Onondaga Lake Natural Resource Damage Assessment Restoration Plan and Environmental Assessment

Draft Report | April 2017

prepared for:

United States Fish and Wildlife Service

State of New York Department of Environmental Conservation

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IEc

INDUSTRIAL ECONOMICS, INCORPORATED

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LIST OF EXHIBITS

LIST OF ACRONYMS

BTEX	benzene, toluene, ethylbenzene, and xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Federal Code of Regulations
cm	centimeter
COC	Contaminant of Concern
DAP	Damage Assessment Plan
DOI	United States Department of the Interior
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	United States Enviromental Protection Agency
FCA	Fish Consumption Advisory
FONSI	Finding of No Significant Impact
fw	fresh weight
FWS	United States Fish and Wildlife Service
Honeywell	Honeywell International, Inc.
mg/kg	milligrams per kilogram
MOA	Memorandum of Agreement
NEPA	National Environmental Policy Act
ng/g	nanograms per gram
NPL	National Priorities List
NRDAR	Natural Resource Damage Assesment and Restoration
NYSDEC	New York State Department of Environmental Conservation
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
PECQ	Probable Effects Concentration Quotient
PRP	Potentially Responsible Party

RP/EA	Restoration Plan/Environmental Assessment
ug/kg	micrograms per kilogram
wb	whole body
ww	wet weight

EXECUTIVE SUMMARY

For decades, mercury and other hazardous substances were released into Onondaga Lake in New York, its tributaries, and associated uplands. Natural resources (e.g., surface water, sediments, invertebrates, fish, amphibians, reptiles, birds, and mammals) have been exposed to and adversely affected by these contaminants. As part of the natural resource damage assessment and restoration (NRDAR) process, the Trustees (the United States Fish and Wildlife Service and the New York State Department of Environmental Conservation) developed this Restoration Plan and Environmental Assessment (RP/EA) in accordance with 43 CFR § 11.82 and 11.93 to inform the public as to the types and scale of restoration that are expected to compensate for contaminant-related injuries to natural resources.

The ultimate goal of NRDAR is to restore, replace, rehabilitate, or acquire the equivalent of injured natural resources and resource services lost due to the release of hazardous substances. Therefore, in accordance with relevant regulations, the Trustees identified three potential restoration alternatives, including a No Action alternative. After a review of the potential project types that would occur under each alternative, specific proposed projects compiled from Trustee- and publicly-generated suggestions, and likely environmental consequences, the Trustees identified Alternative B: Restoration that Satisfies Site-specific Criteria as their Preferred Alternative.

The Trustees are soliciting comments on this draft RP/EA, and will incorporate comments into a final RP/EA wherein the Trustees will identify the Selected Restoration Alternative for the Onondaga Lake NRDAR.

Onondaga Lake

CHAPTER 1 | INTRODUCTION

1.1 PURPOSE AND NEED FOR RESTORATION

For decades, mercury and other hazardous substances were released into Onondaga Lake in New York, its tributaries, and associated uplands. Natural resources (e.g., surface water, sediments, invertebrates, fish, amphibians, reptiles, birds, and mammals) have been exposed to and adversely affected by these contaminants. Over the last few years, Honeywell International Inc. (Honeywell), in cooperation with the New York State Department of Environmental Conservation (NYSDEC) and the United States Environmental Protection Agency (EPA), has removed and isolated contaminated sediments in Onondaga Lake and implemented habitat improvement projects. These remedial actions, while beneficial, do not themselves compensate the public for past, present, and future contaminant-related injuries to natural resources.

Therefore, as part of the natural resource damage assessment and restoration (NRDAR) process, the Trustees developed this Restoration Plan and Environmental Assessment (RP/EA) in accordance with 43 CFR § 11.82 and 11.93 to inform the public as to the types and scale of restoration that are expected to compensate for injuries to natural resources. Consistent with the U.S. Department of the Interior (DOI) NRDAR regulations, this RP/EA includes a reasonable number of alternative restoration actions and identifies a preferred alternative.

Onondaga Lake

1.2 ORGANIZATION OF THIS CHAPTER

This chapter discusses the following:

- Trusteeship and compliance with other authorities,
- Coordination with Potentially Responsible Parties (PRPs),
- An overview of Site history and remediation,
- Natural resource damage assessment activities at the Site,

- The relationship between natural resource damage assessment and remedial activities,
- Public participation, and
- The administrative record.

1.3 TRUSTEESHIP AND COMPLIANCE WITH OTHER AUTHORITIES

This RP/EA has been prepared by the Onondaga Lake Trustees. Under Federal law, the Trustees are authorized to act on behalf of the public to assess and recover natural resource damages, and to plan and implement actions to restore, replace, rehabilitate, or acquire the equivalent of injured natural resources and resource services lost due to the release of hazardous substances (42 U.S.C. § 9601 *et seq.*; Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); 43 CFR Part 11). In this case, DOI, as represented by the U.S. Fish and Wildlife Service (FWS), and NYSDEC are designated as trustees for natural resources actually or potentially affected by hazardous substances released to the Onondaga Lake area under state and Federal authorities, including, but not limited to, CERCLA; the Federal Water Pollution Control Act (33 U.S.C. § 1251 *et seq.*); Subpart G of the National Contingency Plan (40 CFR § 300.600 *et seq.*); and Executive Order 12580 (52 Fed. Reg. 2923 (January 23, 1987)), as amended by Executive Order 12777 (56 Fed. Reg. 54757 (October 19, 1991)).

Restoration alternatives described in this document will be conducted in compliance with all applicable Federal, state, and local regulations. For example, actions undertaken by the Trustees to restore natural resources or services under CERCLA and other Federal laws are also subject to the National Environmental Policy Act (NEPA; 42 U.S.C. § 4321 *et seq.*), and the regulations guiding its implementation at 40 CFR Parts 1500 through 1517. NEPA and its implementing regulations outline the responsibilities of Federal agencies under NEPA, including requirements for environmental documentation. In general, Federal agencies contemplating implementation of a major Federal action must produce an Environmental Impact Statement (EIS) if the action is expected to have significant impacts on the quality of the human environment. When it is uncertain whether a contemplated action is likely to have significant impacts, Federal agencies prepare an Environmental Assessment (EA) to evaluate the need for an EIS. Therefore, in accordance with NEPA and its implementing regulations, this RP/EA summarizes the current environmental setting, describes the purpose and need for restoration actions, identifies alternative actions, assesses their applicability and potential impact on the quality of the physical, biological and

Bald Eagle

cultural environment, and outlines public participation in the decision-making process.

Other Federal natural resource and environmental laws and regulations considered during the development of this RP/EA include, but are not limited to: the Endangered Species Act of 1973; the Migratory Bird Treaty Act; the National Historic Preservation Act; the Archaeological Resources Protection Act; the Fish and Wildlife Coordination Act of 1934; the U.S. Fish and Wildlife Mitigation Policy of 1981; Executive Order 11990 on Wetlands; Executive Order 11988 on Floodplains; Executive Order 12580 on Superfund; and the Information Quality Act of 2001.

The major state environmental statute considered during the development of this RP/EA is the New York State Common Law (public nuisance).

1.4 COORDINATION WITH POTENTIALLY RESPONSIBLE PARTIES

Under CERCLA, the parties responsible for releases of hazardous substances may be invited to participate in a cooperative NRDAR effort (43 CFR § 11.32(a)(2)). Cooperative assessments can reduce duplication of effort, expedite the assessment, and accomplish resource restoration earlier than might otherwise be the case. The Trustees signed a Cooperative Assessment and Funding Agreement with Honeywell International Inc. (Honeywell) to facilitate the cooperative resolution of natural resource damages resulting from hazardous substance releases in the Onondaga Lake area (Trustees and Honeywell 2009). To date, Honeywell's active involvement in the damage assessment and restoration planning process includes the following:

- Providing funding and assistance for assessment activities,
- Providing data and relevant literature,
- Participating in Cooperative Assessment Teams, which focused on assessing ecological and recreational losses, providing input to the Remedial Habitat Plan (Honeywell 2009)[1], and coordinating public outreach.
- Assisting with the identification and benefits assessment of restoration alternatives.

The Trustees also engaged with Onondaga County, which, as the owner of a substantial amount of the land surrounding Onondaga Lake, provided input into the restoration planning process.

1.5 SUMMARY OF SITE HISTORY AND REMEDIATION

Hazardous wastes from industrial facilities, including Honeywell and its predecessor companies, were discharged to Onondaga Lake from approximately 1881 to 1986 (USEPA & NYSDEC 2005). These releases contained a suite of contaminants, including

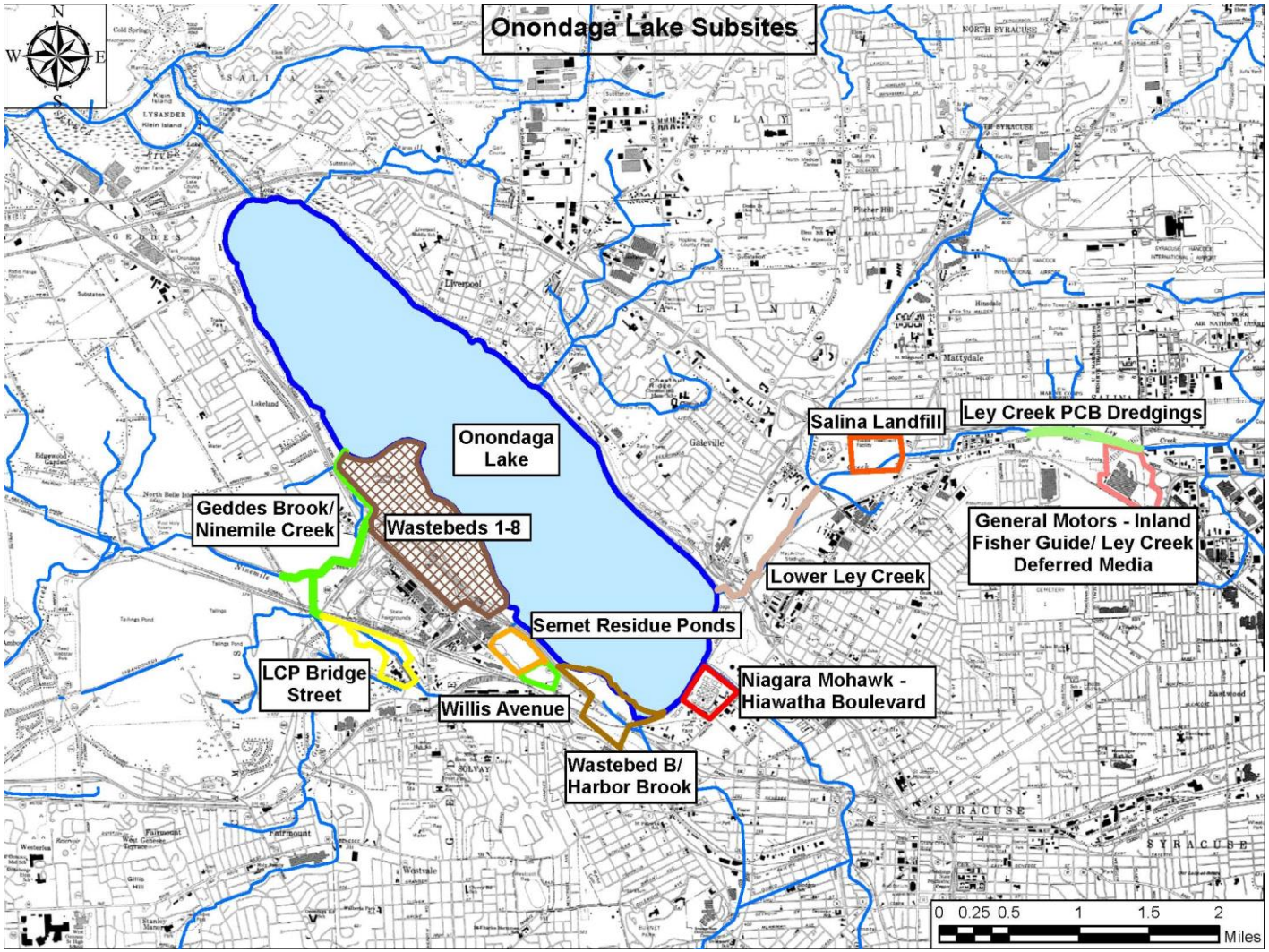
[1] The Habitat Plan can be found at: http://www.dec.ny.gov/chemical/61073.html.

large quantities of mercury. This extensive contamination led the State of New York to file a lawsuit in 1989 against Allied-Signal, Inc. (Honeywell's predecessor in interest) pursuant to CERCLA and state law seeking remediation, response costs and natural resource damages. Subsequently, the U.S. Environmental Protection Agency (EPA) placed Onondaga Lake and related areas on the National Priorities List (NPL) on December 16, 1994. In addition, several sites have been listed as "sub-sites" of the Onondaga Lake NPL site, including, but not limited to, the Honeywell LCP Bridge Street, Honeywell Semet Residue Ponds, Honeywell Wastebed B/Harbor Brook, Honeywell Willis Avenue, the Town of Salina Landfill, General Motors - former Inland Fisher Guide facility, Ley Creek Deferred Media, the GM - Ley Creek Dredgings, and the Niagara Mohawk – Hiawatha Boulevard sites (Exhibit 1-1). Together, the Onondaga Lake NPL site and designated sub-sites are referred to as the Site. Industrial activities associated with the Site are discussed in greater detail in the 1996 Damage Assessment Plan (DAP) (Normandeau Associates 1996) and the 2012 DAP Addendum (IEc 2012). Other sources of contamination to the Lake include the Metro facility, the Crucible Materials Corporation (via Tributary 5A), and the former Oil City petroleum facilities (USEPA & NYSDEC 2005).

