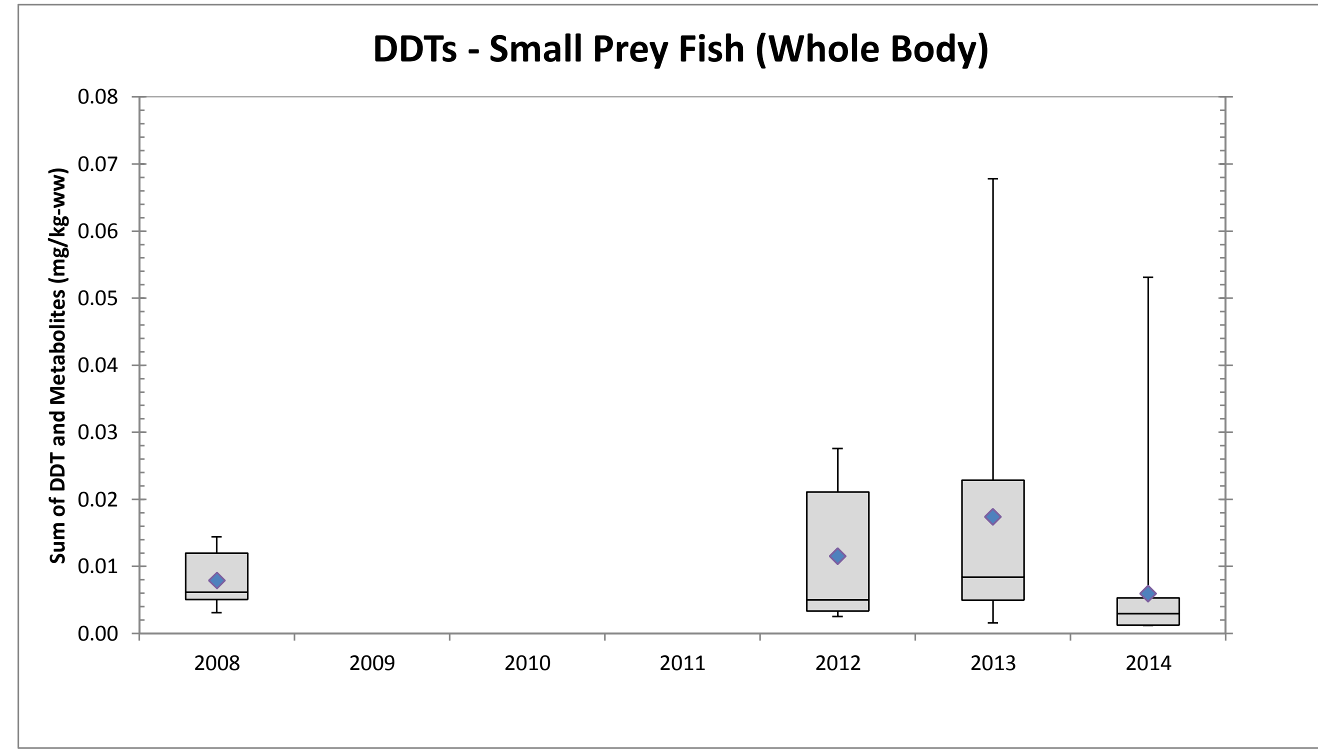
Honeywell Data (2008-2014)

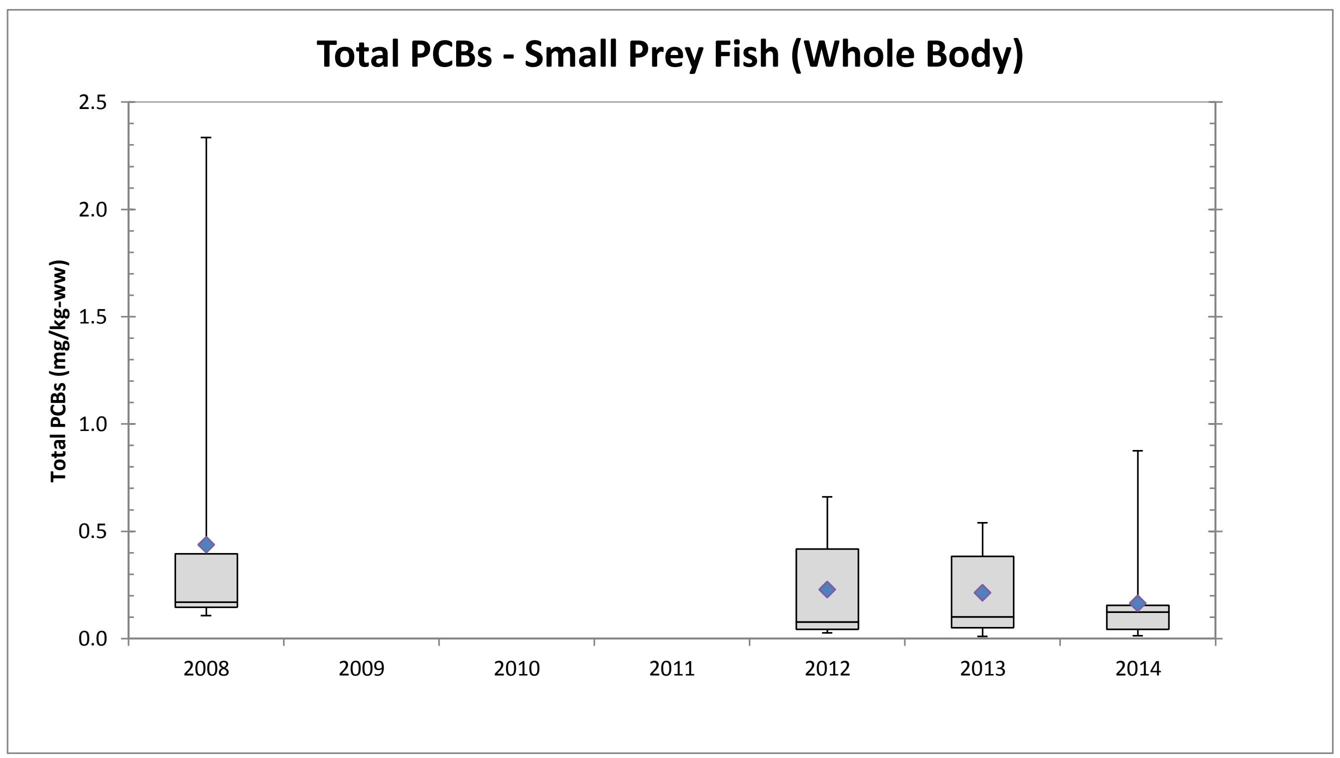
AECOM

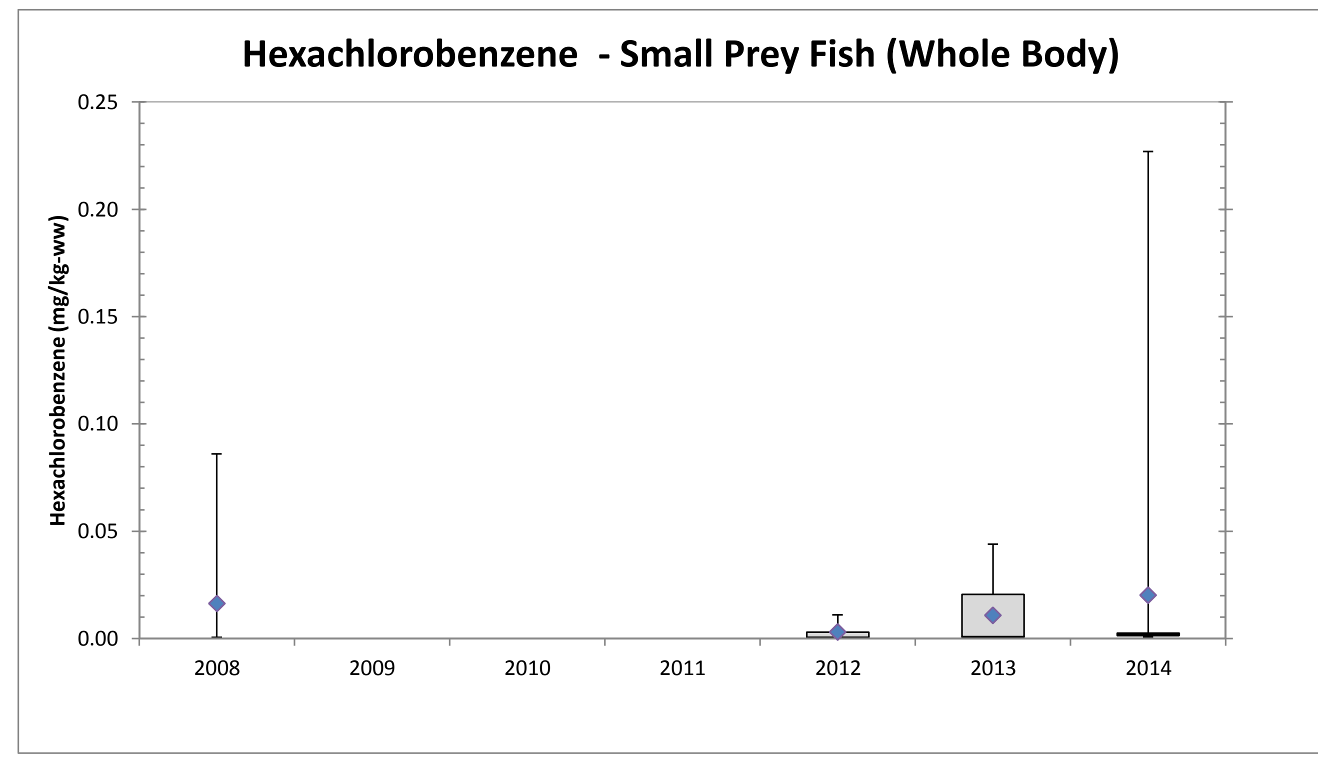
June 2015

Honeywell Small Prey Fish Data - Set 2









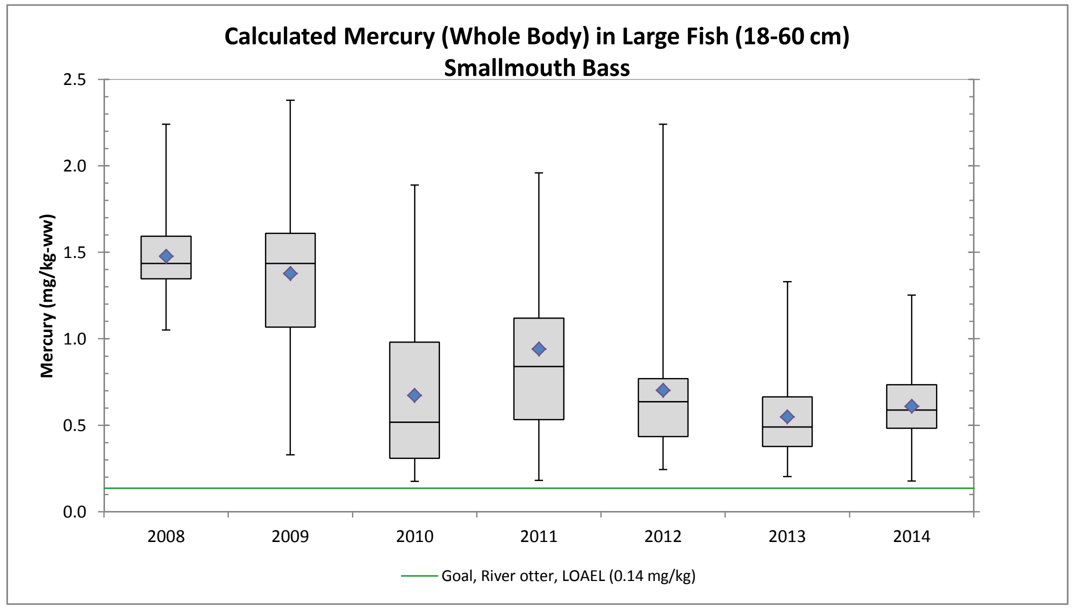
Set 3:
Large (18 to 60 cm) Prey Fish Whole-Body Concentrations for Ecological Goal

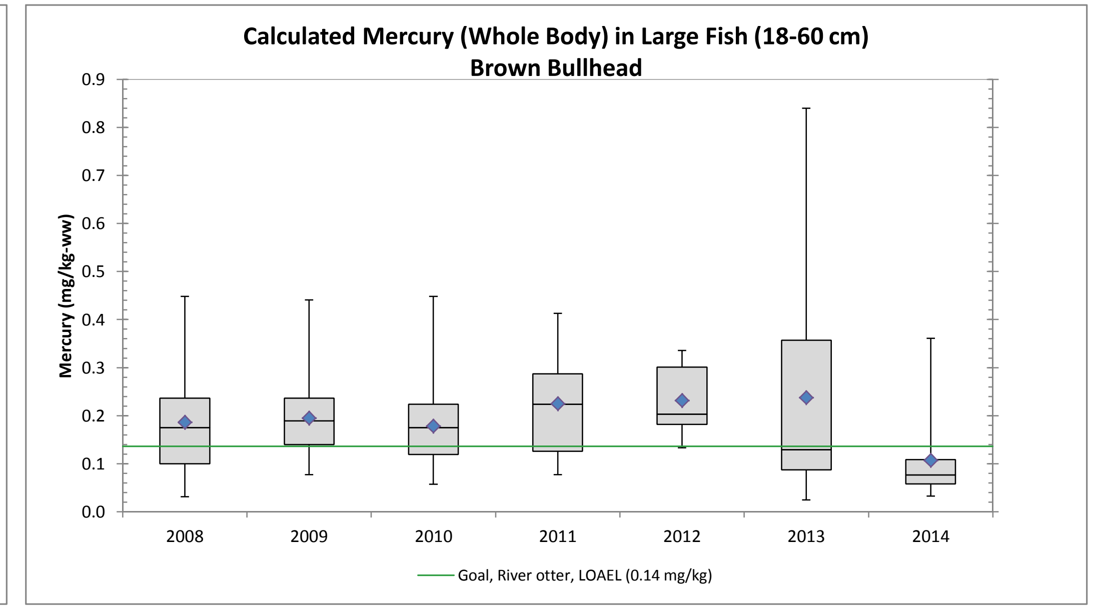
Honeywell Data (2008-2014)