Pre-remedy contaminant loads to the lake were primarily derived from Honeywell sites on the lake perimeter as well as in its vicinity, with surface water and groundwater pathways delivering much of the associated contamination to the lake. These sites include the Main Plant, which produced soda ash and a variety of benzene products (1884-1986); the Willis Avenue Plant, which manufactured chlor-alkali products and chlorinated benzenes (1918-1977); and the Bridge Street Plant, which produced chlor-alkali products and hydrogen peroxide (1953-1988) (NYSDEC/TAMS 2002b).

Dense non-aqueous phase liquid plumes at the Willis Avenue and Wastebed B/Harbor Brook sites also conveyed contaminants of concern (COCs) to the lake. These COCs include, but are not limited to, mercury, BTEX (benzene, toluene, ethylbenzene, and xylene) compounds, chlorinated benzenes, naphthalene and other polycyclic aromatic hydrocarbons (PAHs), other metals (e.g., lead, chromium, cadmium), and ionic wastes. Honeywell's historical waste discharges to the lake (e.g., via the East Flume) resulted in the significant accumulation of contaminated material in the southwest corner of Onondaga Lake. This "in-lake waste deposit" was estimated to be approximately 11 yards thick and contain over three million cubic yards of material, including some of the most contaminated sediment in the lake. Studies documented the ongoing re-release of contamination from the in-lake waste deposit area, adding to the contaminant load in the Onondaga Lake system (NYSDEC/TAMS 2002a).

EXHIBIT 1-1 ONONDAGA LAKE SUPERFUND SITE AND SUB-SITES



The GM Former Inland Fisher Guide Facility on Ley Creek is another known major source of contamination. There are four state and Federal superfund sites related to the contamination emanating from the Fisher Guide facility: 1) the Fisher-Guide plant site, 2) the Ley Creek PCB Dredgings site, 3) the Old Ley Creek Channel site and 4) the Onondaga Lake Bottom Sediments site. The Fisher Guide plant produced wastes containing elevated levels of polychlorinated biphenyls (PCBs) and heavy metals. It is likely that some of the GM facility wastes were deposited at the Town of Salina Landfill, which leaches contaminants into Ley Creek (elevated levels of PCBs and heavy metals have been found in the sediments of Ley Creek; NYSDEC/TAMS 2002b).

To address the ongoing resuspension of existing contamination within the Lake, in 2006 Honeywell entered into a consent decree with the State of New York to clean up the lake bottom consistent with the requirements of CERCLA, the National Contingency Plan and State law. Cleanup was extensive, with the removal of 2.2 million cubic yards of contaminated sediment, and capping that spanned one sixth of the lake bottom's area. Dredging began in 2012 and was completed in 2015. The capping component was recently completed.

Dredging boat in Onondaga Lake and bags of dredged sediment in wastebed.

In addition to cleanup of the lake bottom, Honeywell and other PRPs conducted remediation at a number of sites upstream of the Onondaga Lake Superfund site. These are described in the 1996 DAP (Normandeau Associates 1996), the 2012 DAP addendum (IEc 2012), and documents posted on the NYSDEC Region 7 Environmental Remediation Project Information webpage: http://www.dec.ny.gov/chemical/37558.html (e.g., Parsons 2014a, 2014b). Some examples include:

- Excavation, off-site treatment and disposal, and some on-site disposal and capping of PCB-contaminated soils at the Ley Creek PCB Dredgings sub-site (conducted from 1999 through 2000).
- Removal of portions of an on-site sewer system and plugging sewers remaining on-site to address residual mercury contamination at the LCP Bridge Street sub-site (conducted in 2000).

- Demolition and removal of on-site buildings and structures contaminated with mercury at the LCP Bridge Street sub-site (conducted in 2001).
- Cleaning and modification of storm drains for Interstate-690, downgradient from the Willis Avenue and Semet Tar Ponds sub-sites (conducted from 2003 through 2014).
- Installation of a groundwater barrier wall and groundwater collection and treatment system downgradient from the Willis Avenue and Semet Tar Ponds sub-sites (i.e., between the sub-sites and the Lake; conducted from 2006 through 2009).
- Removal of over 100,000 cubic yards of soil and sediment from the Geddes Brook and Ninemile Creek channels and adjoining floodplains, implementation of erosion controls, backfilling of material to appropriate elevations, and the restoration of habitat affected by construction activities. Geddes Brook activities were conducted from 2011 through 2012, and Ninemile Creek actions were conducted from 2012 through 2014.

Geddes Brook Restoration Site

Pending remedial work includes (NYSDEC 2015a, USEPA and NYSDEC 2015):

- The installation of non-aqueous phase liquid recovery wells at the Niagara Mohawk Erie Boulevard site;
- The bank-to-bank excavation of 9,600 cubic yards of Ley Creek sediments containing PCBs, and 15,000 cubic yards of floodplain soil excavation adjacent to operable unit 2 of the General Motors – Inland Fisher Guide site.

1.6 NATURAL RESOURCE DAMAGE ASSESSMENT AND RESTORATION

The ultimate goal of NRDAR is to restore, replace, rehabilitate, or acquire the equivalent of injured natural resources and resource services lost due to the release of hazardous substances. To achieve this goal, the Trustees completed a number of interim steps outlined in the DOI NRDA regulations (43 CFR Part 11).

1.6.1 NRDAR ACTIVITIES AT THIS SITE

NYSDEC initiated NRDAR activities at the Site in the 1990s, completing a Preassessment Screen Determination[2] in 1994, which determined that the five criteria for conducting a NRDAR (43 CFR § 11.23(e)) were met and it that was appropriate for NYSDEC to proceed (NYSDEC 1994). NYSDEC then released a Damage Assessment Plan in 1996 that focused primarily on hazardous wastes produced by Allied-Signal, Inc., Honeywell's corporate predecessor (Normandeau Associates 1996). The 1996 DAP was developed to provide a framework for conducting the damage assessment and to ensure both that the assessment was performed in a systematic manner and the methodologies selected could be conducted at a reasonable cost. Subsequently, the FWS completed a Preassessment Screen in 2005, confirming NYSDEC's earlier conclusion that it was appropriate for the Trustees to proceed with the NRDAR process. In 2008, the Trustees signed a Memorandum of Agreement (MOA) that created a Trustee Council for the purpose of coordinating NRDAR activities.[3] In the MOA, the Trustees agreed to together conduct:

- The assessment of natural resource damages…for injury to, destruction of, or loss of natural resources and natural resource services,
- Restoration planning and implementation, and
- Coordination of assessment and restoration activities…with remedial design or implementation activities carried out by or under the direction of Federal and state agencies at the Site (NYSDEC et al. 2008).

From 2008 through 2015, NYSDEC and FWS (in cooperation with Honeywell, see Section 1.4) conducted a series of site-specific studies assessing the exposure to and potential effects of site-related COCs on natural resources (e.g., waterfowl, songbirds, amphibians, reptiles, and bats). The Trustees and Honeywell together also conducted a study of the number of recreational anglers and boaters at Onondaga Lake. These studies are discussed in more detail in Chapter 3 and most can be found at: http://www.fws.gov/northeast/nyfo/ec/onondaga.htm.

In 2013, the Trustees and Honeywell began efforts to identify potential NRDAR-relevant restoration projects. This included compiling the Onondaga Lake Proposed Restoration and Redevelopment Project Database, a collection of a wide range of

Great blue heron and mallards - Onondaga Lake

[2] The purpose of a preassessment screen is to provide a review of readily available information on hazardous substance releases and potential impacts of those releases on natural resources under the trusteeship of Federal and state authorities. The review should ensure that there is a reasonable probability of making a successful claim against the parties responsible for releasing hazardous substances to the environment (43 CFR § 11.23(b)).

[3] In 2015, the Onondaga Nation elected to withdraw from the Trustee Council MOA.

suggestions and visions for restoration, enhancement, or redevelopment of Onondaga Lake and its tributaries, as described in existing documents and plans. The Trustees also solicited restoration project ideas from the public (see Section 1.7).

1.6.2 RELATIONSHIP TO REMEDIAL ACTIVITIES

NRDAR is a process that occurs *in addition* to the remedial process conducted by regulatory agencies like NYSDEC and EPA. These two processes have different goals. Remedial action objectives are risk-based, and are developed to protect human health and the environment from further unacceptable harm or risks of harm. Remedies are selected based on evaluation criteria that are used to compare remedial alternatives and may result in contamination remaining in the environment above levels that existed prior to their release. In contrast, the goal of NRDAR is the restoration of resources to their baseline condition (i.e., what their condition would be absent the release). Injuries are assessed over time until that baseline is achieved or expected to be achieved, which may still be years after remedial actions are completed (i.e., post-remedial contaminant levels may be sufficient to cause injury). There are components of NRDAR and remedy that overlap, however. For example, remedial decisions can include consideration of NRDAR restoration objectives. Work to remedy a site may partially or completely restore injured natural resources, which NRDAR analyses take into account. Remedial actions may cause "collateral injury" to habitat, and assessment and restoration of this remedy-induced injury is also evaluated within NRDAR.

For the Onondaga Lake NRDAR, the Trustees have interacted with the remediation staff at NYSDEC and EPA by reviewing and providing comments on remedial documents such as the Habitat Plan (Honeywell 2009), and identifying supplemental restoration opportunities (e.g., additional fish structures in areas beyond those identified for direct remedial action, invasive species control beyond the period required under the remedy).

1.7 PUBLIC PARTICIPATION

Public participation and review is an integral part of the restoration planning process. The Trustees have coordinated with the public throughout this NRDAR and will continue to encourage active public participation. For example, the Trustees:

- Developed the Onondaga Lake Proposed Restoration and Redevelopment Project Database that summarizes restoration projects presented in the 2010 Onondaga Nation's Vision for a Clean Onondaga Lake, 2010 Onondaga Lake Watershed Progress Assessment and Action Strategies, 1991 Onondaga Lake Development Plan, 1974 Onondaga Lake Environmental Action Plan, 2009 Onondaga Creek Conceptual Revitalization Plan, and the 2012 Syracuse Land Use and Development Plan 2040 (https://www.fws.gov/northeast/nyfo/ec/files/onondaga/OnondagaPotentialRestorationRedevelopmentProjectsDatabase.pdf).

- Presented information on this NRDAR and requested suggestions for restoration projects at public meetings, including the Onondaga Lake Watershed Partnership and the Greater Syracuse Focus Forum.
- Solicited restoration project suggestions via the Onondaga Lake News E-mail Listserve managed by NYSDEC, an exhibit at the New York State Fair, an article in the Syracuse Post Standard newspaper, and via a letter sent to a wide range of agencies (e.g., nonprofits, local towns, City of Syracuse, Onondaga County, and academic institutions) that included the project solicitation form.
- Posted information on the NRDAR process on the USFWS New York Field Office website and Facebook page.

This RP/EA is available for review and comment for a period of a minimum of 30 days in accordance with 43 CFR § 11.32(c)(1). The Trustees will address public comments and will document responses to those comments as part of the final Onondaga Lake NRDAR RP/EA.

Copies of this RP/EA are available at:
http://www.fws.gov/northeast/nyfo/ec/onondaga.htm.

This link will be sent to subscribers of the NYSDEC Onondaga Lake News E-mail Listserve, and the Trustees will present this RP/EA, as well as general information regarding the NRDAR process, at a public meeting to be held during the public comment period.

Comments on this RP/EA may be submitted in writing or via email, and are due to the Trustees by June 2, 2017. To request a copy of this RP/EA, to submit a comment, or for additional information, please contact:

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As restoration progresses, the Trustees may amend this RP/EA and will subsequently notify the public. Amendments, if any, will be publicly available. In the event of a significant modification to the RP/EA, the Trustees will provide the public with subsequent opportunity to comment.

1.8 ADMINISTRATIVE RECORD

An administrative record, that is, a catalog of all documents Trustees used to develop and make decisions related to the NRDAR, including this RP/EA, is maintained by the USFWS.

CHAPTER 2 | AFFECTED ENVIRONMENT

This RP/EA evaluates restoration options to compensate the public for the natural resource injuries and associated losses in ecological and recreational services resulting from exposure to Site-related COCs. As part of this evaluation, the Trustees assessed the current physical, biological, socio-economic, and cultural resources of the area within which restoration is likely to occur (i.e., the affected area). This information will assist the Trustees in planning future restoration activities and ensure that potential restoration projects are designed to both maximize ecological and human use benefits while minimizing or eliminating project-related adverse environmental consequences.

2.1 PHYSICAL ENVIRONMENT

The affected area encompasses Onondaga Lake, its tributaries, and associated wetlands and uplands. Onondaga Lake is located in the northern portion of the Onondaga Lake watershed, which covers 285 square miles in Onondaga and Cortland counties in central New York (Exhibit 2-1). The Onondaga Lake watershed also encompasses the City of Syracuse and the lands of the Onondaga Nation. The second largest lake in the watershed, Onondaga Lake lies at an elevation of approximately 400 feet above sea level, is approximately 4.7 miles long, has a maximum depth of 60 feet, and covers almost 3,000 acres. A single outlet allows water from the lake to drain to the Seneca River, which eventually empties into Lake Ontario. The water level in Onondaga Lake is controlled by a dam located approximately 15 miles downstream in Phoenix, New York (Honeywell 2009).

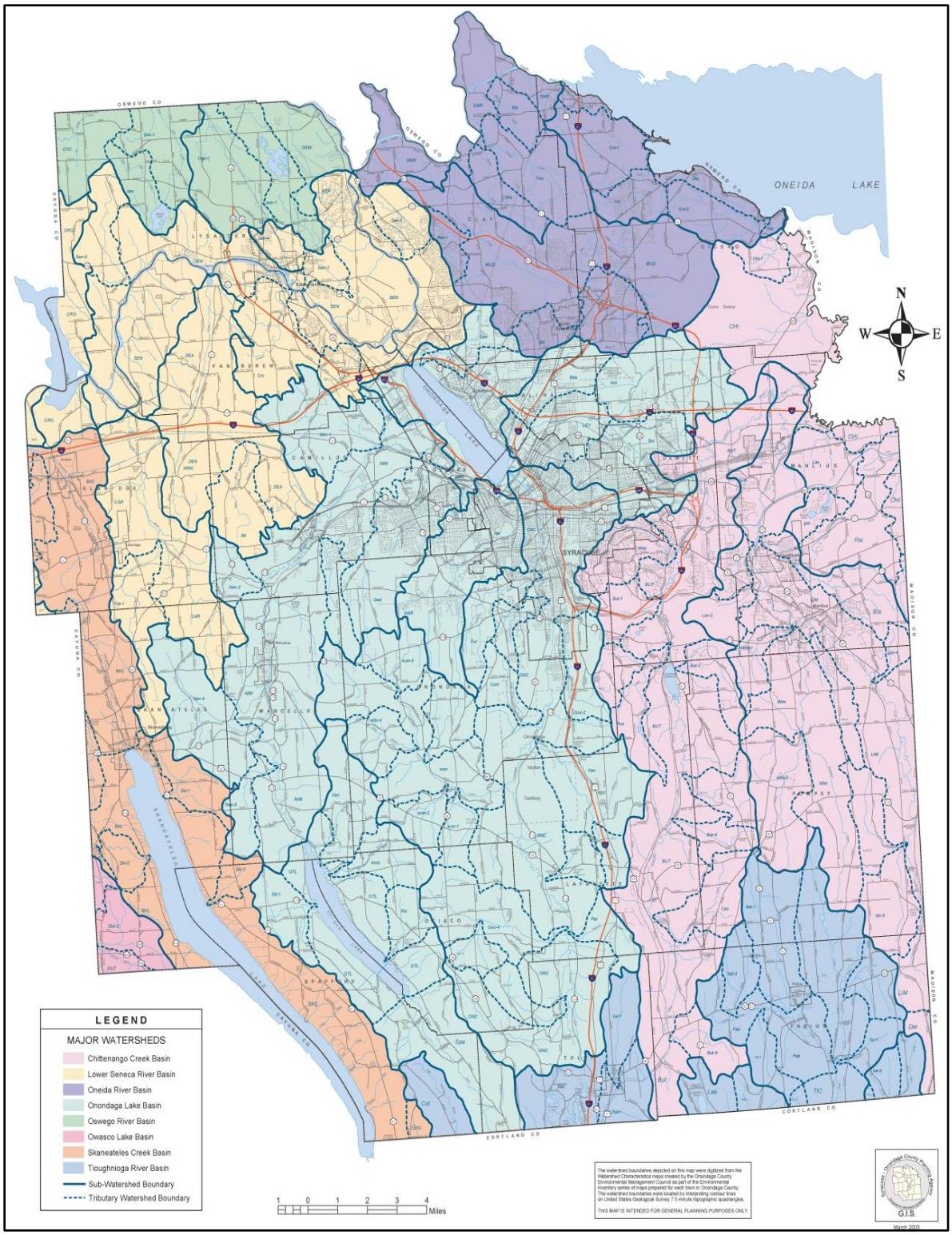
City of Syracuse

Major tributaries to Onondaga Lake include Ninemile Creek and Onondaga Creek, which together account for 70 percent of the water that flows into the lake annually (NYSDEC 2016b, OLWP 2016). Ninemile Creek flows approximately 22 miles from Otisco Lake to Onondaga Lake, and is known for its trout fishery. Onondaga Creek flows 27 miles from Tully, NY through the Onondaga Nation lands and the City of Syracuse before emptying into Onondaga Lake. Other inputs to Onondaga Lake include the Metropolitan Syracuse Wastewater Treatment Plant, which supplies 20 percent of the lake's inflow, as well as Bloody Brook, Harbor Brook, Ley Creek, and Saw Mill Creek.

Onondaga Creek

Ninemile Creek water trail from Otisco Lake to Onondaga Lake

EXHIBIT 2-1 ONONDAGA LAKE WATERSHED (SYRACUSE-ONONDAGA COUNTY PLANNING AGENCY 2003)



Land use throughout the watershed includes both urban and industrial uses, as well as agriculture in rural locations. Urban and industrial uses are concentrated within the northern portion of the Onondaga Lake watershed, including those areas surrounding Onondaga Lake and the City of Syracuse, while suburban uses, parks, and farmlands account for a greater proportion of the downstream land uses (Syracuse-Onondaga County Planning Agency 1998). To the southeast of Onondaga Lake, the Syracuse Metropolitan Statistical Area spans 3,083 square miles across Cayuga, Madison, Onondaga, and Oswego Counties. As of 2015, Syracuse had a population of approximately 145,000 people (US Census Bureau 2016). The Onondaga Nation lands are located due south of Syracuse and occupy 11.4 square miles, significantly less than their historic territory.

Considering information about land use in the watershed enables the Trustees to assess the conservation landscape, anthropogenic pressures, and the manner in which lands are utilized, all of which may affect the benefits expected from planned restoration. For example, urbanization and sprawl near Syracuse directly borders Onondaga Lake and decreases the amount of land available for restoration while increasing costs associated with land preservation and restoration.

2.2 NATURAL RESOURCES AND BIOLOGICAL ENVIRONMENT

Natural resources within the Onondaga Lake watershed include, but are not limited to sediment, soil, water (surface water and groundwater), aquatic plants, invertebrates, reptiles and amphibians, fish, birds, and mammals. Wildlife and other biological resources utilize a suite of habitats within the watershed, ranging from open water to wetlands to upland grasslands. Some species, such as the northern long-eared bat (*Myotis septentrionalis*), are of particular concern to the Trustees due to either their threatened or endangered conservation status (see Appendix A), or because they are culturally and/or economically important. For example, certain species (e.g. ducks, smallmouth bass) are caught and consumed through hunting and fishing activities. Varied habitats provide opportunities for recreation, including boating, hiking, and bird watching. This section describes the natural resources within the affected area, with particular attention to the habitat types and wildlife species present.

2.2.1 HABITAT TYPES

A variety of habitats are present within the Onondaga Lake watershed. While historically nearby salt springs contributed to rare habitats such as inland salt ponds and marshes (NYSDEC/TAMS 2002a, Honeywell 2009), currently, most of the shoreline is classified as shallow lake (lacustrine littoral) habitat, with deciduous forest wetlands, freshwater wetlands, and shallow emergent marshes surrounding the lake. Twenty-two wetlands regulated by NYSDEC exist within two miles of Onondaga Lake (NYSDEC/TAMS 2002a).

Onondaga Lake supports several distinct aquatic habitat types. Waters within the lake become stratified (i.e., layered) during the summer months, with inflows from tributaries mixing into the warmer waters at the lake's surface but remaining distinct from the cooler waters beneath the thermocline [4] (located approximately nine meters below the surface; Honeywell 2009). Further, Onondaga Lake's distinct nearshore littoral zone supports submerged aquatic vegetation and unconsolidated bottom sediments that contain precipitated calcite deposits. Deeper waters in Onondaga Lake's profundal zone support fish species such as the state-threatened lake sturgeon (Honeywell 2009).

Various habitat types and land uses around Onondaga Lake

Riparian and upland habitats near Onondaga Lake include wooded areas and park lands on the northern edge of the lake, urban development associated with the City of Syracuse along the eastern edge, and historic wastebeds generated by Honeywell's corporate predecessors along the western and southern edges (NYSDEC/TAMS 2002a, Honeywell 2009). Soils surrounding the lake consist of materials historically deposited by glaciers, ancient rivers, and unconsolidated (i.e., loose) sediments. Many soils along the western, southern, and eastern sides of the lake have been altered by urban development or placement of soda-ash waste. Residential and urban/industrial lands account for a combined 75 percent of cover within a half mile of the lake, while the rest is characterized by open, forested, or palustrine (i.e., marshes, bogs, swamps) habitat (NYSDEC/TAMS 2002a). Further from the lake, floodplain forests, hardwood forests, shrublands, and farmlands are present, in addition to urban and industrial structures.

[4] A thermocline is a steep temperature gradient in a body of water such as a lake, marked by a layer above and below which the water is at different temperatures.

Gizzard shad

White perch

Smallmouth bass

Leopard frog

Green frog

Snapping turtle

2.2.2 FISH

In general, the fish community in Onondaga Lake consists predominantly of warm water species such as gizzard shad, white perch, carp, and freshwater drum, with smallmouth bass and walleye supporting an important recreational fishery (NYSDEC/TAMS 2002a). Sampling efforts between 1927 and 1994 found 54 fish species present in Onondaga Lake and its tributaries (NYSDEC/TAMS 2002a), while the Onondaga County Department of Water Environment Protection documented 46 species from 2000-2008, including the lake sturgeon, a New York State threatened species (OCDWEP 2008). Lake sturgeon were introduced through a stocking effort in nearby Oneida Lake as part of an effort to reestablish the species, and through connected waterways were able to migrate to Onondaga Lake (OCDWEP 2008). Recent water quality improvements due to wastewater treatment upgrades have led to an increased abundance of fish species (OCDWEP 2008).

2.2.3 REPTILES AND AMPHIBIANS

Reptiles and amphibians have the potential to utilize wetland, riverine, and upland habitats in the Onondaga Lake watershed. In surveys between 1994 and 1997, seven species of amphibians were documented within 250 meters of the Lake shoreline, including American toad, grey tree frog, spring peeper, green frog, northern leopard frog, spotted salamander, and eastern newt (NYSDEC/TAMS 2002a). Surveys also identified six species of reptiles, including northern water snake, brown snake, garter snake, snapping turtle, painted turtle, and musk turtle (Ducey et al. 1998, NYSDEC/TAMS 2002a).

In 2011 and 2012, the Trustees conducted a study of amphibians and reptiles in the Onondaga Lake watershed (Ducey 2014). The thirteen reptile and amphibian species at the Lake reflect a viable herpetofauna, but one with fewer species than have been documented in surrounding areas (Ducey 2014). No evidence of successful amphibian breeding within the lake is available, but limited reproduction has been reported for three frog species in one wetland (SYW-6) adjacent to the lake. Ducey (2014) hypothesizes that herpetofaunal abundance, diversity, and successful reproduction may be limited by factors including sediment chemistry (i.e., due to industrial and municipal contaminants), habitat fragmentation and site modifications associated with urbanization, limited aquatic plants or dense invasive species in wetlands, inadequate upland soils, and lack of corridors to facilitate recolonization and altered water quality.

2.2.4 BIRDS

Great blue heron

Onondaga Lake is located within the Atlantic flyway, provides habitat for both migrating and resident birds, and is recognized as an Important Bird Area for New York State. More than 100 bird and waterfowl species have been identified utilizing the Lake and its shoreline, including bald eagle, great blue heron, American kestrel, wild turkey, common loon, and a number of songbirds. Migratory shorebirds and waterfowl breed and nest in and around the Lake, which is a recognized waterfowl concentration area during spring, fall, and winter months (FWS 2005, NYSDEC/TAMS 2002a, Honeywell 2009).

2.2.5 MAMMALS

Mammalian species such as shrew, eastern mole, eastern cottontail rabbit, groundhog, gray fox, and white-tailed deer are found in riparian and wetland habitats similar to those near Onondaga Lake (NYSDEC/TAMS 2002a). The Federally-listed endangered Indiana bat occurs in Onondaga County within foraging distance of the lake (FWS 2005), and the shoreline and surrounding wetlands may support small populations of mink and river otter (Honeywell 2009).

Indiana bat

A complete list of mammal species expected to be found within the affected area is provided in Chapter 3 of the Baseline Ecological Risk Assessment (http://www.lakecleanup.com/publicdocs/docs/08acb31e-cc33-468b-afa9-7ca7e8b9e94b.pdf; NYSDEC/TAMS 2002a).

2.2.6 THREATENED AND ENDANGERED SPECIES

Certain wildlife species have been adversely impacted by environmental stressors (e.g., habitat degradation) to an extent that their long-term viability is uncertain. Many of these species are afforded special protection under Federal and/or state legislation for endangered species. Rare species have been documented within the affected area, notably the Federally endangered Indiana

Lake sturgeon

bat (*Myotis sodalis*), the Federally threatened northern long-eared bat, and the state threatened lake sturgeon. A list of state- and Federally listed threatened and endangered species present in Onondaga County is provided in Appendix A. Future restoration actions would need to minimize ecological impacts on these species, and may be designed to specifically benefit these species.