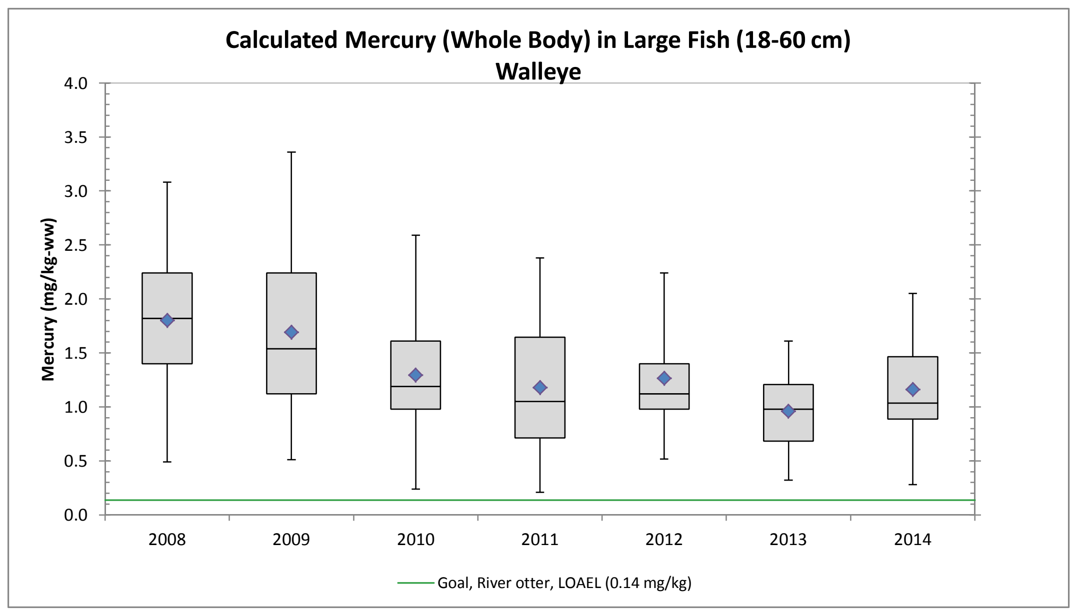
AECOM

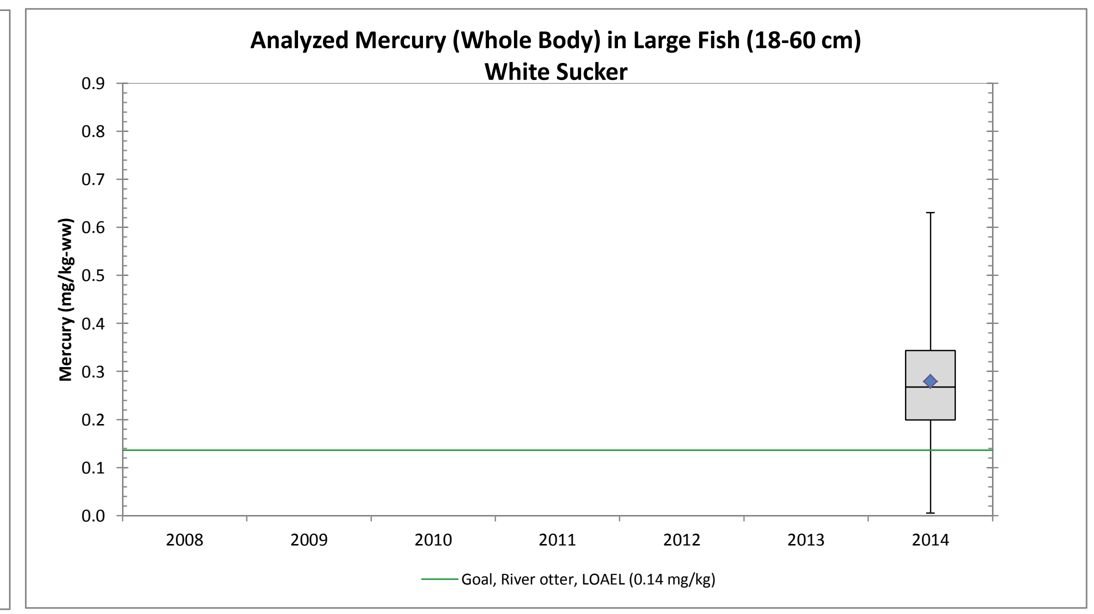
June 2015

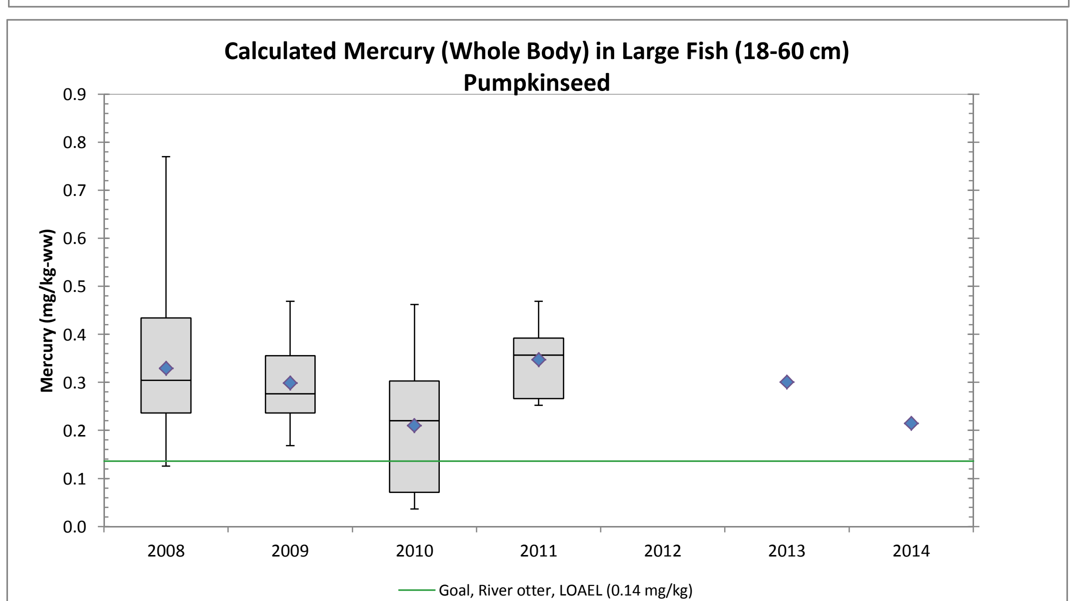
Honeywell Large Prey Fish Data, Mercury - Set 3



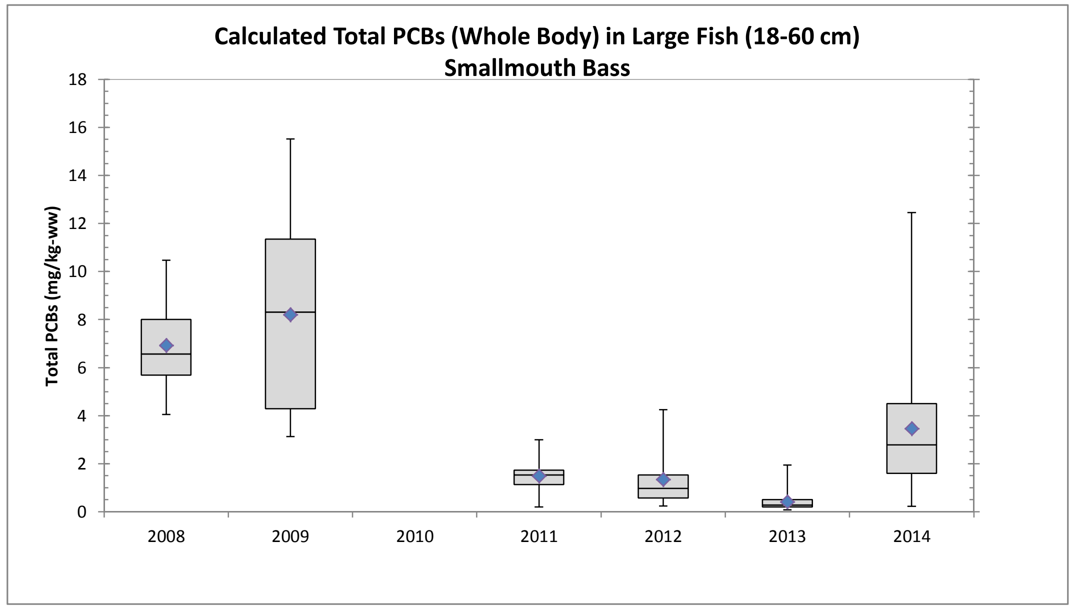


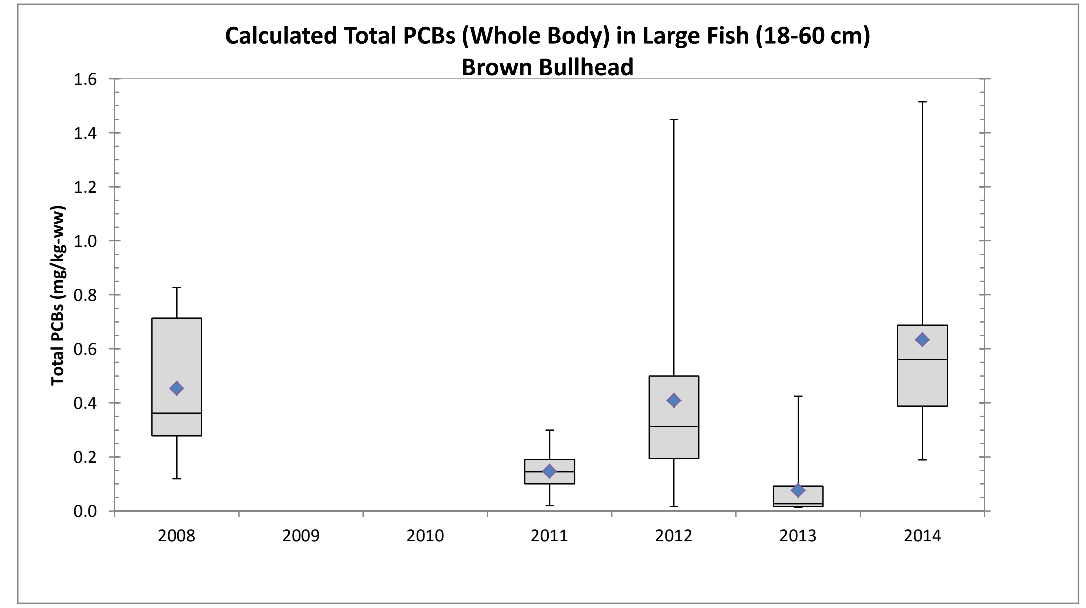


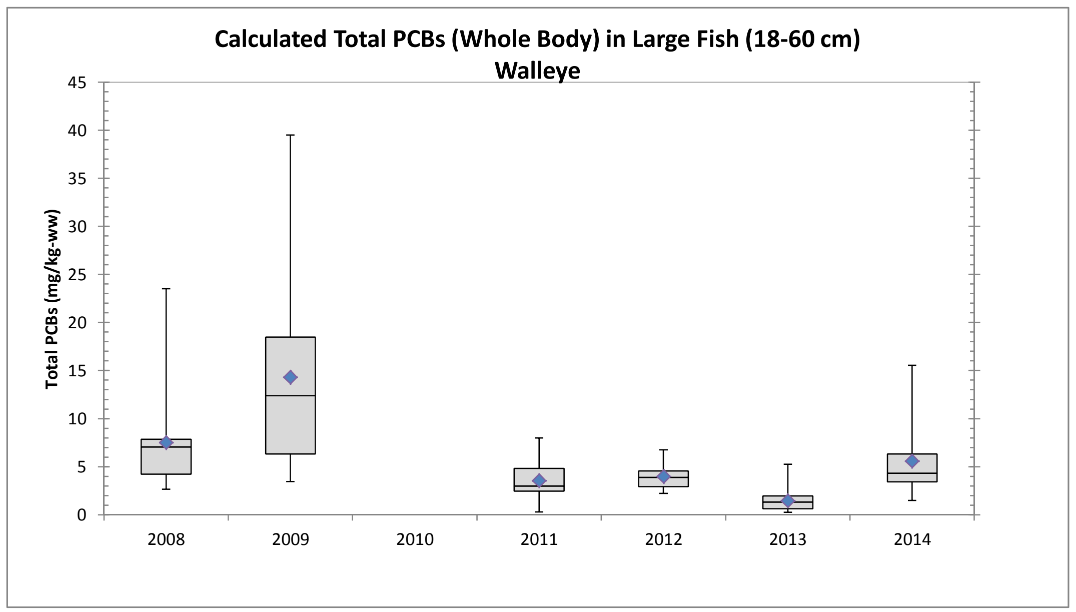


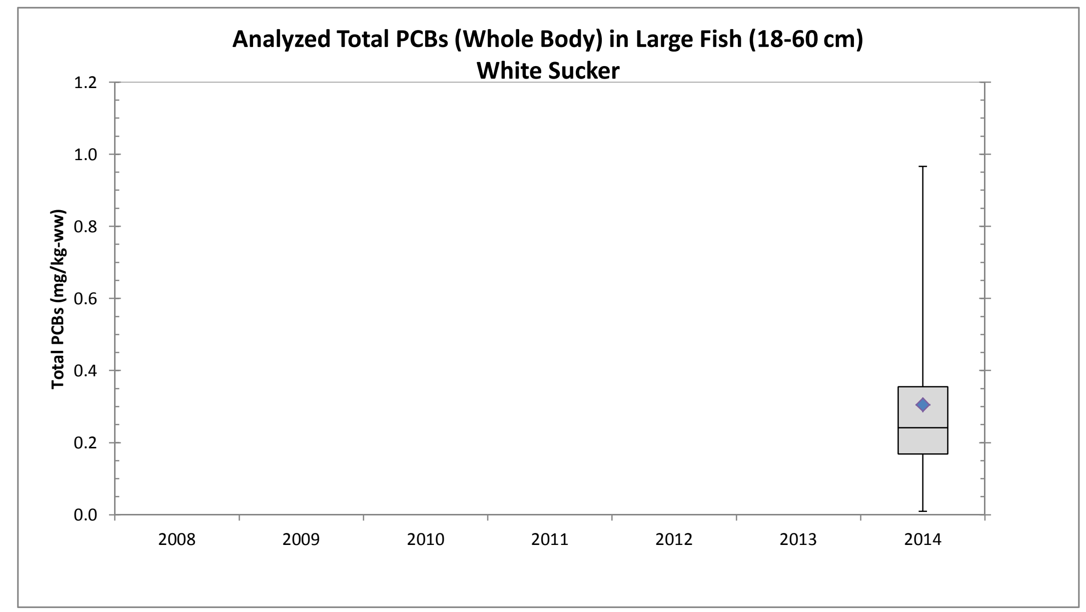


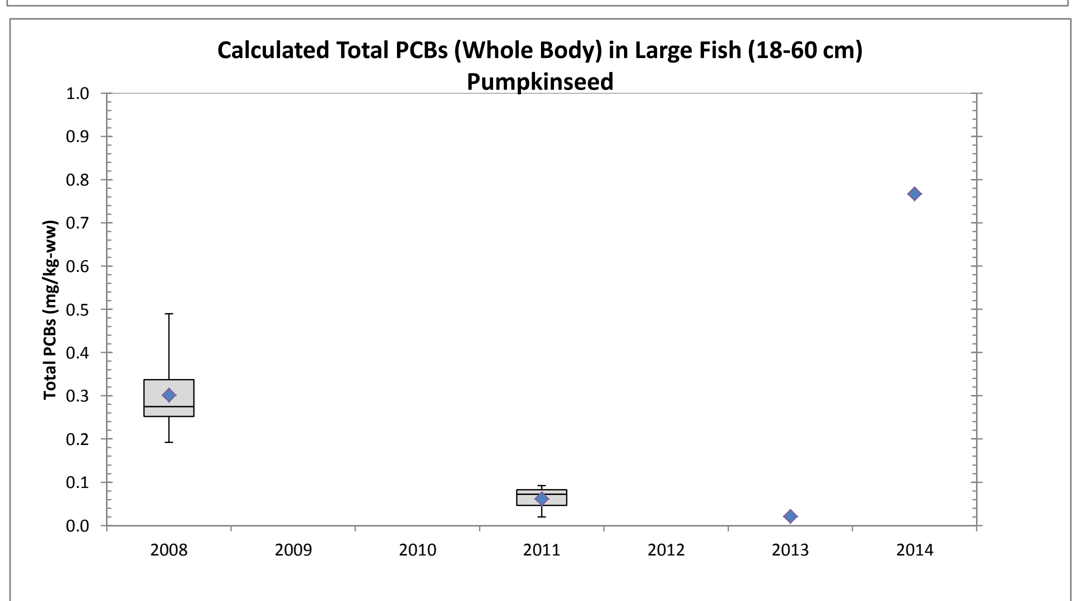
Honeywell Large Prey Fish Data, Total PCBs - Set 3