2.3 SOCIOECONOMIC RESOURCES

In Onondaga County, the majority of residents are employed in the education, health, social services, manufacturing, and retail industries (US Census Bureau 2016). In the Syracuse area, the manufacturing industry has been in decline over the last 10 years, while the education, health services and leisure and hospitality industries have expanded (US Department of Labor 2016).

The population of Onondaga County is about 468,000, and has remained steady over the last few years. According to U.S. Census population estimates, the population increased by about 1,400 from 2010 to 2015 (US Census Bureau 2016). In Onondaga County, racial minorities (defined as all US Census race/ethnicity categories other than white alone) comprise approximately 19 percent of the population, slightly below the national average of 26 percent. Fifteen percent of residents are living below the poverty level, a proportion comparable to the national average (US Census Bureau 2016).

2.4 CULTURAL AND HISTORICAL RESOURCES

Onondaga Lake has played a central role in the cultural history of the Onondaga Lake region. Prior to European settlement and continuing today, the lake and its environment are a central meeting place for the six Nations of the Haudenosaunee, "People of the Longhouse." For over 1,000 years, the Haudenosaunee Confederacy has existed at Onondaga Lake and on lands that stretched across New York state. The Onondaga people consider the lake and the resources it provides to be sacred. Onondaga Lake is "an intrinsic part of [the Onondaga Nation's] existence," once providing water, food, and medicinal plants as well as a place to fish, hunt, play, swim, and learn (Onondaga Nation 2015). The Onondaga people are strong stewards of land, and have a unique cultural relationship and history with the area, including Onondaga Lake, its tributaries, and surrounding lands.

Additionally, historical resources within Onondaga County include 147 properties and 20 historic districts listed as part of the National Register of Historic Places (NPS 2016).

2.5 LANDSCAPE-SCALE ECOLOGICAL STRESSORS

Widespread, complex ecological stressors are causing changes to the ecological landscape of New York. Some of these stressors, such as fluctuating water levels, invasive species, and non-point source pollution, all of which can be exacerbated by climate change, have become both more prevalent and better understood over the last

decade. Of particular relevance to Onondaga Lake, the ramifications of invasive species and climate change are presented below as each relates to the ecological function of the watershed.

2.5.1 INVASIVE SPECIES

Aquatic invasive species have contributed to the degradation of aquatic communities in central New York and the Great Lakes. Hydrologically connected to Onondaga Lake, Lake Ontario contains a number of invasive species, including fish, mollusks, crustaceans, and plants that have entered the Great Lakes since the early 1800s (Domske and O'Neill 2003). Non-native species such as common carp, sea lamprey, round goby, rainbow smelt, alewife, common reed grass, zebra mussels, and quagga mussels have negatively impacted native species through direct predation, competition, and/or habitat alteration. For example, the non-native *Phragmites australis*, or common reed, can rapidly form dense stands of stems that crowd out or shade native vegetation in wetland areas. These dense areas reduce vegetative diversity, alter hydrology, change local topography, and decrease the ability of wildlife to utilize the habitat. Invasive species also negatively impact the local economy by threatening agriculture, forestry, navigation, tourism, recreation, and the fishing industry.

Non-native Phragmites (Common reed grass)

To mitigate these negative impacts, programs have been developed to stop the spread of invasive species within the affected area. For example, NYSDEC developed a statewide plan to manage aquatic invasive species in 2015 (NYSDEC 2015b). Water chestnut is an invasive species of concern in central New York, and recent initiatives have included education, harvesting, and application of herbicides (LaManche 2007). Eurasian watermilfoil is an aquatic invasive species present within Onondaga County, and has been the subject of harvesting and research on potential biological control agents (LaManche 2007).

Changing ecological conditions, such as declining lake levels and increasing air temperature, may increase the vulnerability of natural systems to invasive species and

favor their continued spread and proliferation (NOAA 2010). The Trustees will review restoration options for invasive species management and benefits to native species.

2.5.2 CLIMATE CHANGE

Although predicting the impacts of climate change is an inherently complex task, some climate-induced changes are already manifest in central New York and are likely to continue. For example, climate change is likely to affect water budgets in terms of precipitation and air temperature, though the magnitude of these shifts is unclear. New York climate predictions include warmer conditions and an increase in intense precipitation events greater than one inch (NYSERDA 2014). Recent climate assessments have identified impacts that are currently observed in New York State, such as decreased winter snow cover and increased average annual temperatures (NYSDEC 2016a). These altered conditions could affect flow regimes, cause fluctuations in species compositions, and reduce habitat sustainability (e.g., if habitats cannot migrate or adapt to new climate conditions). Precipitation and temperature fluctuations may affect at-risk biological resources in niche riparian and aquatic habitats.

The Trustees will consider the long-term implications of fluctuating climate and climate change adaptation principles (see http://www.dec.ny.gov/regulations/65034.html) when developing a preferred restoration alternative. Although there is a high degree of uncertainty regarding the effects of climate change on restoration, precautionary approaches can be taken to consider a range of possible effects and increase resiliency of NRDA restoration projects.

2.6 SUMMARY

The Onondaga Lake watershed encompasses a suite of habitat types that together support a wide range of plant, fish, and wildlife species. Current land use and socio-economic conditions, combined with increases in urbanization and environmental degradation due to landscape-scale stressors such as climate change and the spread of invasive species, have adversely affected these natural resources. In addition to ecological functions, these natural resources provide recreational, commercial, and cultural services. The Trustees will take these current resource conditions into account when evaluating and planning future restoration.

CHAPTER 3 | NATURAL RESOURCES AND CONTAMINANT-RELATED INJURIES

To understand the scale and scope of necessary restoration, the Onondaga Lake Trustees evaluated available information to inform the severity, magnitude, and extent of injury to natural resources as a result of exposure to hazardous substances released into Onondaga Lake, its tributaries and associated wetlands and uplands. This Chapter describes the geographic scope within which the Trustees assessed injuries, the contaminants of concern upon which this NRDAR is focused, the pathways of those COCs through the environment, the natural resources that have been injured, and the associated losses in ecological and recreational services.

3.1 ASSESSMENT AREA

A key component in the determination of natural resource injuries is the assessment area, defined as, "the area or areas within which natural resources have been affected directly or indirectly by the discharge of oil or release of a hazardous substance and that serves as the geographic basis for the injury assessment" (43 CFR 11.14 (c)). In this case, the assessment area includes Onondaga Lake, its tributaries, and surrounding wetland and terrestrial habitats that have been exposed to hazardous wastes released from industrial and waste disposal facilities in the area, as described below and illustrated in Exhibits 3-1 and 3-2:

- **Onondaga Lake**, which covers approximately 3,000 acres and is located in a largely urban area near the City of Syracuse, Onondaga County, New York.
- **Tributaries to Onondaga Lake**, including Ley Creek, Ninemile Creek, Onondaga Creek, Harbor Brook, Bloody Brook, Sanders Creek, Sawmill Creek, Iron Brook, Geddes Brook, the East and West Flume, and Tributary 5A. Together these tributaries support approximately 90 acres of aquatic habitat.
- **Wetlands** associated with Onondaga Lake and tributaries, including New York State Wetlands SYW-1, SYW-6, SYW-10, and SYW-18.
- **Uplands** associated with the Lake and the Site, including Wastebeds 1-6, 9-11, and 12-15, along with land surrounding Harbor Brook and along the southeast corner of the Lake.

EXHIBIT 3-1 AQUATIC GEOGRAPHIC SCOPE OF ONONDAGA LAKE NRDAR

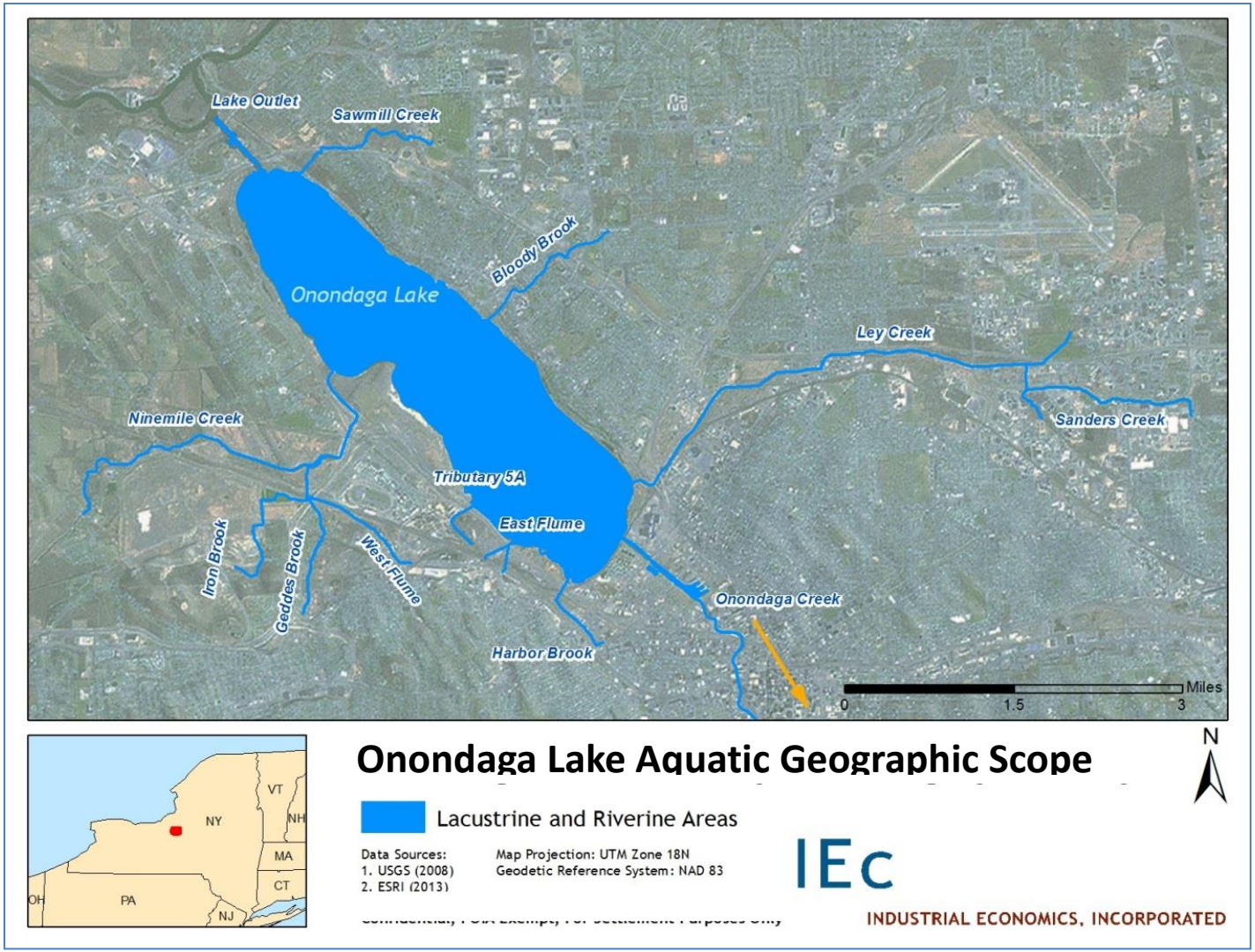
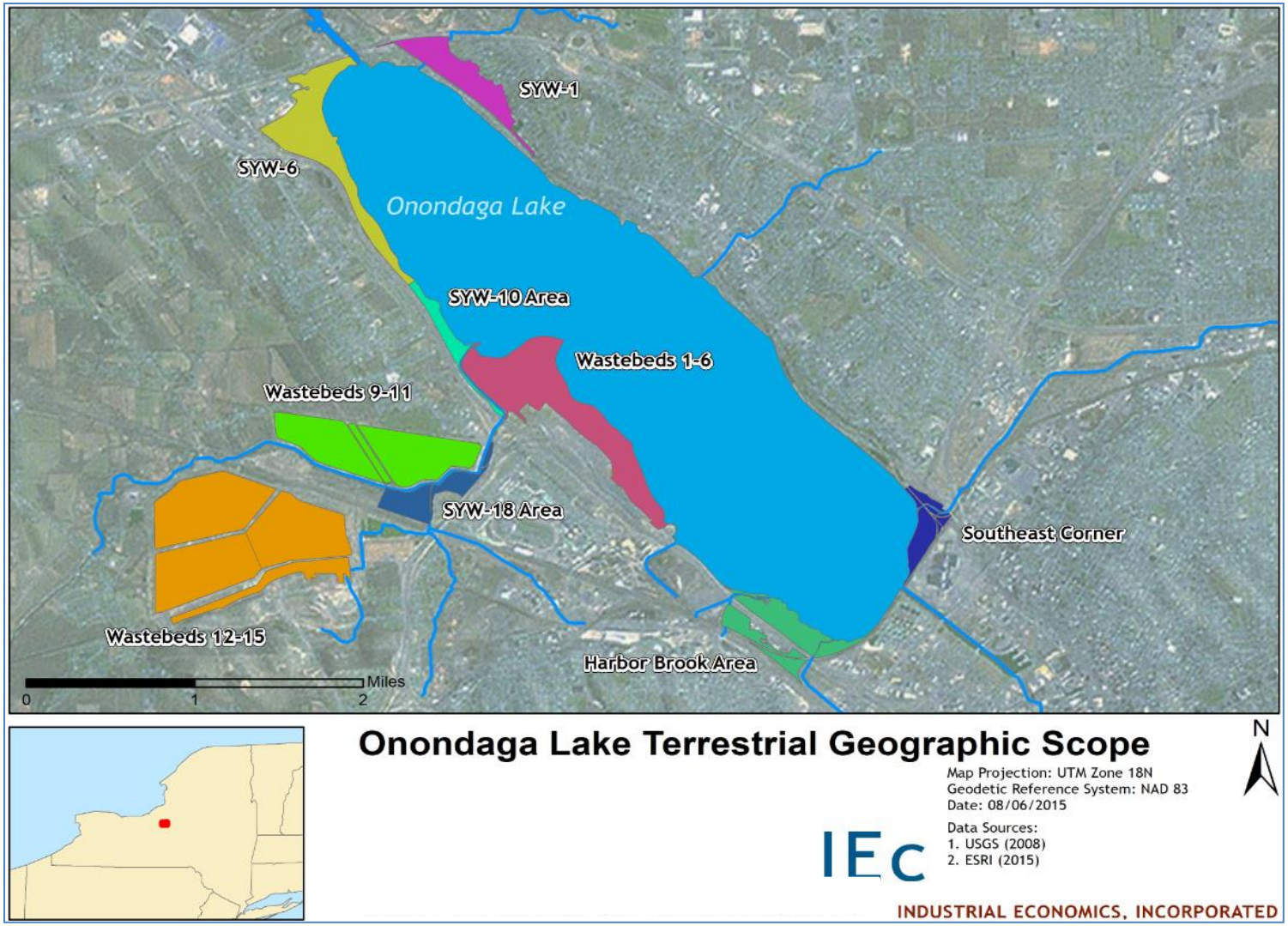