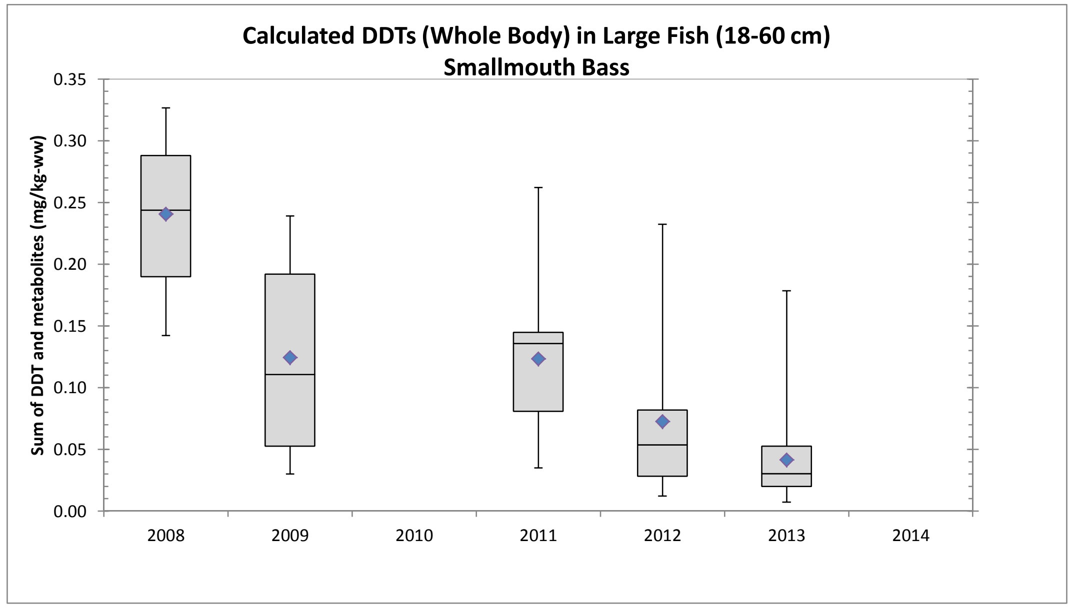


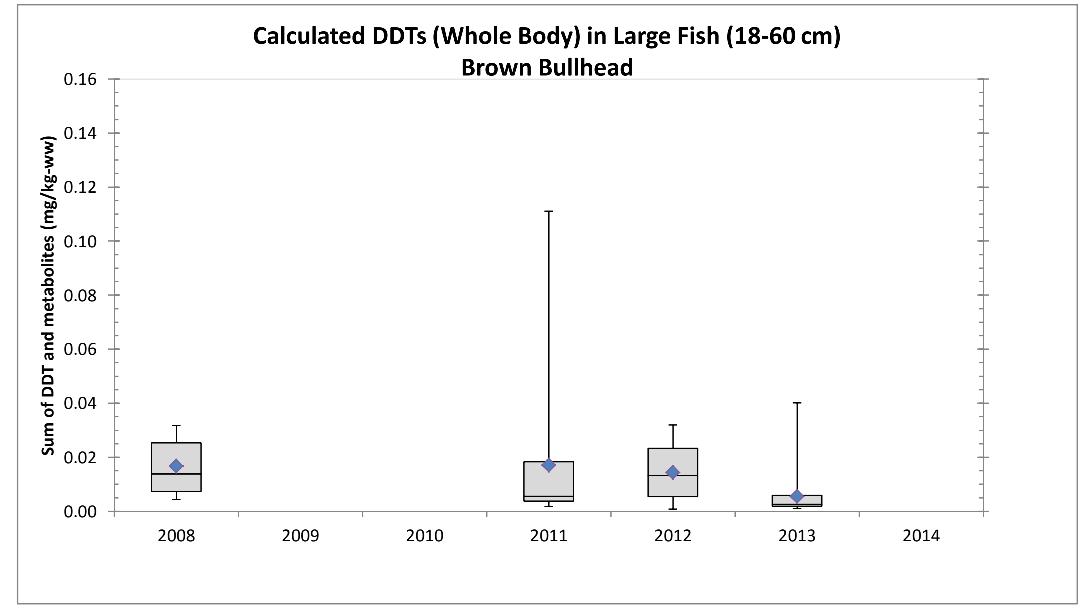


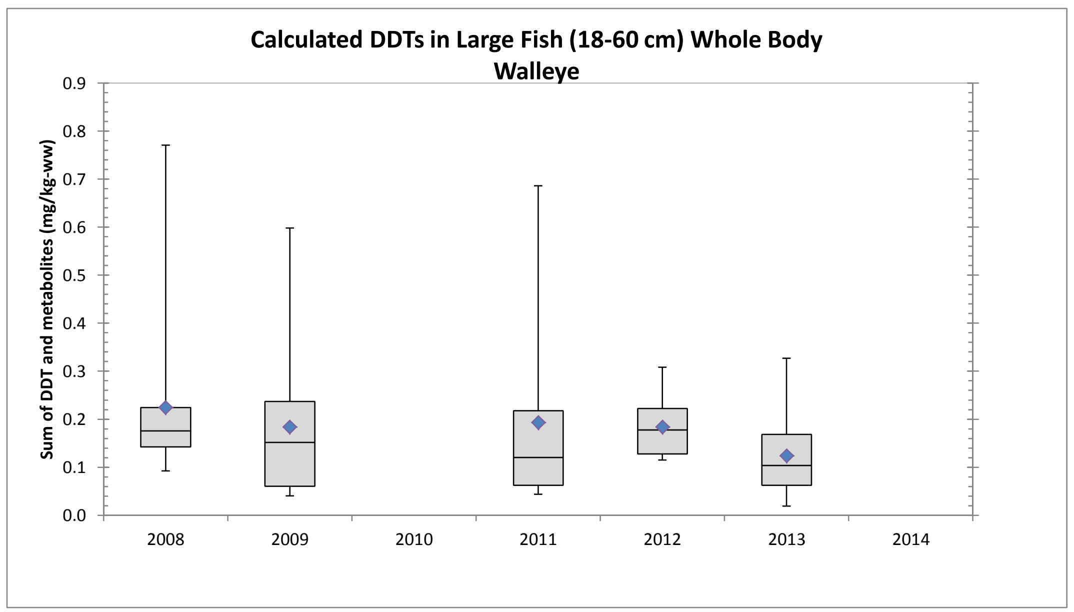


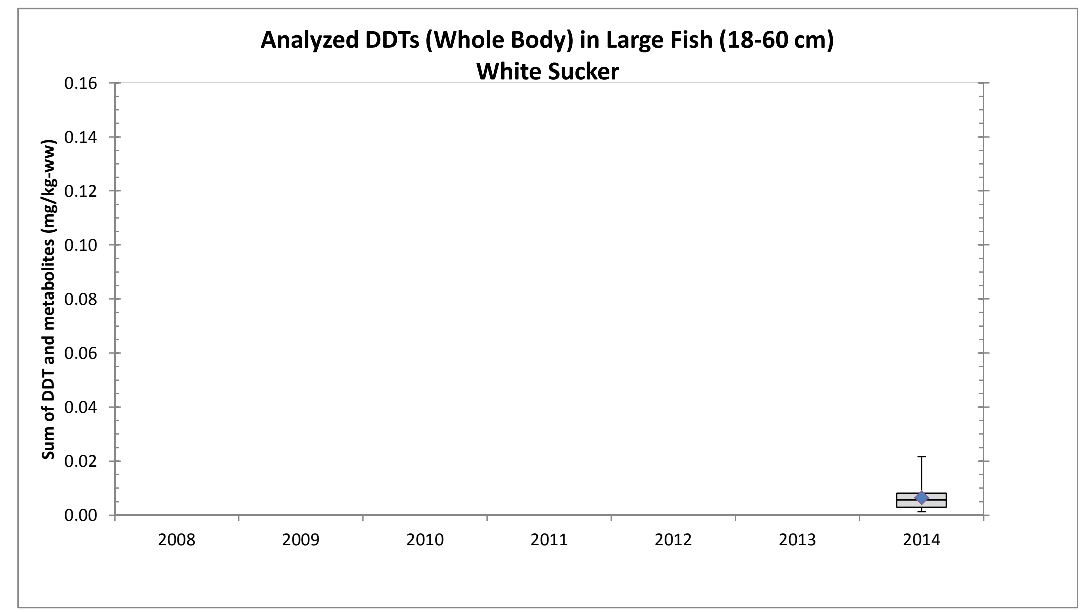


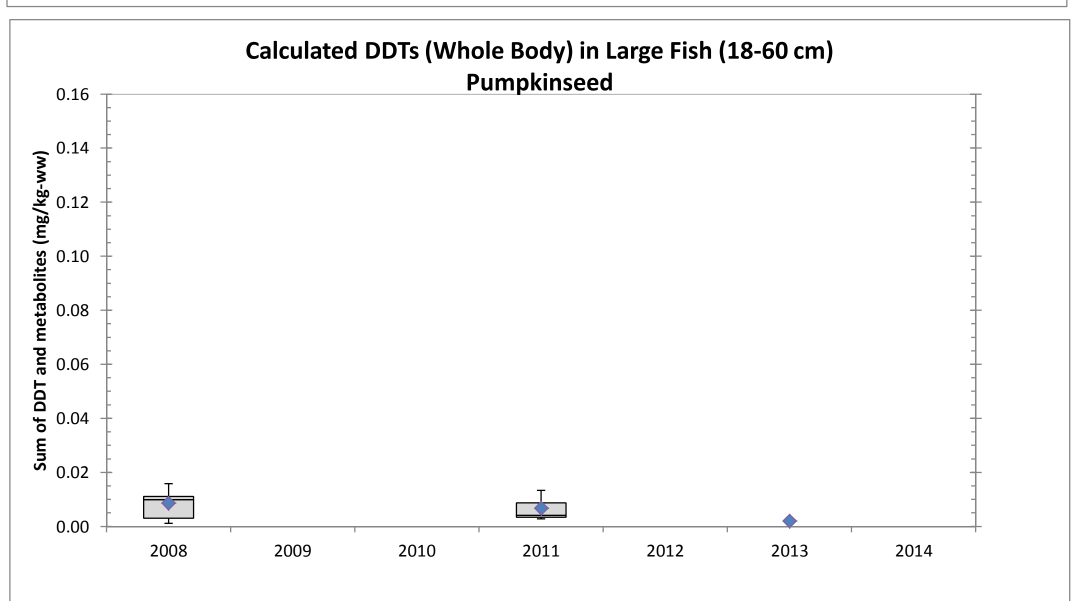
Honeywell Large Prey Fish Data, DDTs - Set 3



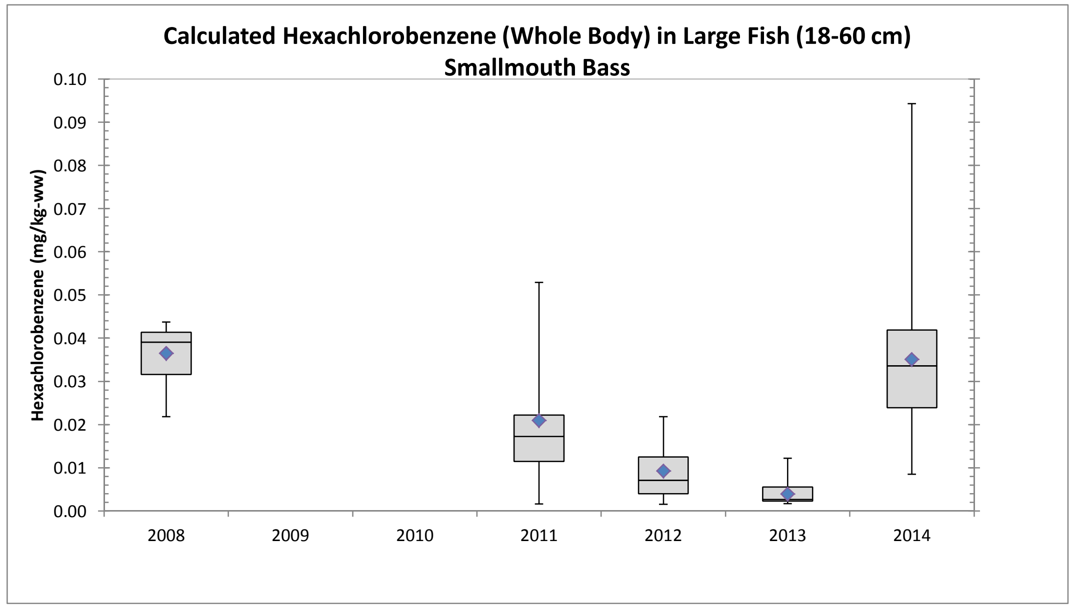


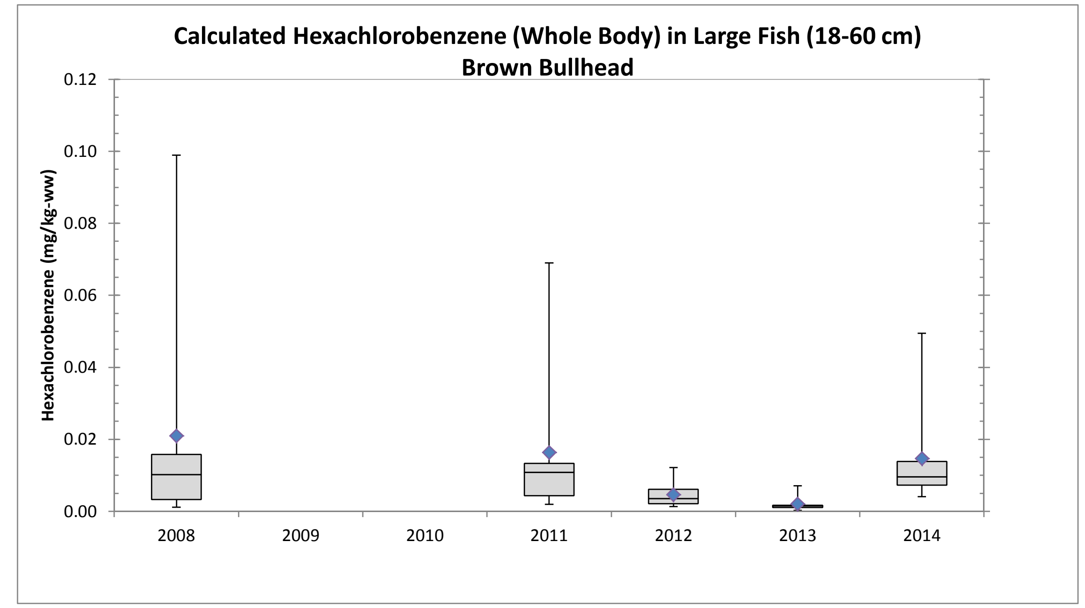


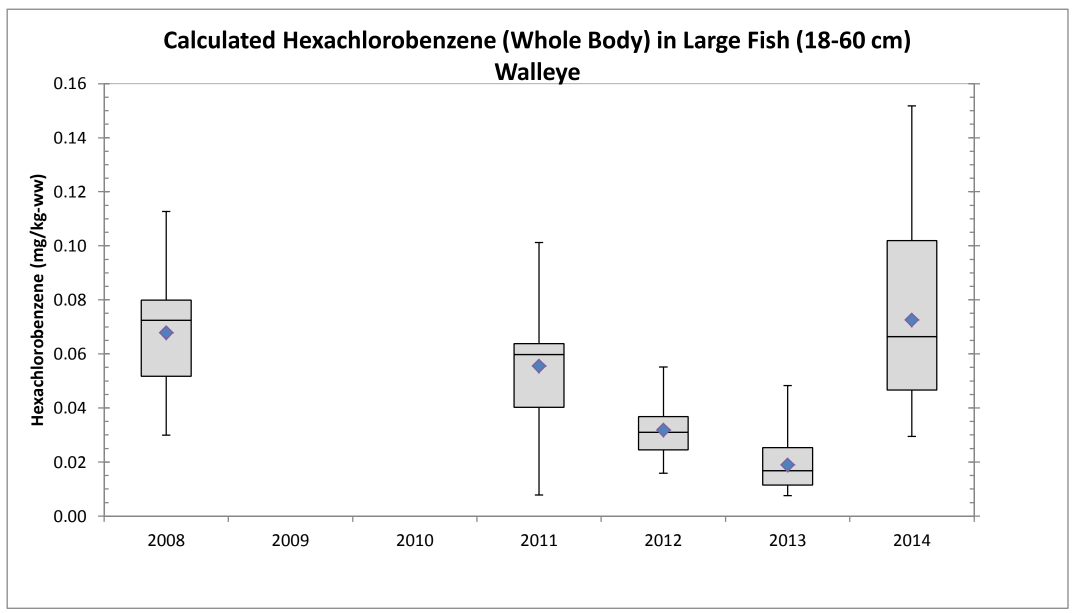


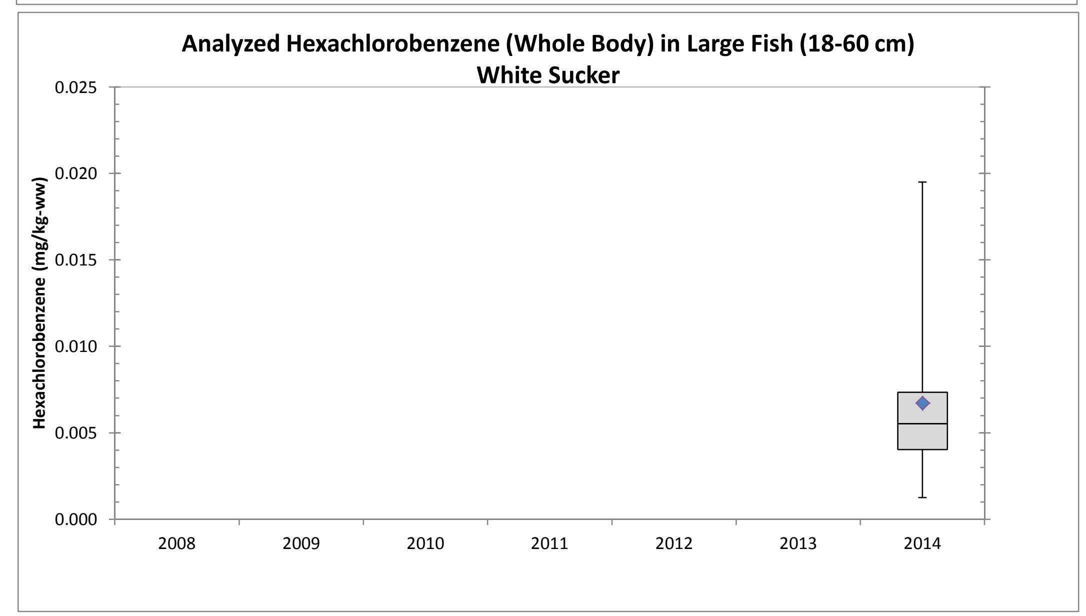


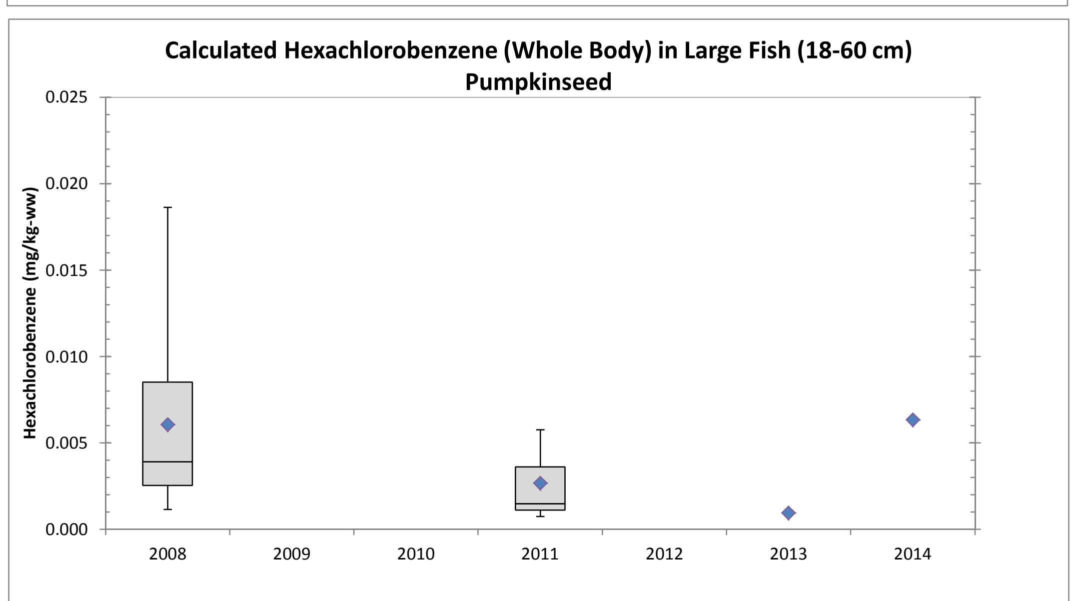
Honeywell Large Prey Fish Data, Hexachlorobenzene - Set 3







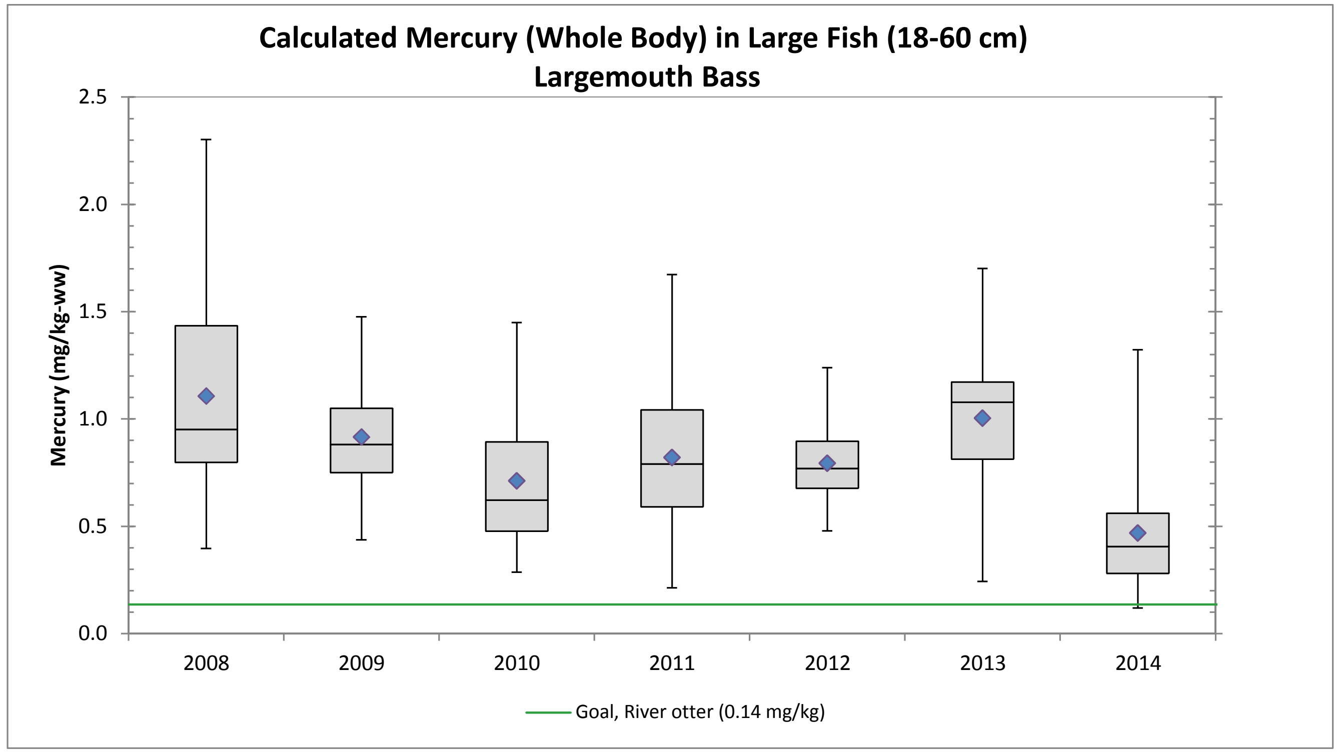


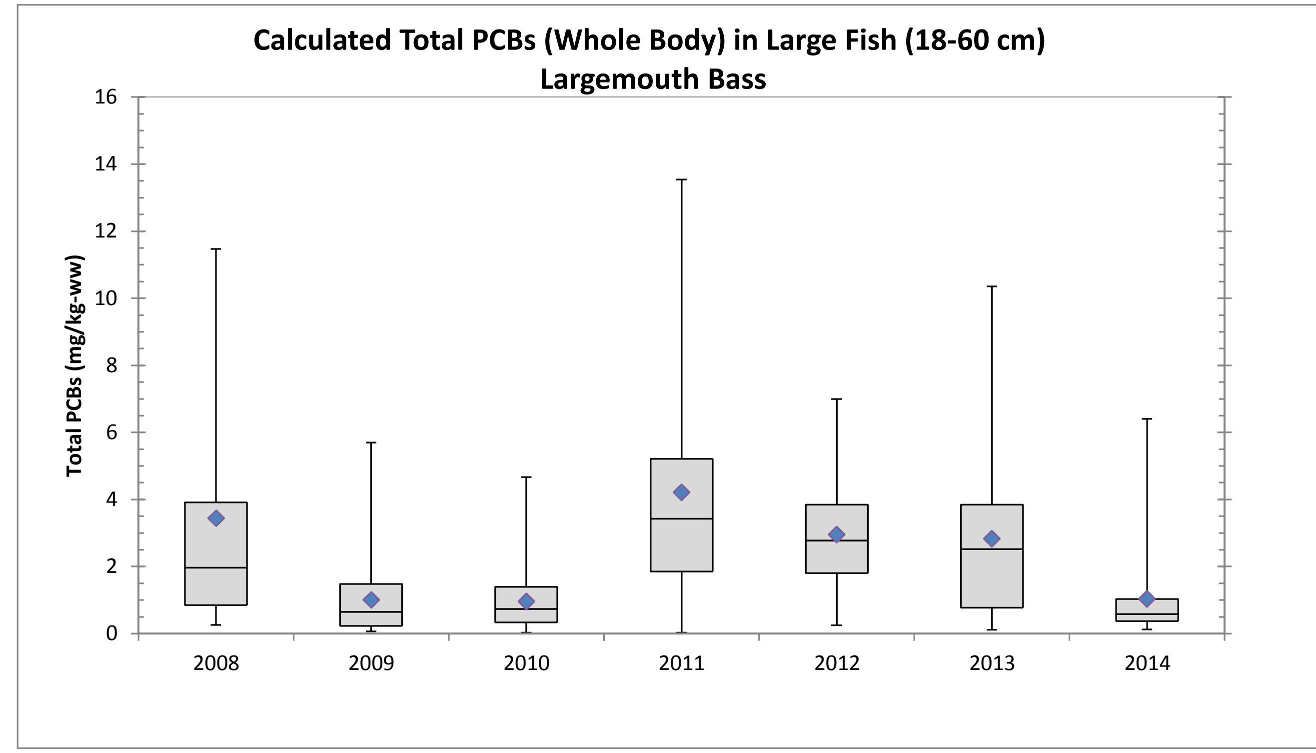


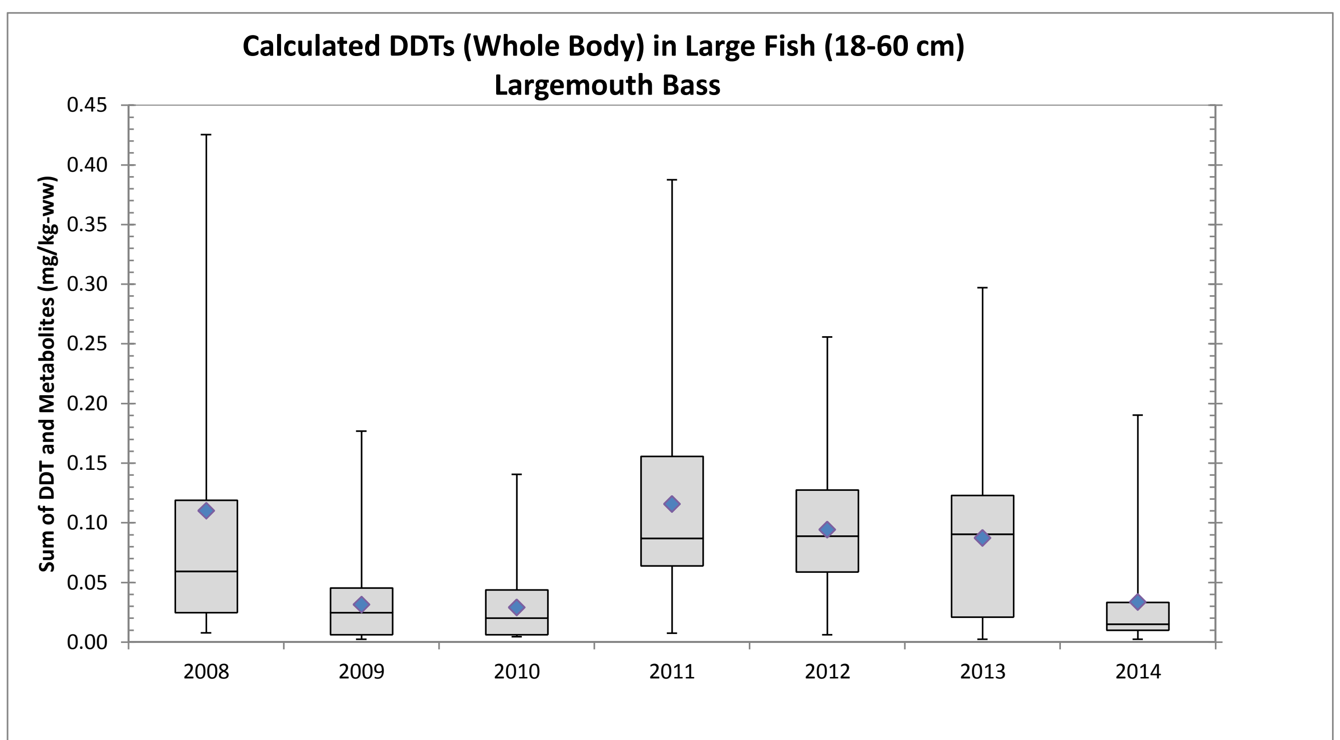
NYSDEC Data (2008-2014)