EXHIBIT 3-2 TERRESTRIAL GEOGRAPHIC SCOPE OF ONONDAGA LAKE NRDAR



3.2 NATURAL RESOURCES

The assessment area includes open water (lake and river), wetland, and upland areas in the vicinity of Onondaga Lake and its tributaries. As noted in Section 2.2, natural resources that comprise or utilize these habitats within the assessment area and that are of concern to the Trustees include, but are not limited to sediment, soil, water (surface water and groundwater), aquatic plants, invertebrates, reptiles and amphibians, fish, birds, and mammals (43 CFR § 11.14(z)).

3.3 NATURAL RESOURCE INJURY

The natural resources listed above provide a variety of services. Services are, "the physical and biological functions performed by the resource, including the human uses of those functions, [that result from the resource's] physical, chemical, or biological quality" (43 CFR § 11.14 (nn)). For example, ecological services provided by benthic (i.e., sediment-dwelling) invertebrates include foraging opportunities for fish and birds and nutrient cycling. Similarly, wetland soils provide services by supporting healthy vegetation and diverse plant communities that in turn provide animals with foraging opportunities, nesting or denning areas, and protective cover. Examples of human use services provided by natural resources include opportunities for fishing, boating, and wildlife viewing and appreciation.

Injury has occurred when a resource's viability or function is impaired such that the type and/or magnitude of services provided by that resource is reduced or altered as a result of contamination (43 CFR § 11.14 (v)). Determination of injury requires documentation that there is: (1) a viable pathway for the released hazardous substance from the point of release to a point at which natural resources are exposed to the released substance, and (2) that injury of exposed resources (i.e., surface water, sediment, soil, groundwater, biota) has occurred as defined in 43 CFR § 11.62. The first condition is satisfied based on clear documentation of direct historical discharge of hazardous substances into the lake and tributaries from facilities such as the Honeywell Main Plant, Honeywell Willis Avenue Plant, Honeywell LCP Bridge Street Plant, and the GM Inland Fisher Guide facility (See NYSDEC/TAMS 2002a). The second condition is satisfied because: 1) measured and modeled concentrations of COCs in assessment area resources exceed levels at which the scientific literature reports adverse effects on endpoints such as reproduction, growth, and survival, and 2) there is a contaminant-driven fish consumption advisory that impacts human use of fishery resources.

The Trustees identified mercury and PCBs as the primary COCs in the assessment area because they are persistent in the environment (i.e., do not readily degrade), site-specific concentration data and relevant effects literature are readily available, and elevated concentrations have been measured throughout the assessment area.

Mercury does not serve any biological function, and is universally toxic in sufficient concentrations. Mercury can also biomagnify and bioaccumulate through foodwebs,

affecting higher trophic level organisms.[5] Even at low concentrations, mercury can cause adverse impacts to reproduction, growth, development, behavior, blood chemistry, vision, and metabolism, and at high concentrations is lethal (Eisler 2000).

PCBs are a class of compounds consisting of 209 chlorinated hydrocarbon chemicals (individually known as PCB congeners). The chemical structure of PCBs allows these compounds to accumulate in the fatty tissues of organisms and, similar to mercury, bioaccumulate and biomagnify through food webs. In organisms, PCBs can cause a range of adverse health effects, including liver and dermal toxicity, teratogenic and other reproductive effects, and neurological effects (Eisler 2000).

Because of the method used to assess natural resource injury to sediment-dwelling organisms, the combined effects of all COCs were accounted for in that analysis (see Section 3.3.1). For other natural resources, however, additional COCs were evaluated with respect to their contribution to injury to natural resources but corresponding injuries were not quantified due to either limited site-specific exposure data and/or limited information in the literature on the effects of those COCs on relevant resources.

Below is an overview of the natural resource injuries demonstrated to have occurred within the assessment area.

3.3.1 ECOLOGICAL LOSSES RESULTING FROM INJURY TO NATURAL RESOURCES

To assess the losses in ecological services as a result of natural resource exposure to and injury from Site-related hazardous substances, the Trustees used measured and modeled contaminant concentration data in combination with site-specific and literature-based toxicological study results. Together, these data informed the expected magnitude and severity of the effects of relevant COCs on Trust resources. Based on the DOI NRDAR regulations, the Trustees evaluated injury to sediment-dwelling invertebrates, fish, amphibians, reptiles, soil invertebrates, bats, and birds. These injuries were then assessed on a habitat basis in order to facilitate the development of appropriate habitat-based restoration projects (Exhibit 3-3). Details of this evaluation are presented below by resource.

[5] *Bioaccumulation* is the intake of a chemical and its concentration in the organism by all possible means, including contact, respiration and ingestion. *Biomagnification* occurs when the chemical is passed up the food chain to higher trophic levels, such that in predators it exceeds the concentration to be expected where equilibrium prevails between an organism and its environment.

EXHIBIT 3-3 REPRESENTATIVE RESOURCES BY HABITAT TYPE

HABITAT TYPE	RESOURCE	RESOURCE EXAMPLE
Lacustrine/Riverine	Sediment-dwelling Invertebrates	Chironomids, Mussels
	Fish	Smallmouth bass, Walleye
	Aquatic Birds	Belted kingfisher, Osprey
Wetland/Upland	Soil-dwelling Invertebrates	Spider, Earthworm
	Terrestrial Birds	American robin, Tree swallow
	Reptiles and Amphibians	Northern leopard frog, Painted turtle
	Bats	Indiana bat, Big brown bat

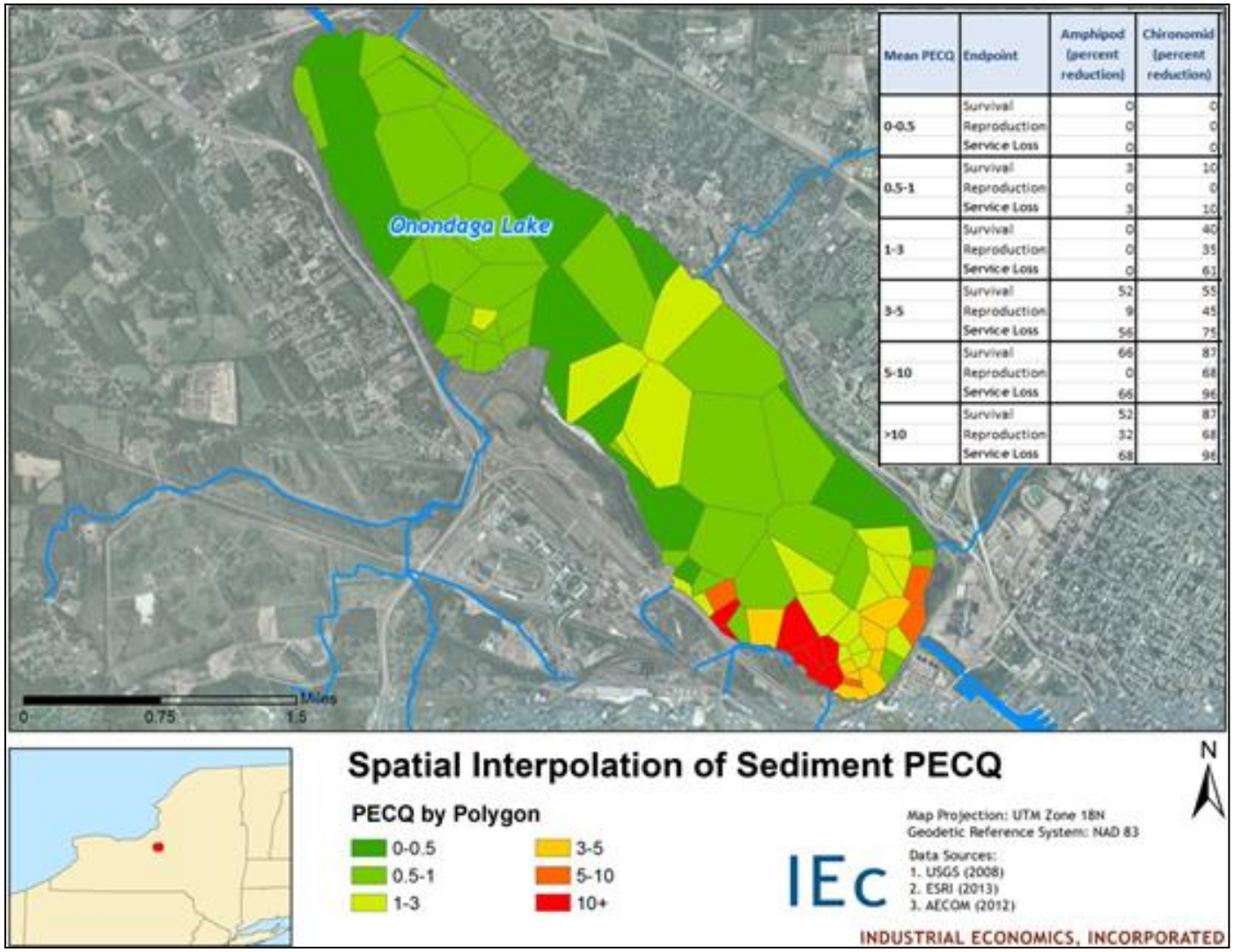
Sediment-dwelling Invertebrates

Chironomid (midge)

The Trustees evaluated injury to sediment using site-specific contaminant concentration data together with amphipod (shrimp-like invertebrates) and chironomid (midges) toxicity tests conducted under the Baseline Ecological Risk Assessment for Onondaga Lake (NYSDEC/TAMS 2002a). The toxicity tests related reductions in invertebrate survival and reproduction to contamination in the sediments where these organisms were tested. The degree of contamination was quantified using probable effects concentration quotients (PECQs), which measure the magnitude of adverse effects threshold exceedances for a combined set of COCs, including mercury and PCBs. By understanding the impacts on survival and reproduction of test organisms at different sediment PECQ ranges, the Trustees were able to use available PECQ data to estimate reductions in survival and reproduction of sediment invertebrates at sampling locations throughout the Lake. These data were interpolated using Thiessen polygons[6] to model the likely toxicity of sediments across the entire Lake bottom (Exhibit 3-4). Results indicate that injury was widespread across the lake, with expected reductions in ecological services at PECQs above 0.5 (Exhibit 3-4). Because PECQ data were not available for Onondaga Lake tributaries, the Trustees assumed that service loss in the tributaries was consistent with losses in the shallow (0-2 meter depth) areas of Onondaga Lake.

[6] Thiessen polygons are generated from a set of points. Each Thiessen polygon defines an area of influence around its sample point, so that any location inside the polygon is closer to that point than any of the other sample points.

EXHIBIT 3-4 SPATIAL INTERPOLATION OF ONONDAGA LAKE SEDIMENT PECQS



Mean PECQ	Endpoint	Amphipod (percent reduction)	Chironomid (percent reduction)
0-0.5	Survival	0	0
	Reproduction	0	0
	Service Loss	0	0
0.5-1	Survival	3	10
	Reproduction	0	0
	Service Loss	3	10
1-3	Survival	0	40
	Reproduction	0	35
	Service Loss	0	61
3-5	Survival	52	55
	Reproduction	9	45
	Service Loss	56	75
5-10	Survival	66	87
	Reproduction	0	68
	Service Loss	66	96
>10	Survival	52	87
	Reproduction	32	68
	Service Loss	68	96

Separately, the Trustees compared COC concentration data from Lake and tributary sediments to thresholds developed by MacDonald et al. (2000), finding widespread contamination at concentrations above the probable effects concentration – the concentration above which harmful impacts to sediment-dwelling invertebrates are expected to occur more often than not. For example, the probable effects concentration for mercury is 1.06 milligrams per kilogram (mg/kg), indicating that injury to sediment-dwelling invertebrates is likely at sediment concentrations greater than 1.06 mg/kg and possible at concentrations less than 1.06 mg/kg. Most sediment samples from the Lake exceeded this threshold, indicating that injury to sediment-dwelling invertebrates within the assessment area has occurred.