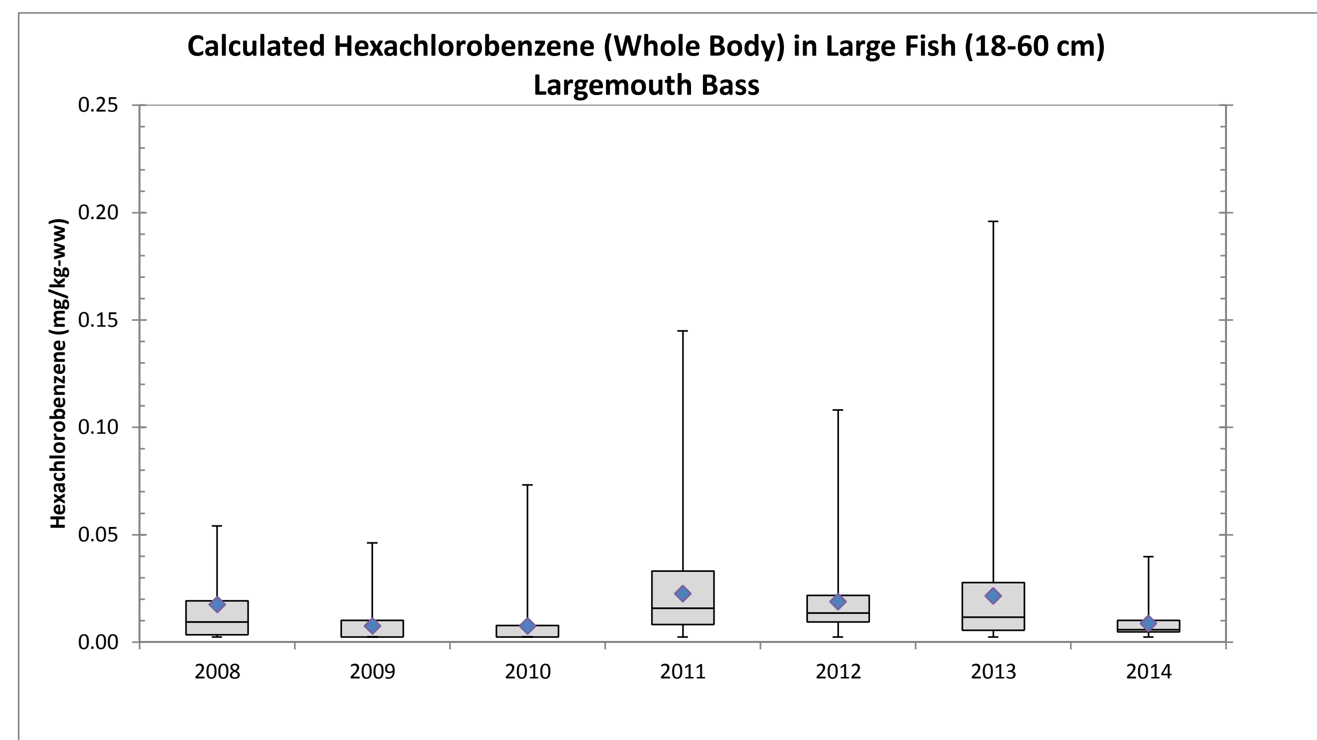
June 2015

NYSDEC Large Prey Fish Data - Set 3









Set 4: Additional Reporting to Assess Potential Impacts of Remediation

AECOM

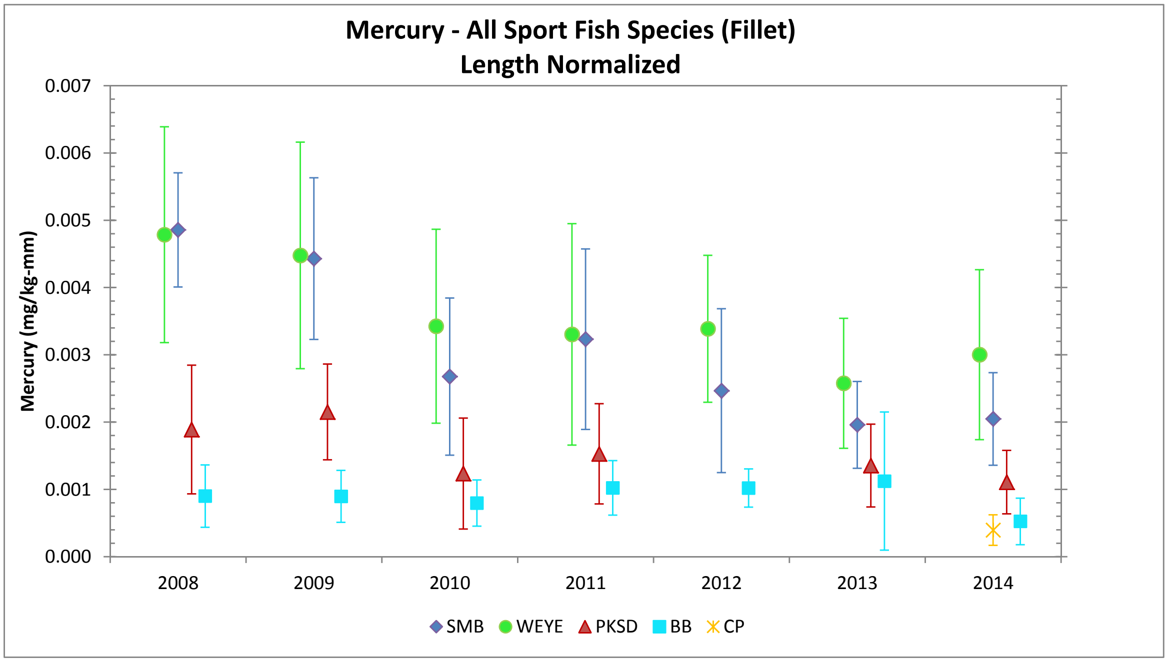
June 2015

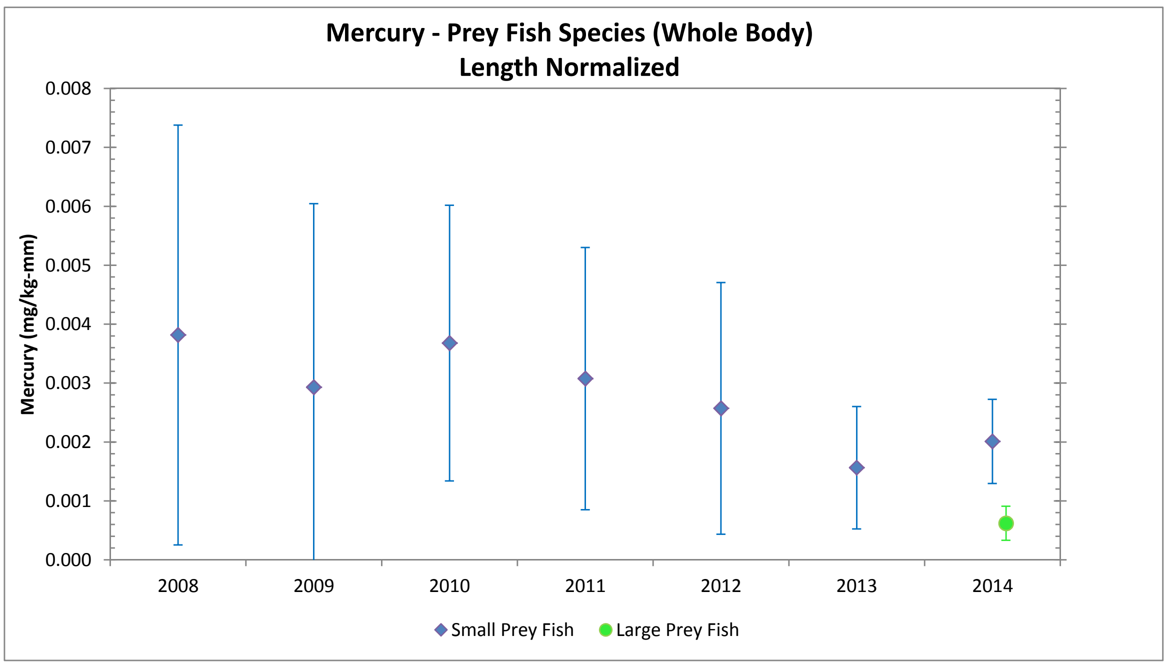
Honeywell Data (2008-2014)

AECOM

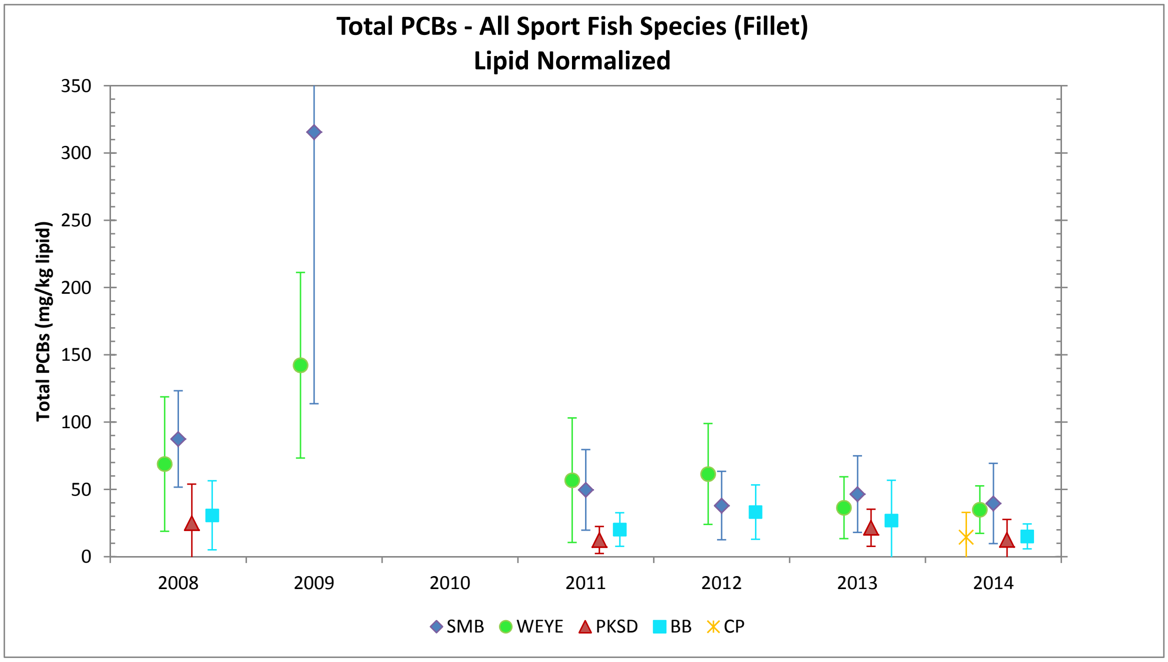
June 2015

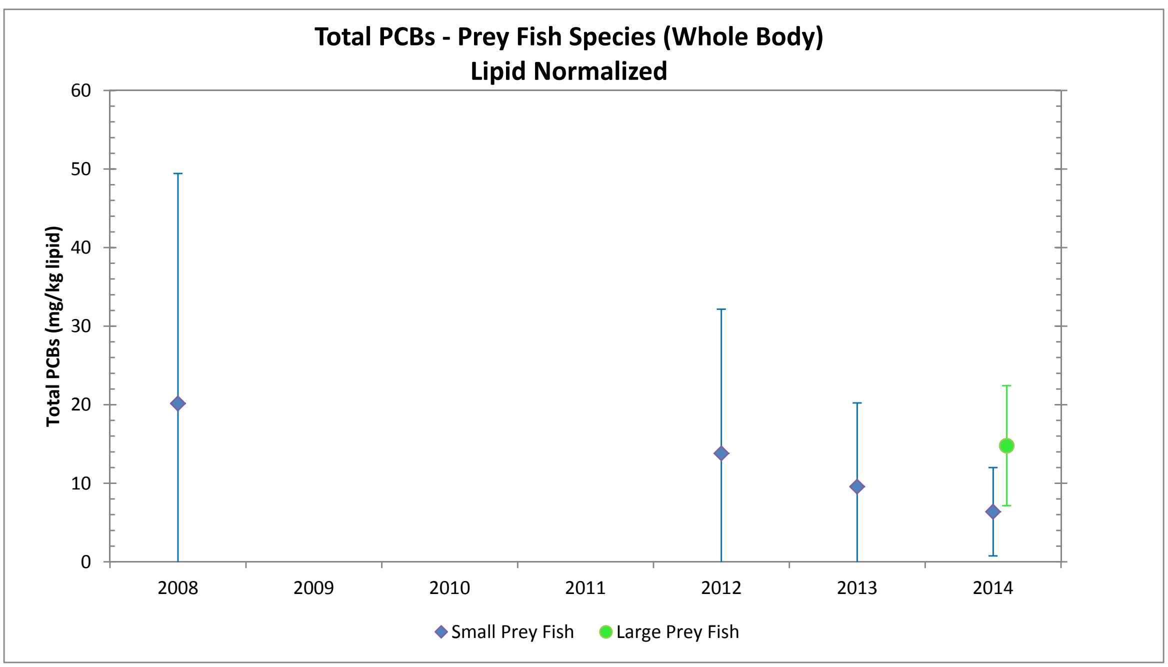
Honeywell Length-Normalized Mercury Data - Set 4



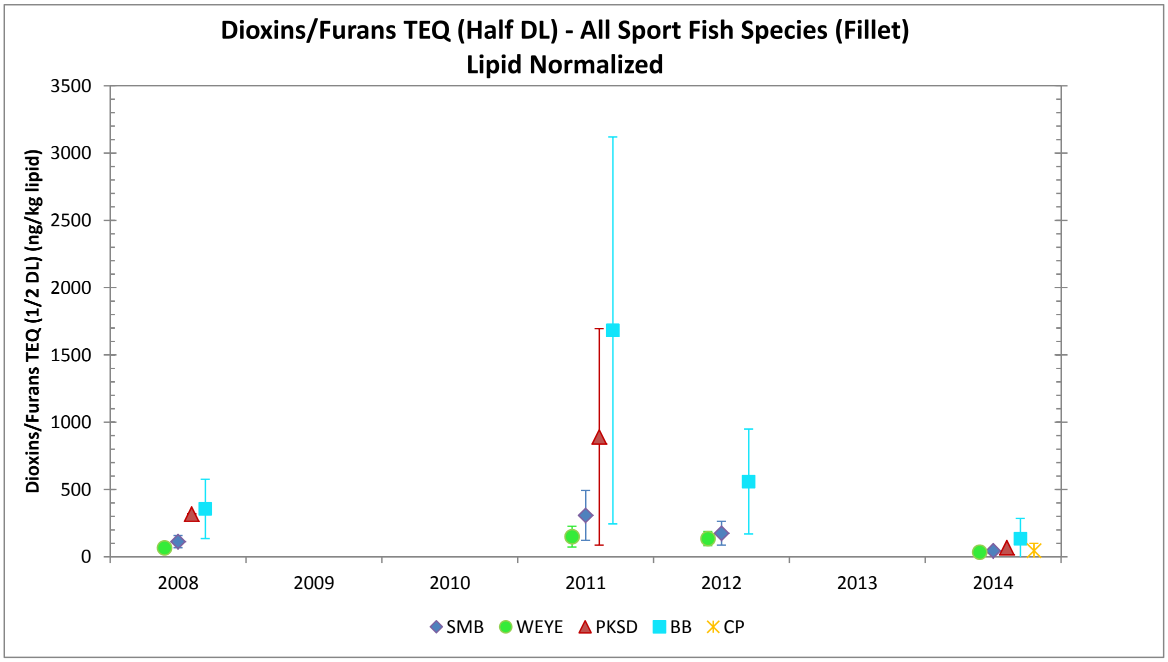


Honeywell Lipid-Normalized Total PCBs Data - Set 4

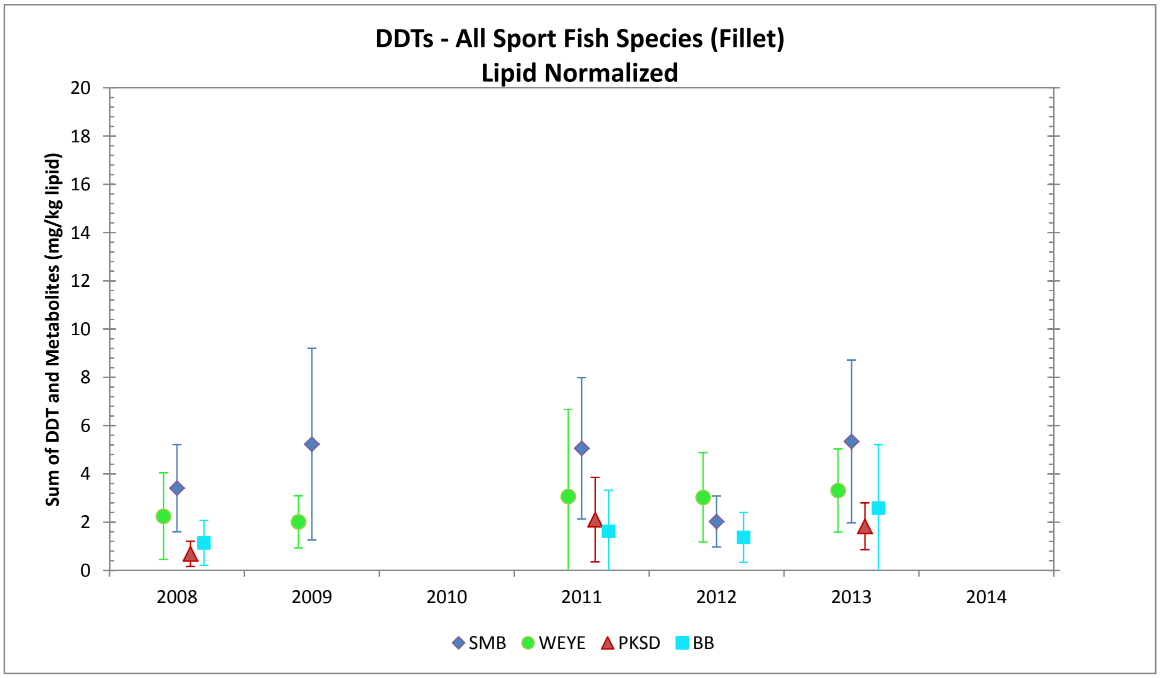


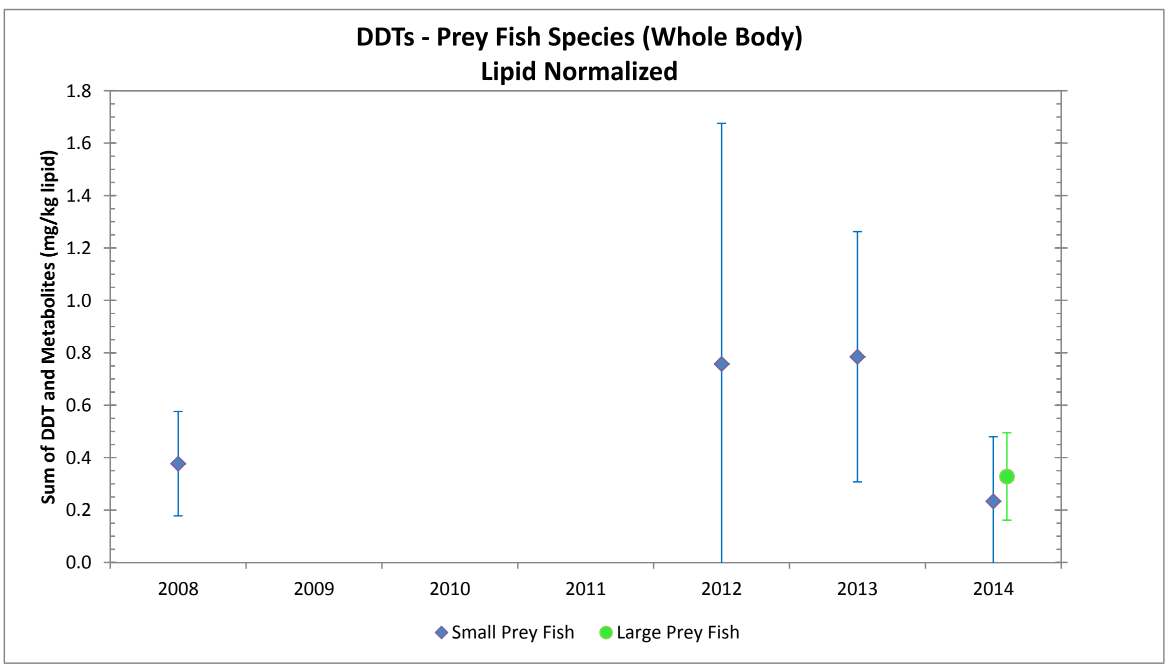


Honeywell Lipid-Normalized Dioxins/Furans Data - Set 4

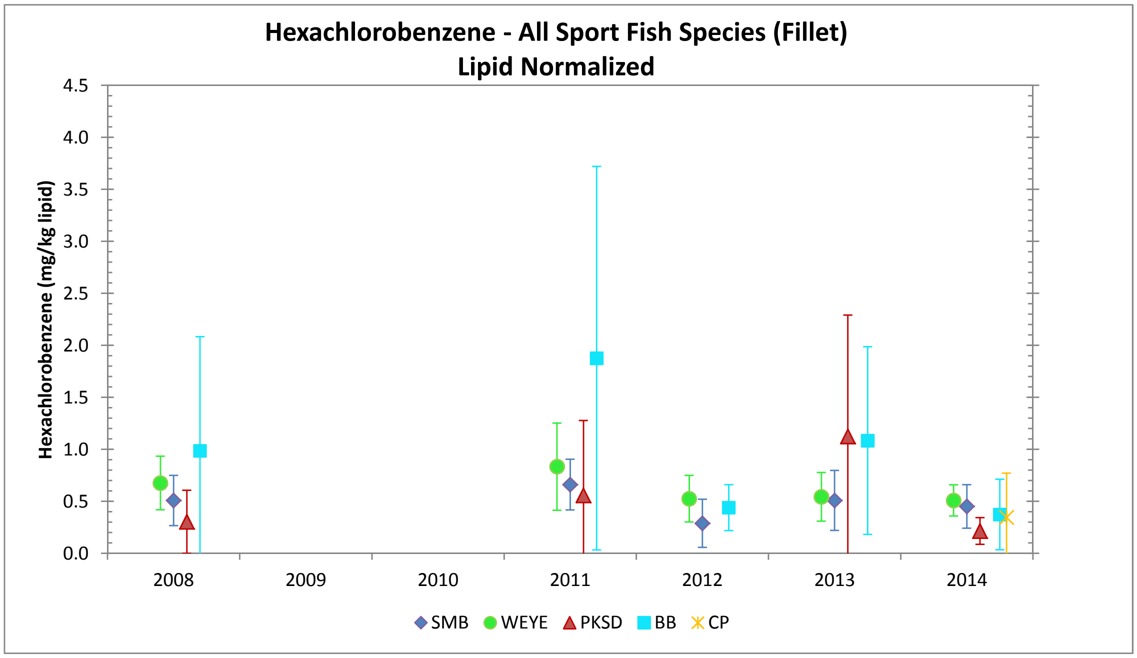


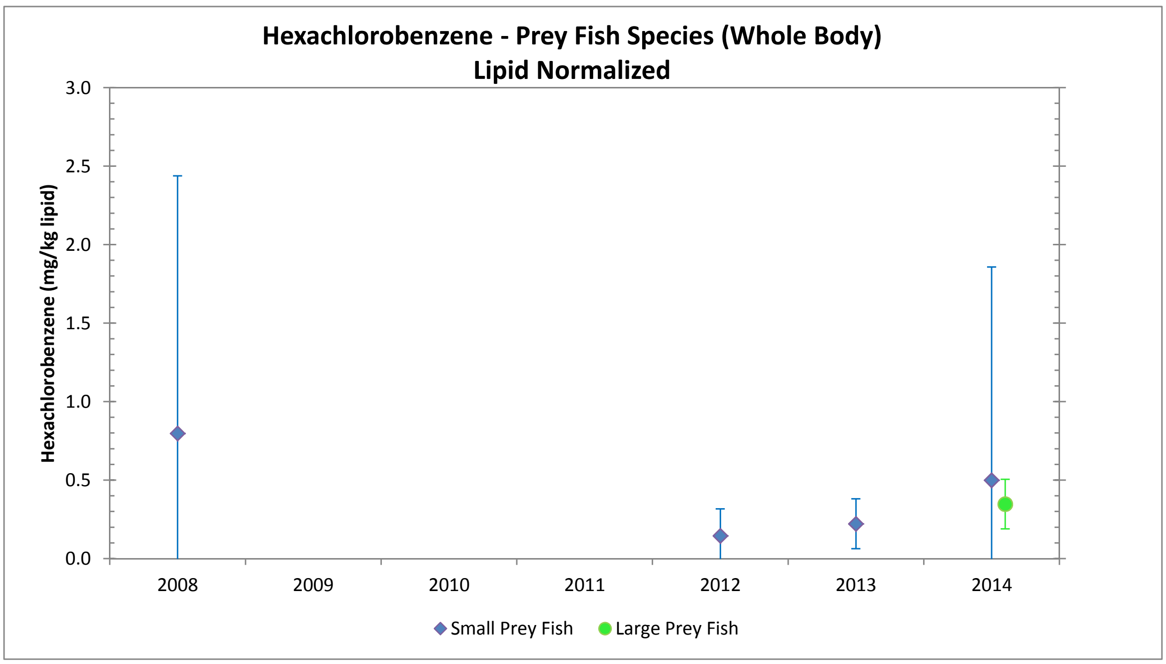
Honeywell Lipid-Normalized DDTs Data - Set 4



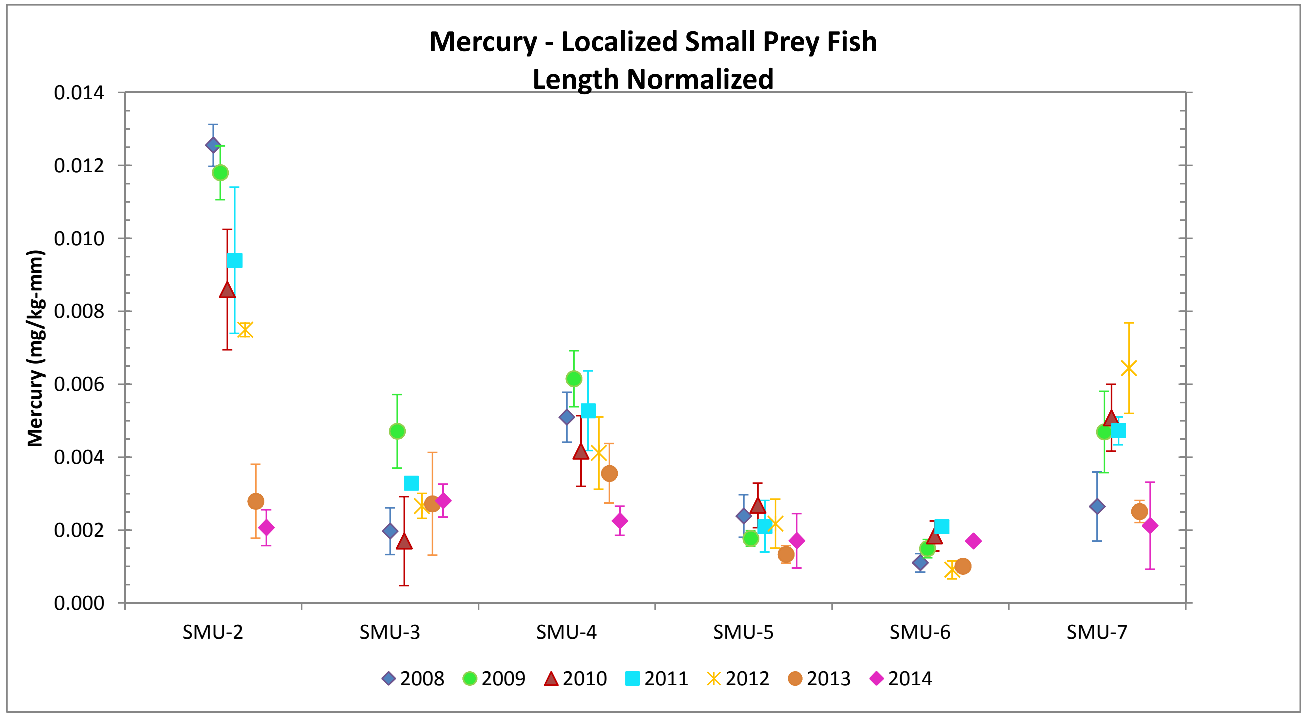


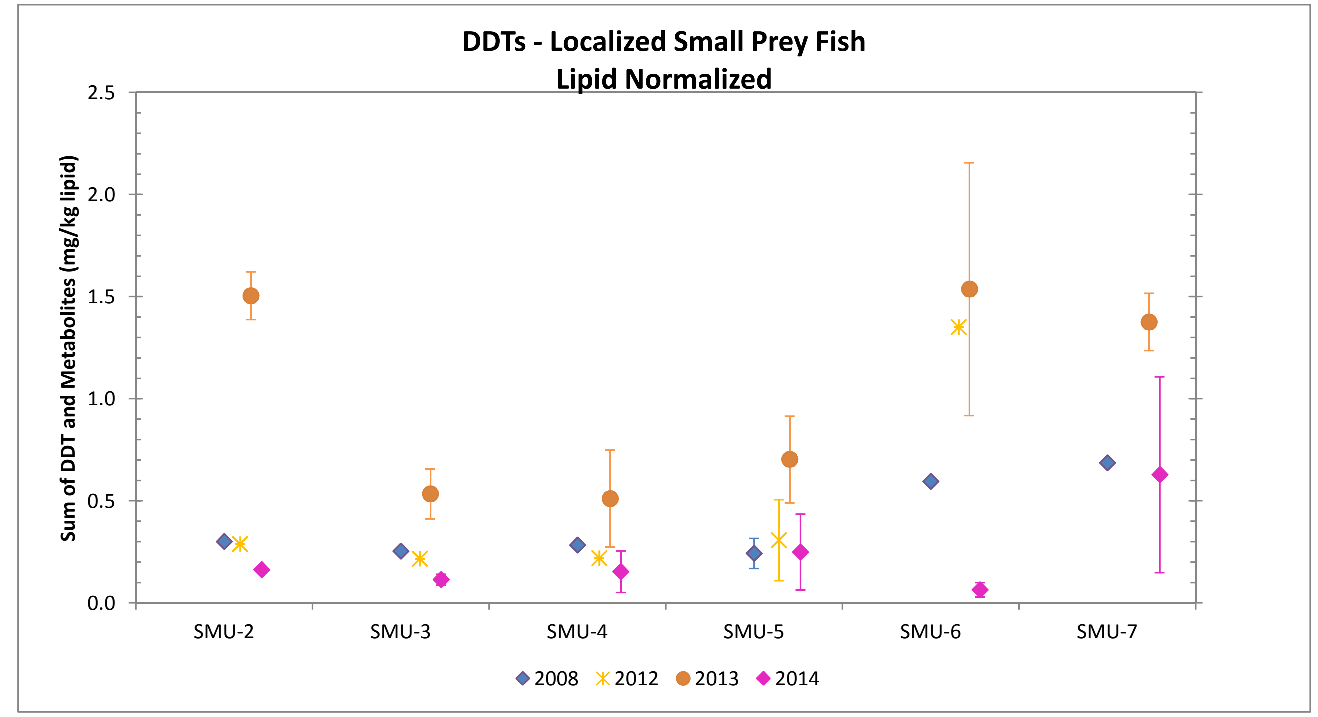
Honeywell Lipid-Normalized Hexachlorobenzene Data - Set 4