Fish

The Trustees evaluated injury to assessment area fish by comparing site-specific fish tissue mercury and PCB concentrations to corresponding effects information in the peer-reviewed literature. Fish tissue contaminant concentration data from 1981 through 2012 were selected from the NYSDEC/AECOM (2012) database, which includes samples collected over time by NYSDEC and Honeywell. The Trustees defined four fish trophic levels, from herbivore to piscivore, and calculated a mean mercury body burden for each trophic level in the assessment area (0.25-1.33 mg/kg wb ww). To estimate the service loss associated with these concentrations, the Trustees used a published relationship between mercury concentrations in fish and percent lethality equivalents (Dillon et al. 2011), and a bounding parameter to account for factors such as sensitive species, a broad range of endpoints, and early life stage effects. Lethality equivalents include adverse effects on survival, reproductive success, and lethal developmental abnormalities in various fish species, which the Trustees assumed reflect a loss in ecological services. The Trustees then calculated the average service loss across all four guilds (accounting for baseline conditions[7]), to be approximately 23 percent.

Because less PCB data were available than mercury, the Trustees determined the average PCB concentration across all Onondaga Lake and tributary fish species between 1981 and 2012 was 1.9 mg/kg wb ww. At this level of contamination, the following adverse effects have been documented to occur in relevant fish species:

- Biochemical changes (as noted in bluegill and channel catfish (EPA 2000, Mayer et al. 1977));
- Behavioral changes (as noted in minnows (Bengtsson 1980));

Bluegill sunfish

[7] The DOI NRDA regulations define baseline as, "the condition or conditions that would have existed at the assessment area had the discharge of oil or release of the hazardous substance under investigation not occurred" (43 CFR 11.14(e)).

- Adverse effects on growth (as noted in minnows (Matta et al. 2001));
- Decreased survival (as noted in trout under conditions where survival is already being impacted by exposure to other contaminants (Bills et al. 1981)).

Therefore, the Trustees conclude that injury to assessment area fish has occurred as a result of exposure to mercury and PCBs.

Aquatic Birds

Injury to aquatic birds was evaluated by comparing measured and modeled dietary contaminant concentrations to adverse effects thresholds documented in the scientific literature. This is a standard approach, as data on prey contaminant concentrations are generally more prevalent than avian tissue contaminant concentration data. Additionally, because contaminants such as mercury and PCBs bioaccumulate, are persistent in the environment, and are poorly metabolized, dietary data provide a reasonable measure of long term exposure.

The dietary composition of the avian community is varied, so species are likely exposed to different levels of contamination, depending on their feeding strategy. To account for this, and because it is impractical to model each potentially exposed species' diet individually, the Trustees divided the avian community into four feeding guilds: high level piscivore, low level piscivore, insectivore and omnivore (Exhibit 3-5). The Trustees assumed that high level piscivores, such as the osprey, consume fish larger than 12 centimeters (cm), while low level piscivores consume fish smaller than 12 cm. Insectivores, such as the tree swallow, consume a diet of insects such as chironomid flies, and omnivores, such as the mallard, consume a mixed diet of insects, plants, and mussels. The Trustees then calculated the average dietary mercury concentration for each of these groups (Exhibit 3-5).

Osprey – Onondaga Lake

EXHIBIT 3-5 SUMMARY OF DIETARY MERCURY CONCENTRATION BY FEEDING GUILD

GUILD	GUILD EXAMPLE	ASSUMED DIET	OVERALL MERCURY CONCENTRATION In DIET (MG/KG)
High Level Piscivore	Osprey	100% Fish > 12cm	0.80
Low Level Piscivore	Belted kingfisher	100% Fish <12cm	0.25
Insectivore	Tree swallow	100% Insects	0.28
Omnivore	Mallard	50% Plants, 25% Invertebrates, 25% Mollusks	0.06
Data Source: NYSDEC/AECOM (2012).			

A literature review indicated that the onset of adverse effects on birds at dietary concentrations above 0.15 mg/kg mercury on a whole body wet weight basis. Some examples of adverse effects include:

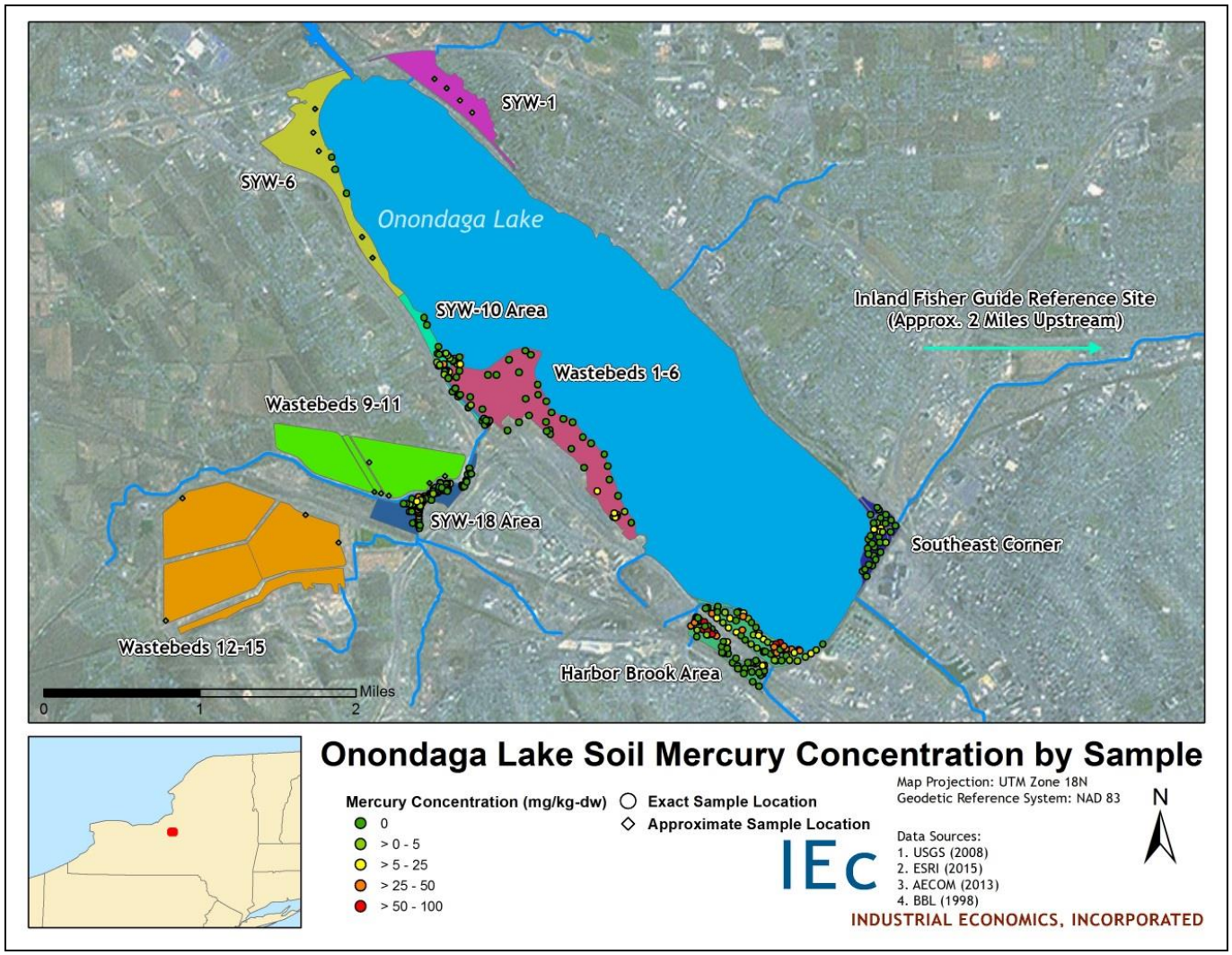
- A 40 percent reduction in fledging success in common loons at 0.16 mg/kg mercury in diet (Evers et al. 2008),
- A 29 percent reduction in fledging of the kestrel at 0.26 mg/kg mercury in diet (Albers et al. 2007), and
- A 35 percent reduction in the productivity of the black-crowned night heron at 0.43 mg/kg mercury in diet (Henny et al. 2002).

Comparing the dietary mercury concentrations presented in Exhibit 3-5 with the effects levels reported in the literature, the Trustees concluded that injury to high level piscivores, low level piscivores, and insectivores in the assessment area has occurred and averages about 17 percent, accounting for baseline conditions.

Soil-dwelling Invertebrates

Similar to the approach taken for other resources, the Trustees compiled available site-specific soil mercury data and conducted a review of the literature regarding the adverse effects of mercury on soil-dwelling invertebrates. Soil mercury concentrations in the assessment area range from non-detect to greater than 10 mg/kg (Exhibit 3-6). Studies on earthworms indicate that within this concentration range, adverse effects are expected. For example 29 percent of earthworms did not regenerate segments at a soil mercury concentration of 5 mg/kg (Beyer et al. 1985). Lock and Janssen (2001) reported a 50 percent decrease in cocoon production in the springtail, *Folsomia candida* at a soil mercury concentration of 3.26 mg/kg, and Beyer et al. (1985) showed increased mortality of springtails of five and 19 percent at soil mercury concentrations of 1 and 5 mg/kg, respectively.

EXHIBIT 3-6 SUMMARY OF ONONDAGA SOIL MERCURY CONCENTRATION BY SAMPLE



Therefore, the Trustees determined that injury to soil and soil invertebrates has occurred and that service losses due to mercury range from zero percent (e.g., Wastebeds 9-11) to 19 percent (e.g., Harbor Brook), with losses in most of the assessment area less than or equal to seven percent.

Terrestrial Birds

Because the dietary composition of the avian community is varied, species are likely exposed to different levels of contamination. To account for this, and because it is impractical to model each potentially exposed species' diet individually, the Trustees divided the relevant avian community into three feeding guilds: 1) invertivores that consume insects, spiders, earthworms, and other soil invertebrates, 2) omnivores that consume plant matter as well as animal prey, and 3) shorebirds that consume soil and sediment invertebrates and are most closely linked to the edge of aquatic habitats.

To assess injury to each of these guilds, the Trustees reviewed exposure data from two site-specific studies and effects data from the peer-reviewed literature. Cohen and Chaudhary (2014) and Lane et al (2012) collected blood mercury data from a suite of avian species. The Trustees compiled these data by guild, season (e.g., invertivores are not expected to be present in the assessment area during the winter months), and sub-section of the assessment area. Resulting averages ranged from 0.22-3.61 mg/kg mercury in blood, with the highest concentrations in the vicinity of Harbor Brook and the Ninemile Creek corridor between Wastebeds 1-6 and SYW-18. These averages were applied to a published relationship between mercury concentration in blood and nest survival (Jackson et al. 2011). For example, Jackson et al. (2011) reported a ten percent reduction in reproductive success of the Carolina wren at blood mercury concentrations of 0.7 mg/kg, with incrementally more severe reductions at higher blood mercury concentrations. Because many of the average blood mercury concentrations of assessment area were greater than 0.7 mg/kg, the Trustees concluded that injury to terrestrial birds had occurred, with service losses due to mercury ranging from six percent (e.g., southeast corner of lake) to 29 percent (e.g., Harbor Brook; accounting for baseline). Losses in most of the assessment area were less than or equal to 16 percent.

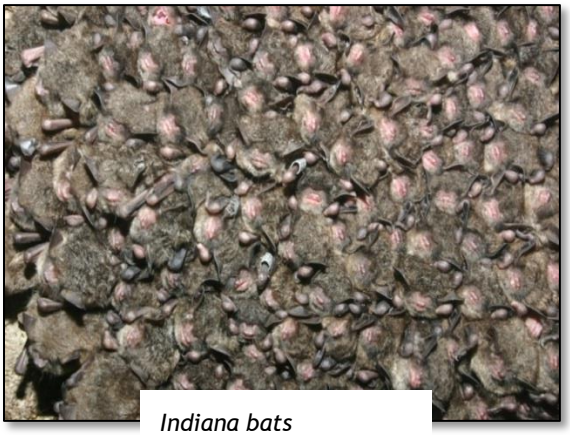
Red-winged blackbirds

Reptiles and Amphibians

To evaluate injury to reptiles and amphibians, the Trustees utilized information from both site-specific studies and the peer-reviewed literature, summarized in "Mercury in Northern Green Frogs and Snapping Turtles from Onondaga Lake, New York" (FWS 2015). TES (2013a, 2 013b) collected eastern snapping turtle blood and toenail tissue, along with whole northern green frogs. The Trustees selected the snapping turtle as a representative reptile because it is abundant and long-lived, and the northern green frog as a representative amphibian because it is abundant around Onondaga Lake. All reptile and amphibian tissues collected within the assessment area had substantially greater mercury concentrations than those at reference sites, indicating elevated mercury exposure.