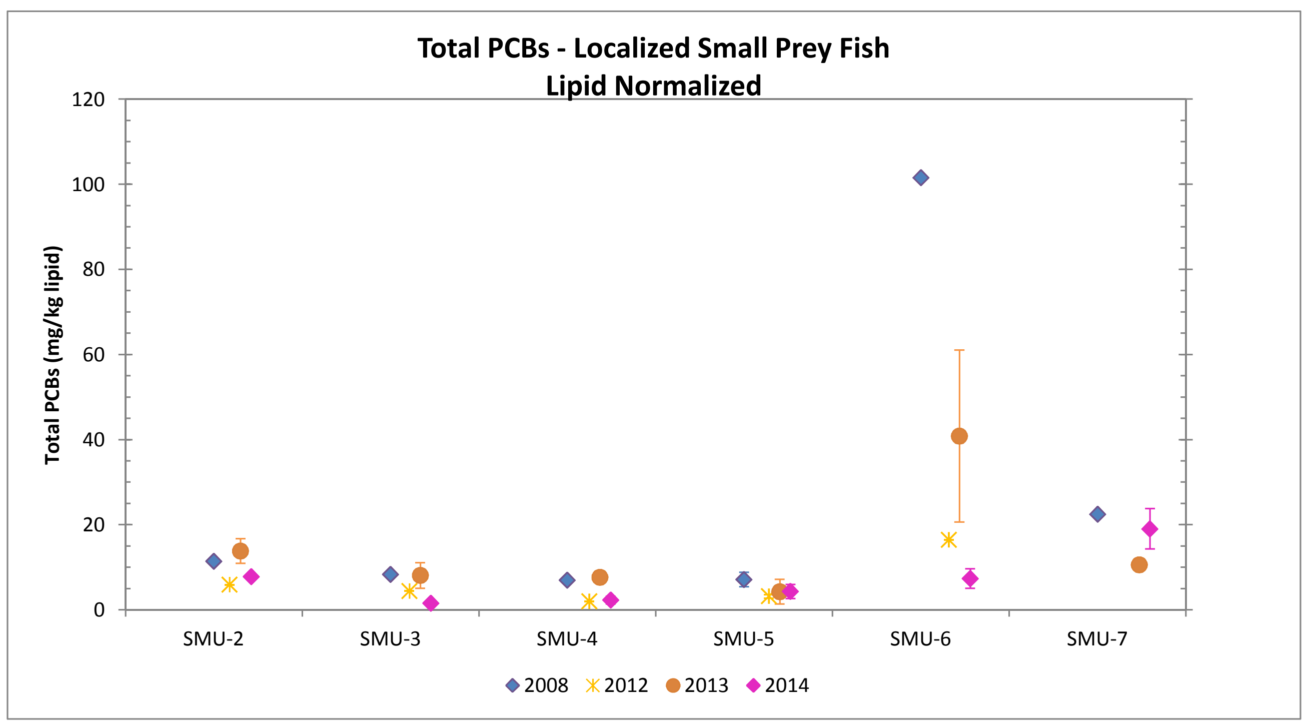


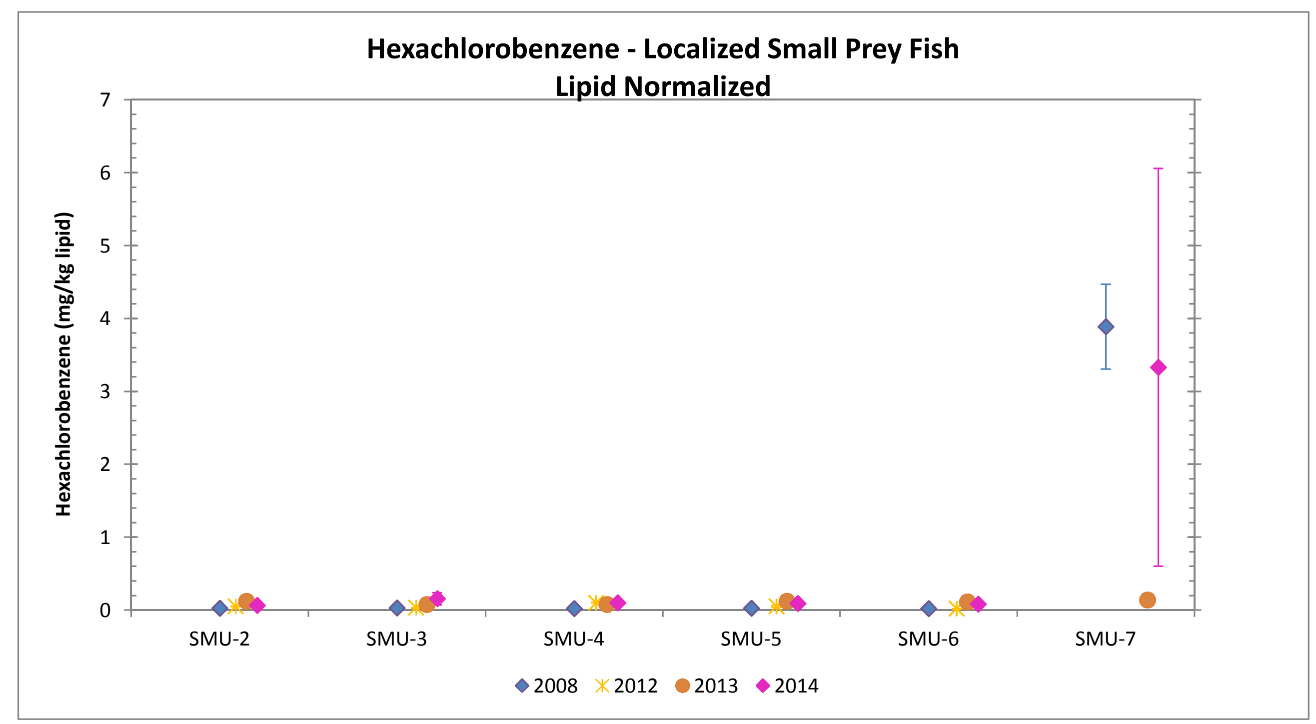


Honeywell Localized Small Prey Fish Normalized Data by SMU - Set 4



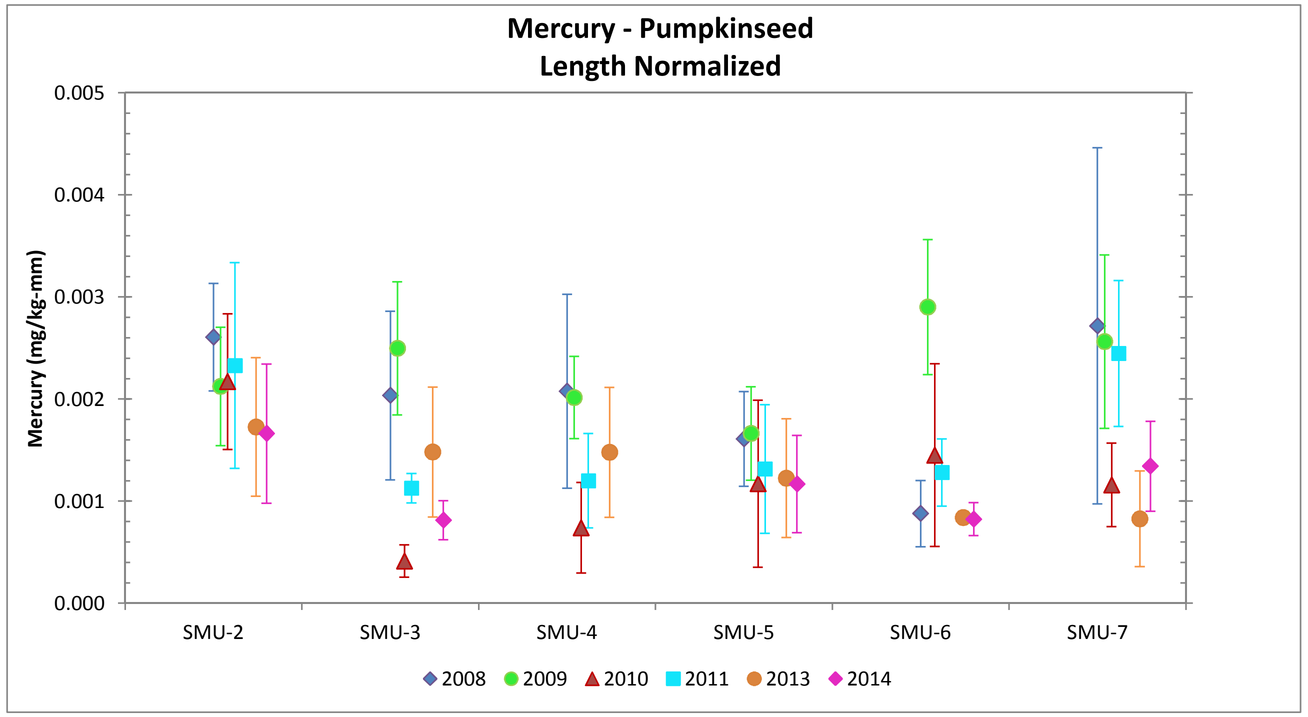


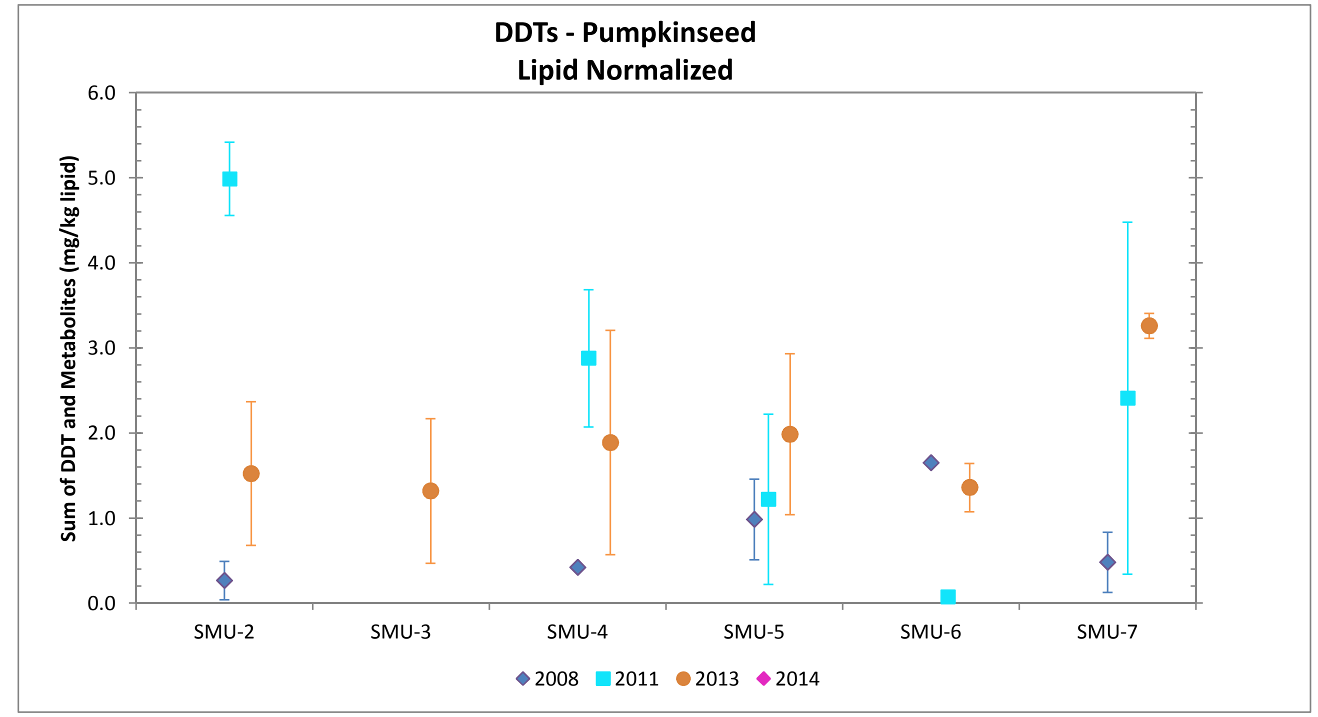


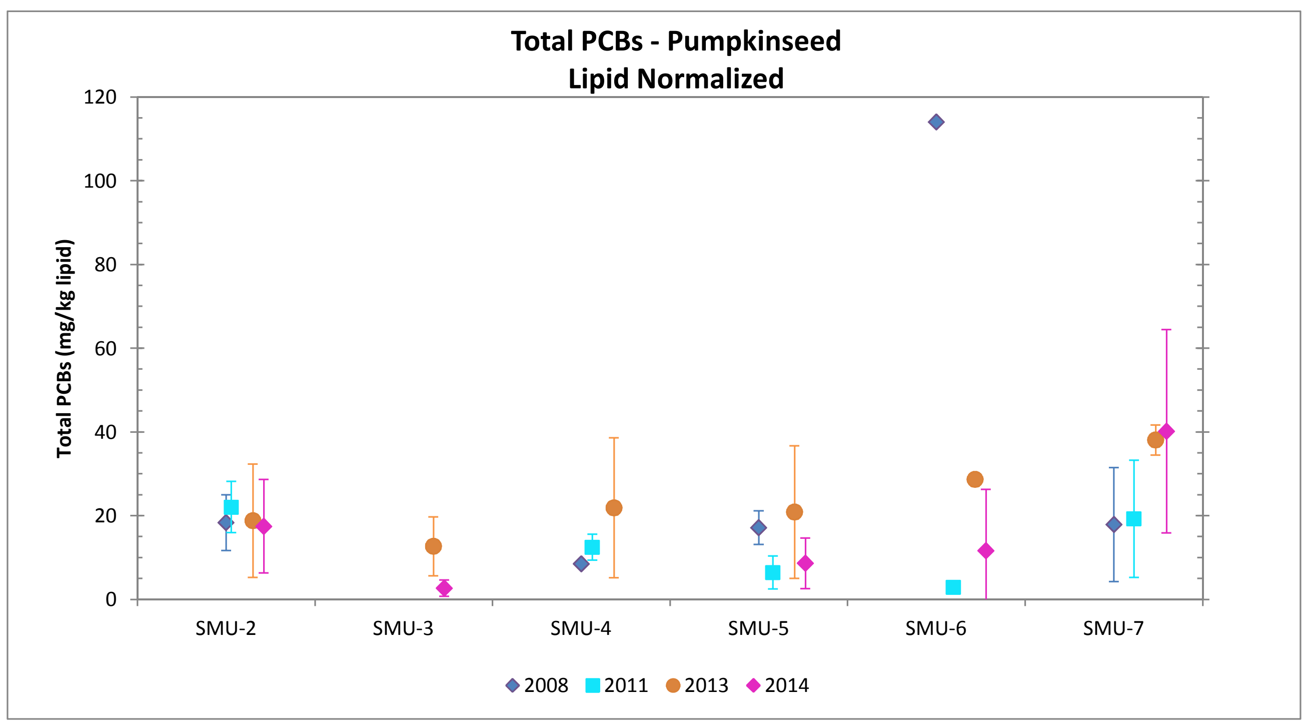


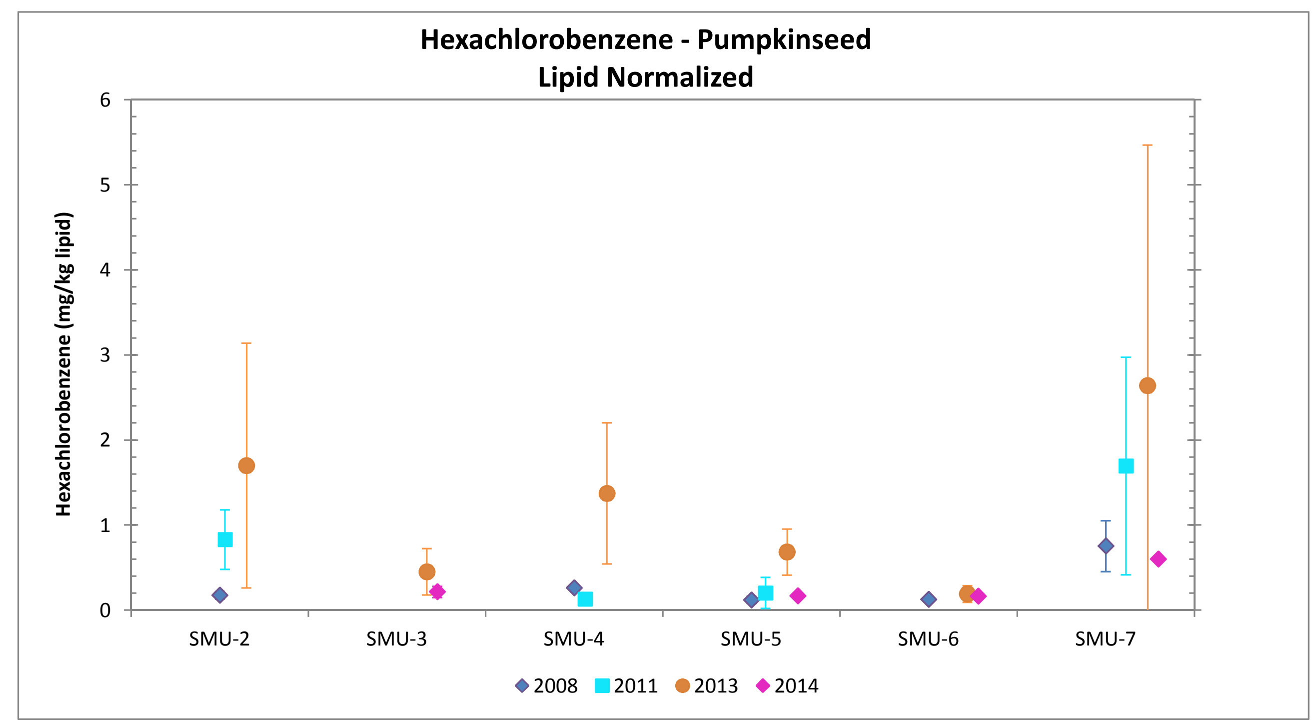
Note: Alewife and gizzard shad not included in Localized Small Prey Fish for these figures. See text.

Honeywell Pumpkinseed Normalized Data by SMU - Set 4

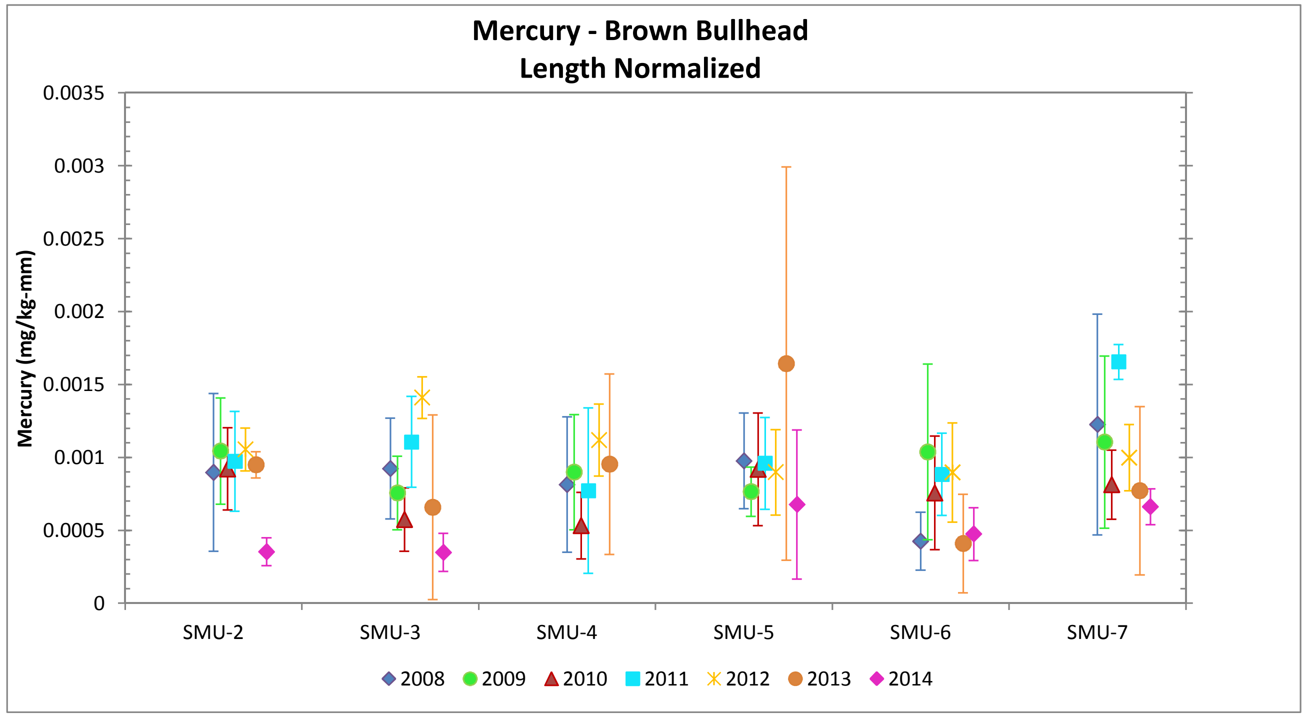


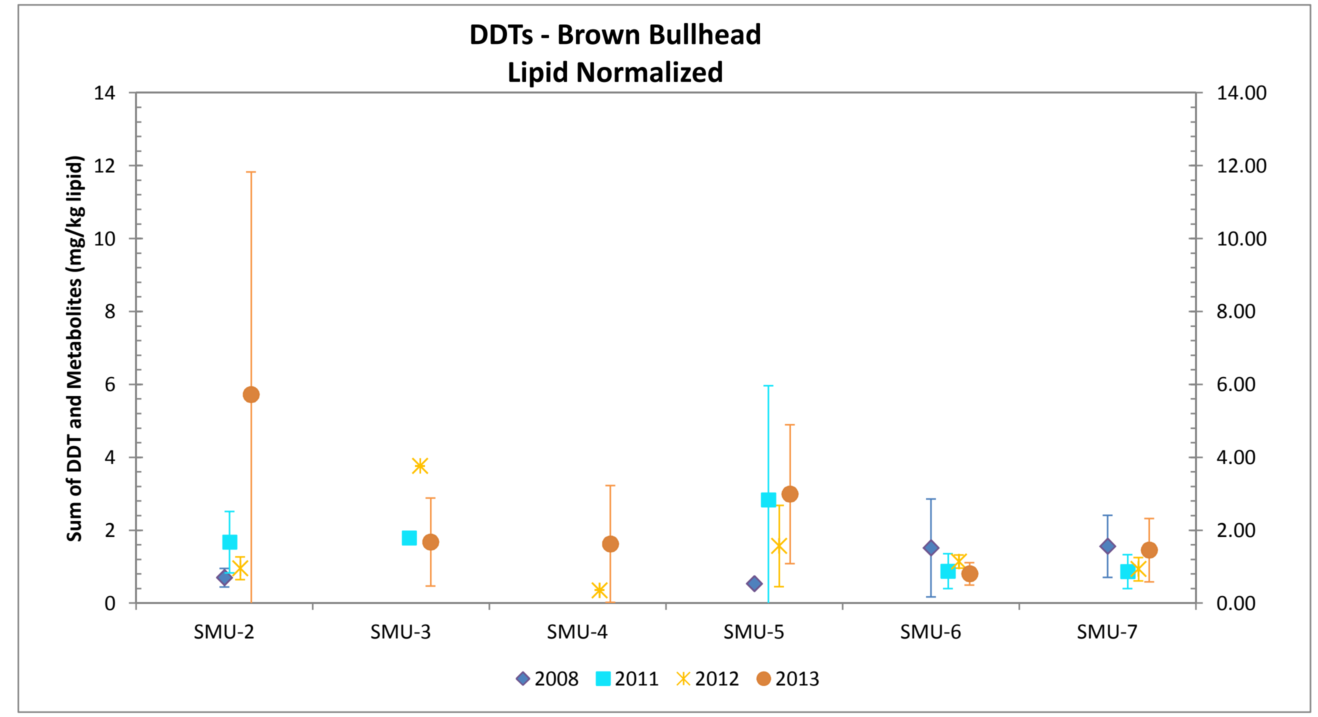


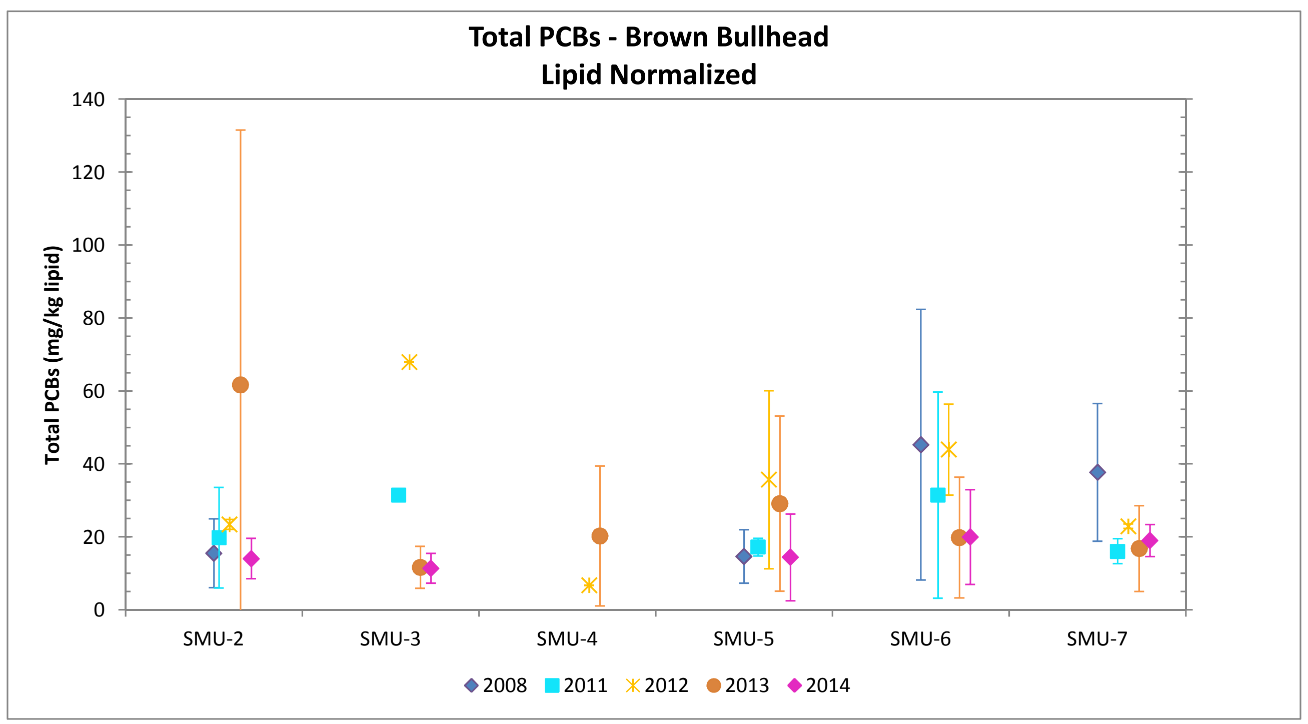


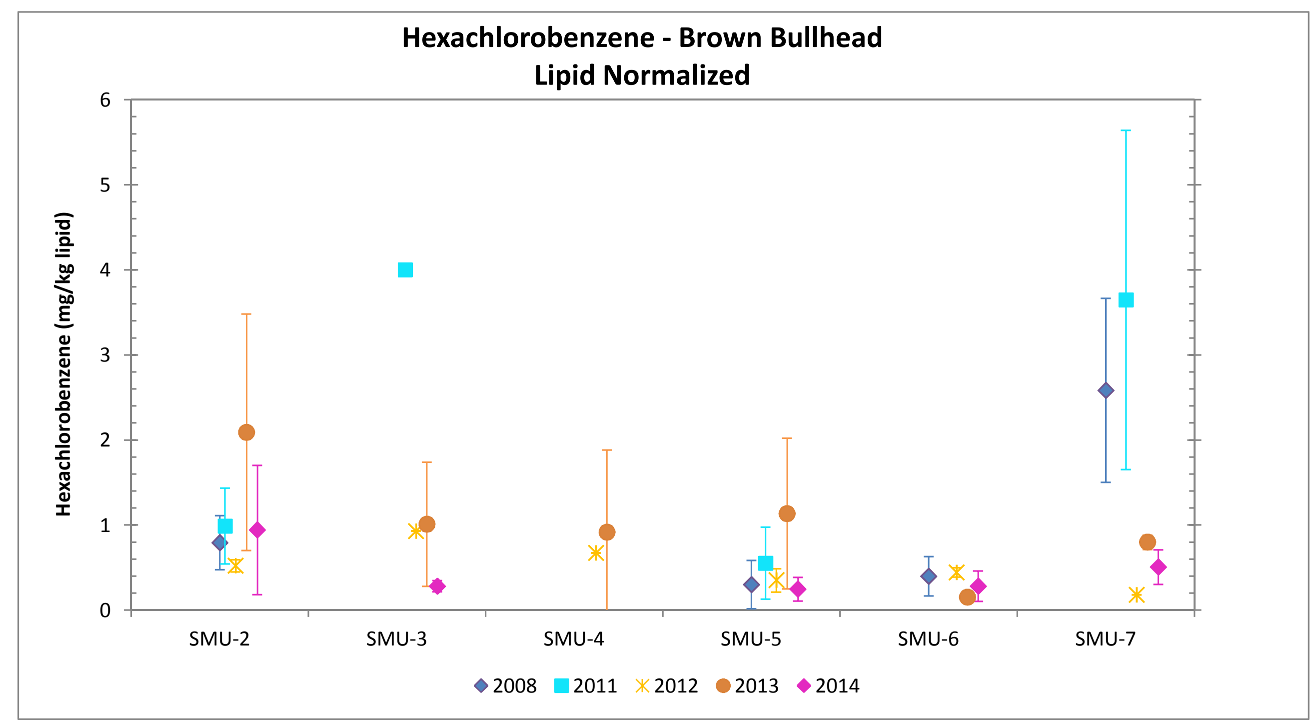


Honeywell Brown Bullhead Normalized Data by SMU - Set 4





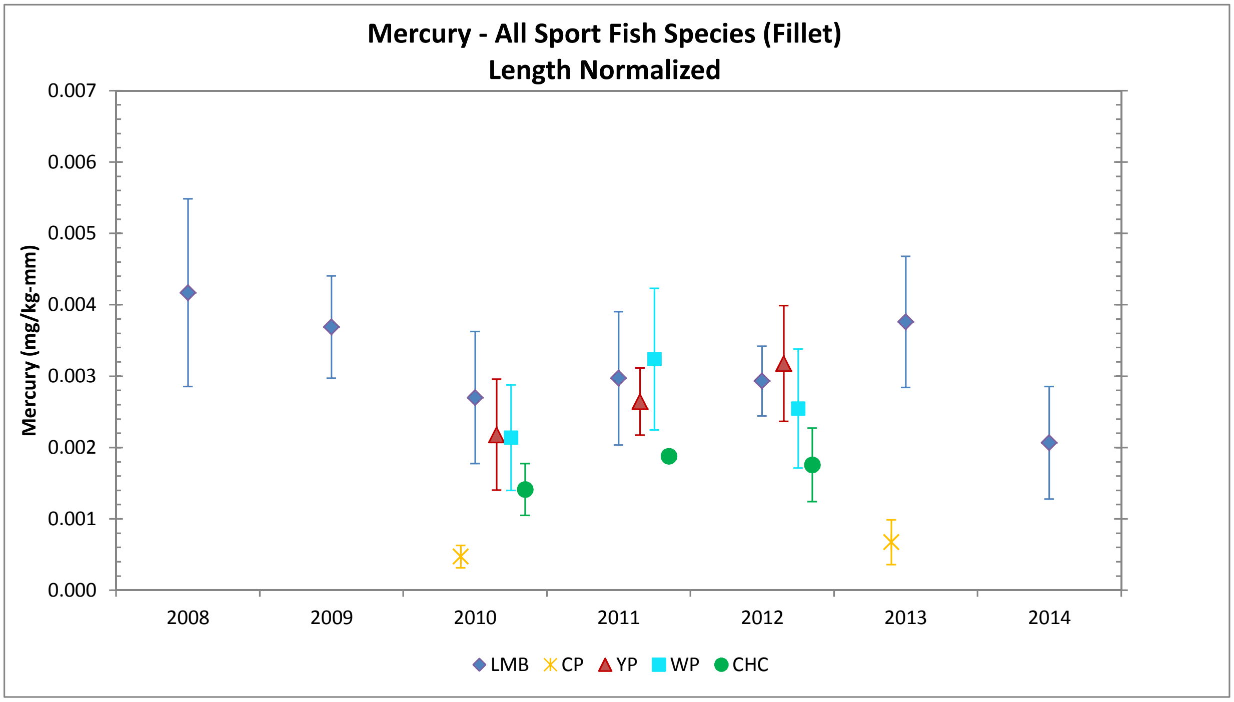




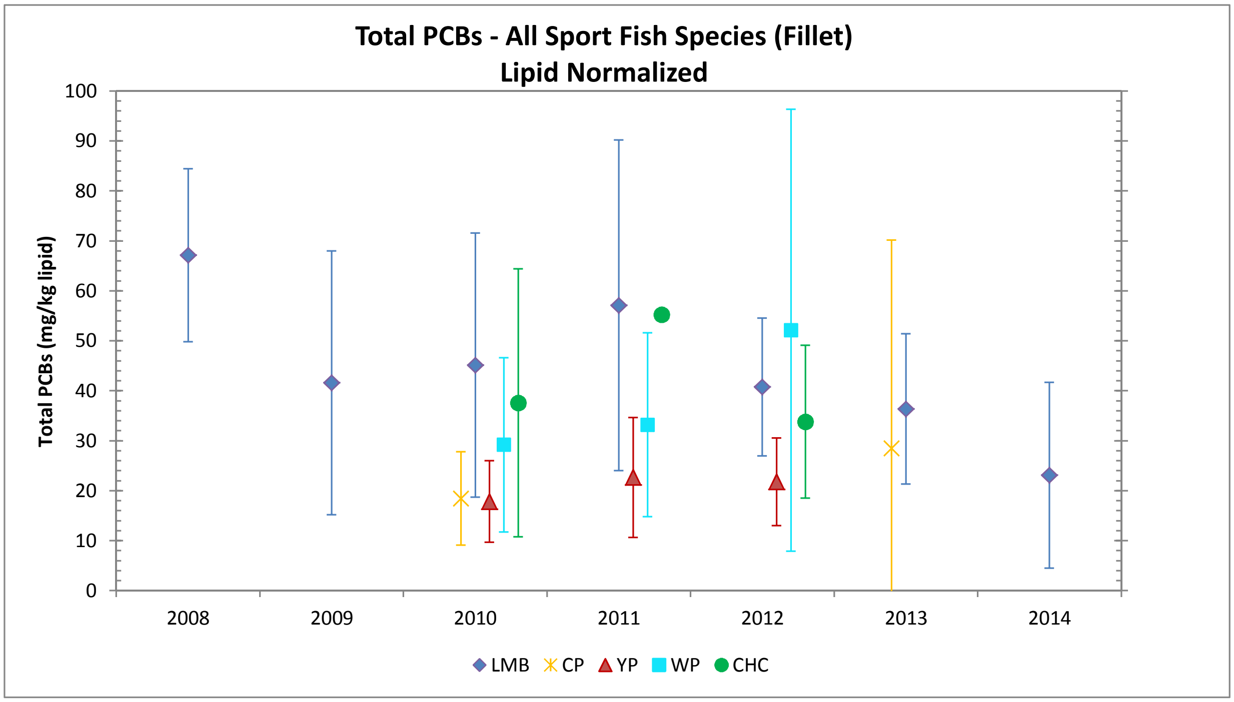
NYSDEC Data (2008-2014)

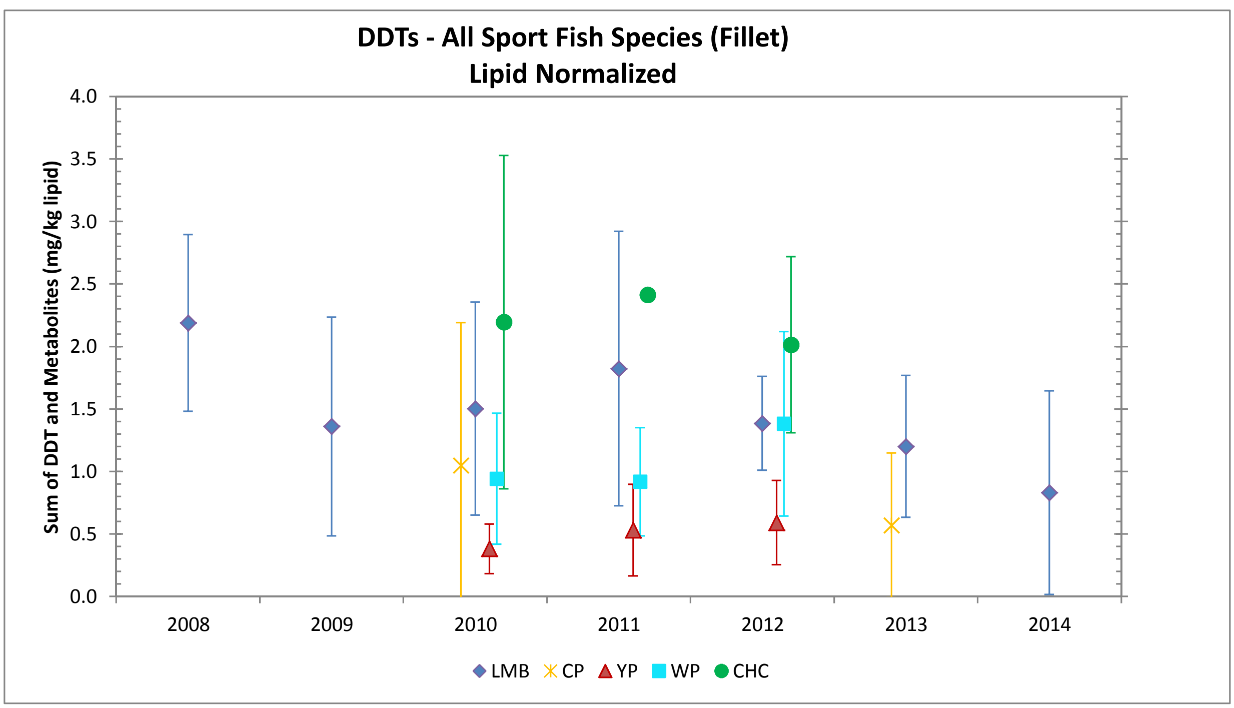
June 2015

NYSDEC Length-Normalized Mercury Data - Set 4



NYSDEC Lipid-Normalized Total PCBs and DDTs Data - Set 4





NYSDEC Lipid-Normalized Hexachlorobenzene Data - Set 4