Only a limited number of studies on the adverse effects of mercury on reptiles and amphibians exist. The Trustees compared Onondaga Lake snapping turtle blood mercury concentrations (262-768 nanograms per gram (ng/g) ww to concentrations reported to cause adverse effects in other turtle species, finding that within this range there is the potential for thyroid hormone alteration in Western pond turtles (322 ng/g) (FWS 2015). This indicates the potential for injury to sensitive reptiles, though the literature is not sufficiently robust to draw strong conclusions. There are no studies on the effects of mercury on the northern green frog, so the Trustees compared northern green frog tissue concentrations (78-276 ng/g wb dry weight) to effects levels for the southern leopard frog (95-236 ng/g; Unrine et al. 2004, Unrine and Jagoe 2004), concluding that some sensitive species of amphibians in Onondaga Lake may be injured by mercury.

Bats



Indiana bats

To evaluate injury to bats, the Trustees utilized exposure data from a site-specific study and effects data from the peer-reviewed literature. Yates et al. (2012) collected bat fur at a suite of Onondaga Lake sites, including from big brown and little brown bats. Fur from these species was also collected at reference sites such as Oneida Lake. The study found elevated mercury concentrations in bat fur around Onondaga Lake. The peer reviewed literature does not currently include information on the adverse effects of mercury on bats, so the Trustees compared

assessment area bat fur mercury concentrations to effects levels in fur of other mammals. For example, Yates et al. (2012) concluded that approximately 53 percent of the adult bats (42 percent of juvenile and adult bats combined) captured at Onondaga Lake in 2009 had fur mercury concentrations (range = 1.43 - 60.78 micrograms per gram (µg/g) that exceeded a deer mouse fur Lowest Observed Adverse Effects Level (LOAEL) of 10.8 µg/g fresh weight (Burton et al. 1977). Approximately 28 percent of adult bats (17 percent of juvenile and adult bats) captured at the reference site had fur mercury concentrations in excess of a deer mouse fur LOAEL of 10.8 µg/g. A small number of bats from Onondaga Lake also had fur mercury concentrations that exceeded an adverse effects threshold for mink (40 – 50µg/g), as described in Basu et al. (2007). Therefore, the Trustees expect that injury to bats in the assessment area as a result of exposure to mercury is likely, but available information is not sufficient to quantify losses.

Habitat Losses

To understand the overall scale and scope of ecological losses incurred as a result of COC exposure, the Trustees used habitat equivalency analysis (HEA), a method commonly applied in NRDAR. The basic premise of HEA is that the public can be compensated for past and expected future losses in ecological services through the provision of additional ecological services in the future. Compensable losses are "interim" losses, that is, the loss in ecological services incurred from the time the resource is injured[8] until the services provided by the injured resource return to their baseline level (which may be some years in the future). Because of its large spatial extent, the Trustees divided the assessment area into sub-sections based on environmental parameters (e.g., hydrology, topography, habitat type). Habitat loss in each of these subsections was estimated as the average percentage service loss incurred by natural resources representative of that habitat (e.g., sediment, fish, and piscivorous birds represent losses to aquatic habitat) in each year of the analysis.

Although injury to additional Trust resources that rely on the aquatic habitat is likely (e.g., amphibians and reptiles), insufficient data exist to quantify these losses. However, because losses are calculated on a habitat basis, injuries to other species groups are qualitatively incorporated. In addition, it is expected that restoration projects implemented to compensate for damages to the aquatic and terrestrial systems will benefit all species groups associated with those habitats, even resources for which data were insufficient to quantify losses.

The Trustees used this information to assess the sufficiency of the expected benefits from restoration actions under the preferred alternative.

[8] Damages are calculated from the start of injury or 1981, whichever is later, in accordance with the promulgation of CERCLA and the divisibility of damages.

3.3.2 RECREATIONAL FISHING, BOATING, AND OTHER WATER-BASED ACTIVITY LOSSES

Onondaga Lake lies along the western/northwestern side of Syracuse, providing potential recreational opportunities to the more than 660,000 people who live in the Syracuse metropolitan area (US Census Bureau 2016). The majority of the lake's shoreline is owned by Onondaga County and is open to the public.

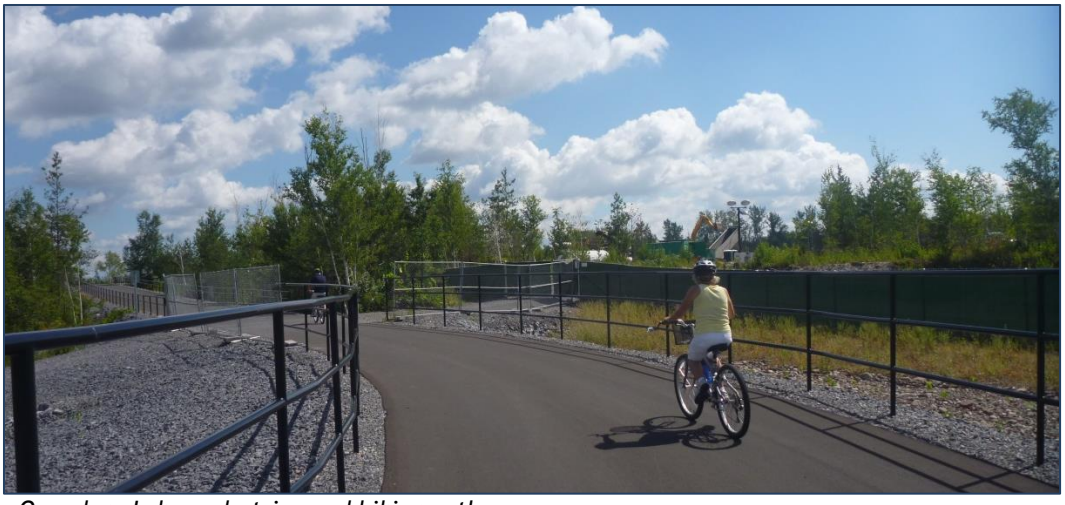
The lake offers abundant outdoor recreation opportunities, including fishing, boating, and shoreline recreation. Anglers can access the lake shoreline at Onondaga Lake Park, at a small fishing pier on the eastern side of the lake, and on jetties at the lake outlet. Species targeted by anglers include walleye, carp, bass, and perch/sunfish. A 2012 count study implemented cooperatively by the Trustees and Honeywell with assistance from the State University of New York College of Environmental Science and Forestry estimated that approximately 9,000 fishing trips were taken to the lake each year: 5,000 shore fishing trips and 4,000 boat fishing trips. Boating access is available via a county-owned marina and boat launch on the eastern shore, and via the Seneca River. The 2012 count study estimated that approximately 13,000 non-fishing boating trips were also taken to the lake that year. Finally, a popular, paved bike path (the East and West Shore Trails) runs along much of the lake shoreline, from the Bloody Brook outlet on the eastern shore to the NYS Fairgrounds Orange Parking Lot on the western shore, providing opportunities for outdoor recreation near the lake such as walking/running and biking.

Recreational fishing at Onondaga Lake has been impacted by releases of hazardous substances as a result of regulatory closures or bans on fishing and by the issuance of fish consumption advisories. Mercury was first detected at dangerous levels in the flesh of Onondaga Lake fish in 1970, and the State of New York banned fishing by regulation in the lake in the same year (a fishing ban is an injury under the DOI NRDA regulations at 43 CFR 11.62(f)(1)(iii)). This ban, issued by NYSDEC remained in place until 1985, and fishing was limited to catch-and-release between 1986 and 1999. Since 1999, fish consumption advisories issued by the New York State Department of Health have been in place due to high levels of mercury, PCBs, and dioxin. Today, the lake's walleye, carp, channel catfish, white perch and bass (over 15 inches) fisheries remain catch-and-release (i.e., eat none), while anglers are advised to consume no more than one meal per month of nearly all other fish species.[9] These advisories are substantially more restrictive than New York's statewide consumption advisory, which advises the general population to eat no more than four meals per month of any fish species taken from New York waters.

[9] The current advisory is more restrictive ("do not eat" for all species) for women under 50 and for children under 15.

Onondaga County park and marina

Onondaga Lake jetty with access for fishing



Onondaga Lake pedestrian and biking path

The fishery closure and fish consumption advisories are likely to have caused a loss in the value the public holds for participating in a fishing trip to Onondaga Lake, that is, a loss in consumer surplus. An angler's consumer surplus from a fishing trip represents the difference between: 1) the maximum amount the angler is willing to pay for the trip, and 2) the amount that the angler actually paid for the trip (in gasoline, bait, etc.). Thus, consumer surplus is a measure of the net economic value of a fishing trip, after all expenses have been paid. An angler's loss due to the advisories/closure is equal to the difference between the consumer surplus the angler would receive from a trip without the advisories/closure and the consumer surplus the angler would receive from a trip with the advisories/closure in place.

There are a variety of ways in which anglers may incur consumer surplus losses from fish consumption advisories and closures:

- **Diminished Trips:** Anglers may continue to fish at Onondaga Lake despite the advisories (e.g., the 9,000 anglers estimated to fish at Onondaga Lake in 2012). These anglers may suffer losses if they modify their behavior in order to avoid the contamination (e.g., eat fewer fish, clean their fish in a different manner, or switch to catch-and-release fishing) or if their experience is diminished due to knowledge of contamination at the site.
- **Substituted Trips**: Anglers may choose to fish at an alternative site rather than at Onondaga Lake. These anglers suffer losses if Onondaga Lake is their preferred destination but they fish at a less desirable substitute fishing site due to the advisories.
- **Lost Trips**: Anglers may choose to pursue an alternative activity as a result of the advisories. These anglers suffer losses if fishing at Onondaga Lake is their preferred activity, but they choose to pursue an alternative, non-fishing activity due to the advisories (e.g., hunting, swimming, or gardening).

In addition, the fishery closure and fish consumption advisories may have led to consumer surplus losses for non-fishing boaters and other lake visitors (e.g., walkers/bikers and birdwatchers). These visitors may have suffered losses if the fishery closure/advisories stigmatized Onondaga Lake for them, reducing the consumer surplus associated with their visits to the lake.

The Trustees used this information to evaluate overall recreational losses, that is, affected trips and the lost value associated with those trips over the timeframe of the fishery closure and fish consumption advisories. For example, using the 2012 count study and extrapolating through time, the Trustees estimated that over 1.2 million fishing trips have been and will be lost as a result of the historic fishing bans and the past and expected future fish consumption advisories on Onondaga Lake. In addition, the Trustees assessed the sufficiency of the expected benefits from restoration actions under the preferred alternative to compensate for these losses, such as by developing estimates of the potential number of trips gained from a particular restoration project option. This enables

the Trustees to scale losses and gains in the same unit – that is, the public is compensated for contaminant-related lost trips by the provision of new similar trip opportunities in the future.

CHAPTER 4 | PROPOSED RESTORATION ALTERNATIVES

The Trustees' primary goal is to select a restoration alternative that sufficiently compensates the public for natural resource injuries and associated service losses resulting from contamination in the Onondaga Lake assessment area. As summarized in Chapter 3, available information indicates that injuries have occurred to resources that utilize aquatic, wetland, and upland habitats and provide ecological and/or recreational services. Therefore, the Trustees are prioritizing restoration projects that satisfy the following criteria:

- Project will provide benefits that are linked directly to potentially injured natural resources or related service losses. This includes a focus on projects within the Onondaga Lake watershed (i.e., geographic proximity to potentially injured resources; Exhibit 3-1), as well as projects that promote habitat connectivity and/or expanded public use.
- Project will provide natural resource benefits and services that would not otherwise be generated. That is, projects must not be otherwise required (e.g., under Federal, state, or local laws, regulations, or permits), funded, or assured of completion irrespective of NRDAR activities.
- Project is sufficiently developed such that implementation can occur in a timely manner.

As described in Sections 1.6.1 and 1.7, the Trustees compiled a list of potential restoration options. Dozens of project suggestions were generated by the Trustees themselves, as well as Honeywell, Onondaga County, and other members of the public. Using the site-specific restoration criteria described above, and consistent with the restoration planning guidance in the DOI NRDA regulations (42 CFR §11.82 (a)) and NEPA (42 U.S.C. § 4321, et seq., and the regulations guiding its implementation at 40 CFR Part 1500), the Trustees considered three restoration alternatives. These alternatives are described below and are evaluated in Chapter 5 to assess compliance with the DOI NRDAR factors (43 CFR § 11.82(d)) and ensure that the preferred alternative does not significantly adversely impact the quality of the human environment.

Habitat near Onondaga Lake

4.1 ALTERNATIVE A: NO ACTION / NATURAL RECOVERY

Alternative A, the "No Action / Natural Recovery" alternative, considers the environmental consequences of conducting no further restoration actions during or after the mandated remediation is completed. Under the "No Action" alternative, remedial actions designed to protect human health and the environment from unacceptable risk are completed as directed by state and Federal authorities. These remedial requirements, however, are not expected to immediately return natural resources to baseline ecological conditions (i.e., conditions but for the release of COCs). Natural resources will likely take years after remedial actions are completed to attenuate to COC concentrations at which adverse effects on natural resources and resource services are not expected, given the continued presence of COCs within the system.

Similarly, the "No Action" alternative is not expected to compensate the public for interim ecological and human use service losses (i.e., contaminant-related losses that occurred from pre-remedy until COC concentrations return to baseline). Remedial actions at this Site, which focus solely on removal or containment of contamination, reduce future injury but do not provide the additional natural resource services required to make the public whole.

Lastly, the "No Action" alternative would not utilize settlement monies for restoration or acquisition of the equivalent of lost resources and resource services, which is the purpose of NRDAR. Therefore, the "No Action" alternative serves as a point of comparison to determine the context, duration, and magnitude of any environmental consequences that might result from the implementation of other restoration actions. Environmental consequences are considered in Chapter 5.

4.2 ALTERNATIVE B: RESTORATION THAT SATISFIES SITE-SPECIFIC CRITERIA

Alternative B, "Restoration That Satisfies Site-Specific Criteria," is expected to generate natural resource services similar to the services that the injured habitat would have provided but for Site-related contamination. Actions under this Alternative would truly be creating *additional* natural resource services as compensation for losses, as these projects are not otherwise required or funded. This alternative would increase habitat quality and quantity, promote habitat connectivity, create new public use opportunities and improve existing use options, and benefit Trust natural resources within the injured ecosystem.

There are a variety of habitat and recreational restoration options within the Onondaga Lake watershed that are expected to provide relevant ecological and public use services. Trust resources potentially benefited by these habitat restoration projects include surface water, sediments, aquatic invertebrates, fish, birds, turtles, amphibians and mammals. Project types, described more fully below, would include habitat creation, habitat restoration, habitat preservation, and recreational improvements. Available settlement funds, restoration opportunities, and restoration costs will influence the final scale and scope of projects implemented in each category.

4.2.1 HABITAT CREATION, RESTORATION, AND ENHANCEMENT

The Trustees are considering habitat creation, restoration, and enhancement projects under this Alternative. Habitat creation involves converting one type of habitat to another. Typically this is undertaken when:

Geddes Brook restoration area

1. A disturbed/non-habitat area is converted to habitat. For example, an abandoned parking lot could be cleared, graded, and planted as native grassland (e.g., to support migratory songbirds).
2. An area is restored to a historic habitat type. For example, a wetland, previously filled, could be excavated, re-graded, hydrologically reconnected to surface water or other wetland, and replanted with native wetland vegetation (e.g., to support waterfowl, amphibians, etc.).
3. There is a specific need for a particular habitat type in an area. For example, if an endangered plant requires vernal pools for survival, protection and restoration for that species is a resource management priority. In the assessment area, vernal pools are sufficiently rare such that conversion of other habitat (e.g., upland) to vernal pool(s) would be appropriate.

Habitat restoration or enhancement includes improvement of degraded habitat, ideally returning the area to conditions that better approximate "natural" conditions. For example, if the hydrologic connectivity of an existing wetland is restricted by an undersized culvert, the existing culvert could be replaced with a larger, more wildlife-friendly culvert. Other examples of habitat restoration activities include invasive species removal, planting of native species, or the addition of soil amendments to promote natural vegetation growth.

The actions the Trustees propose for habitat creation, restoration, and enhancement would maximize use of low impact techniques. For example, invasive management would likely focus on physical removal. That is, plants may be removed by digging, pulling, mowing, or cutting, which are often done by hand. However, some more impactful strategies may need to be implemented. Some herbaceous and woody plants may require mechanical removal with chainsaws, mowers, or other machinery (NOAA 2015), and some may require targeted chemical removal. Revegetation techniques would focus on preparing the seedbed by tilling or plowing; seeding or planting by hand or with mechanical equipment; and installing seeds, plants, or woody materials such as trees and shrubs. Grading would likely be done with heavy machinery to roughly prepare an area (e.g., earth moving, tilling, and compaction) and then using a grader to finish the surface.

4.2.2 HABITAT PRESERVATION

This involves preservation of habitat that would otherwise be developed or degraded. Habitats may be preserved through land acquisition, land donations and/or transfers, or conservation easements. The Trustees would consider projects that may preserve wetland, riparian, and/or upland habitats essential to a variety of fish and wildlife species, including species that are the same as or similar to those injured by COC releases within the assessment area. Habitat preservation activities could also include the acquisition of ecologically valuable habitat or establishment of conservation easements on riparian habitat along ecologically valuable waterways. Where possible, the Trustees would preserve land that is adjacent to protected habitats to increase the benefits of preservation (e.g., maximize the acres of adjacent protected lands to increase connectivity of habitat). For example, a developer is planning to purchase land to construct a shopping center. The land is adjacent to a stream that supports threatened frog species, and is visible from nearby hiking trails. Purchase and preservation of the property would prevent the degradation of the area within the shopping center footprint, the stream, and the viewshed.

Final selection of specific lands that would be preserved would consider factors such as the ecological value of the wetland and riparian habitats, Trustee resource management priorities, inherent improvement of water quality, ownership/protection opportunities, geographic/ecological diversity, local/regional planning, citizens' concerns, and the ability to find willing sellers. Land acquired would be deeded to individual state, tribal, Federal, or local governments; land trusts; or conservation non-governmental organizations in accordance with relevant procedures and standards set for each entity. The primary purpose of these preservation efforts is to protect fish and wildlife habitats. Other uses, such as recreational activities, may be permitted, but only in a manner that supports the goal of ecological preservation.

Ninemile Creek near Hudson Farms

4.2.3 RECREATIONAL ENHANCEMENT PROJECTS

New/improved recreational opportunities within the Onondaga Lake watershed are expected to provide natural resource services similar to the services lost due to contaminant-related closures and advisories. This includes new or improved opportunities for fishing and/or boating within the watershed, as well as other aquatic habitat-related recreational activities (e.g., swimming, walking, hiking, and bird-watching). For example, the Trustees could acquire access to property and develop a fishing/boating pier and ramp in a section of the Lake previously unavailable to the public. The Trustees would also consider improving existing access areas, such as through additional parking, improved amenities, and increased public fishing rights. These types of opportunities would enable the Trustees to conduct restoration both in areas where recreation may have been affected by Site-related contamination, and in areas where the public may have fished instead of at the Lake.

Onondaga Lake angler

4.2.4 SPECIFIC PROPOSED PROJECTS

At this time, the Trustees have identified a suite of restoration projects under this Alternative that encompass all of the project types described above. Ecological projects are summarized in Exhibit 4-1; recreational projects are summarized in Exhibit 4-2. Note that some projects are expected to provide both ecological and recreational services and are listed in both Exhibits. The Trustees received NRDAR settlement funds as part of the General Motors bankruptcy in 2012. These funds, with accrued interest, currently total $2,296,210 and are maintained in an Onondaga Lake Future Project Fund. The Trustees anticipate that additional settlement monies will be added to this Future Project Fund.

EXHIBIT 4-1 PROPOSED ECOLOGICAL RESTORATION PROJECTS UNDER ALTERNATIVE B

PROJECT NAME	POTENTIAL PROJECT LOCATION	POTENTIAL ACTIONS
In-Lake Habitat Creation	Lake bottom, both remedial and other areas – approximately 278 acres	Installation of structures to provide habitat for fish, amphibians and invertebrates
Terrestrial Habitat Ecological Enhancement	Hudson Farms, northwest and west of Settling Basins 12-15 in Camillus – approximately 117 acres currently owned by Honeywell	Wetland enhancement, forest enhancement, vernal pool creation, habitat conservation
Aquatic Habitat Ecological Enhancement	Maple Bay area, northwest shoreline of Onondaga Lake – approximately 38 acres	Shoreline and shallow-water habitat enhancement
Ninemile Creek Corridor Ecological Enhancement	Ninemile Creek between Airport Rd and the NYS Fairgrounds – approximately 100 acres currently owned by Honeywell	Wetland enhancement, floodplain forest enhancement, habitat conservation
Invasive Species Control & Habitat Preservation	Onondaga Lake watershed	15 years of funding for identification and removal of invasive species within approximately 1,700 acres of wetlands, lake/river littoral zone and riparian habitat
Wetland and Upland Conservation in Vicinity of Onondaga Lake	Vicinity of Onondaga Lake – approximately 200 acres	Wetland and upland habitat conservation
Native Grasslands Restoration	Settling Basin 13, Camillus – approximately 100 acres	Native grassland and inland salt marsh planting and maintenance to support breeding grassland birds
Habitat Preservation in southern Onondaga County	Onondaga County Onondaga Creek Watershed - approximately 1,023 acres in the Tully Valley currently owned by Honeywell	Habitat conservation, streambank enhancement

EXHIBIT 4-2 PROPOSED RECREATIONAL RESTORATION PROJECTS UNDER ALTERNATIVE B

PROJECT NAME	SERVICE TYPE	POTENTIAL PROJECT LOCATION	POTENTIAL ACTIONS
Ninemile Creek Fishing Access	Fishing	Ninemile Creek between the southern boundary of Camillus, NY and Onondaga Lake	Public Fishing Rights, acquisition and enhancement of existing parking areas, construction of new parking areas, re-open canoe launch
Deepwater Fishing Pier	Fishing	Onondaga Lake	Installation of floating fishing pier along southwest shoreline
Erie Canal Trail Extension	Bicycling, Walking	Between the existing trailhead of the Erie Canalway Trail and the Onondaga County West Lake Recreation Trail parking area.	Trail extension, parking area construction
Outlet Jetty Enhancement	Fishing	Northern end of Onondaga Lake	Improvement of existing jetties in northern end of Onondaga Lake to facilitate better pedestrian and angler access
Seneca River Boating Access	Boating	Seneca River	Installation of a boat ramp and floating boat dock, parking area construction
Onondaga Lake Recreation Trail	Bicycling, Walking	Onondaga Lake	Starting on Honeywell property, south of the Visitor Center, extend existing trail on southwest shoreline to Harbor Brook
Onondaga Lake Angler Access	Fishing	Onondaga Lake	Public fishing access from Visitor Center to end of the east barrier wall along the southwest shoreline, parking area construction
Public Education Regarding Onondaga Lake Watershed	Education, Boating	Onondaga Lake	Improvements to Visitor Center on west shoreline, boat launch (rinse station), transfer to public entity
Onondaga County Recreational Opportunities	Fishing, Hunting, Hiking	Onondaga County (See Tully Valley project above)	Public Fishing Rights, hunting access, construction of new parking lots

4.3 ALTERNATIVE C: RESTORATION THAT DOES NOT SATISFY SITE-SPECIFIC CRITERIA

Alternative C, "Restoration That Does Not Satisfy Site-Specific Criteria," encompasses restoration projects that were proposed to the Trustees that are: 1) not expected to provide natural resource services similar to injured/lost services, or to provide services in a cost-effective way; 2) already required or funded in non-NRDAR contexts; and/or 3) do not have clearly defined project-specific objectives and designs. These projects are summarized in Exhibit 4-3. With additional details, some of these projects may be considered for funding from the Future Project Fund.

EXHIBIT 4-3 PROPOSED RESTORATION PROJECTS UNDER ALTERNATIVE C

PROJECT	RATIONALE FOR LOWER SUITABILITY *
Historical Ecology Website	1
Murphy's Island Transfer to Nation	3
Mudboil Mitigation	3 A recent expert panel report concluded that additional study is needed prior to implementing a project (SUNY ESF 2016).
Onondaga Creek Flood Control Dam removal	2 This project is being evaluated by the U.S. Army Corps of Engineers.
Additional Solvay Waste Containment	1
Onondaga Lake Museum and Center	2,3 The Skä noñh Great Law of Peace Center and Salt Museum already exist at Onondaga Lake and the Visitor Center on the west shore of Onondaga Lake (Exhibit 4-2) may also be used as a museum and educational center.
Onondaga Lake Beach	2 This project is currently under review as part of a County feasibility study with NYSDEC oversight.
Pumpkin Hollow Biopreserve	3
West Branch Public Access Park	3
Stewardship/Grant Program	3
Collection of Floatables/Debris in Aquatic Habitat	2 This program is already funded.
Oxygenation of Onondaga Lake	1
Streambank Stabilization at Rattlesnake Gulf and Rainbow Creek	3 However, the Trustees may evaluate stream restoration within Onondaga County in the future.
Educational Facilities at Onondaga Lake Park	3

PROJECT	RATIONALE FOR LOWER SUITABILITY *
Funding for Incentive Grants to Municipalities for Green Infrastructure Efforts	3
Floating Classroom	1
Restore Upper Ley Creek	3
Restore Beartrap Creek	3
Dorwin Fish Ladder	1 Not a high priority project due to limited habitat immediately upstream
Furnace Brook Daylighting Feasibility Analysis	1
Harbor Brook Daylighting Feasibility Analysis	1
Fish Passage Restoration Prioritization	1
Water Research and Education Center	1
Bald Eagle Viewing	3

* 1) not expected to provide natural resource services similar to injured/lost services, or to provide services in a cost-effective way.

2) already required or funded in non-NRDAR contexts.

3) do not have clearly defined project-specific objectives and designs.

CHAPTER 5 | EVALUATION AND SELECTION OF THE PREFERRED ALTERNATIVE

The Trustees' primary goal in this chapter is to identify a preferred restoration alternative that compensates the public for natural resource injuries and associated losses resulting from COC releases within the assessment area. Given the discussion of restoration alternatives in Chapter 4, this chapter assesses the environmental consequences of Alternative A: No Action/Natural Recovery and Alternative B: Restoration that Satisfies Site-Specific Criteria to determine whether implementation of either of these alternatives may significantly affect the quality of the human environment, particularly with respect to the physical, biological, socio-economic, or cultural environments of Onondaga Lake and its associated watershed. Alternative C: Restoration that Does Not Satisfy Site-Specific Criteria, is not evaluated because the actions proposed under that Alternative will not address natural resources injuries in an implementable, cost-effective way, as described in 43 CFR § 11.82. This chapter also evaluates readily available information on environmental consequences and serves as a draft environmental assessment (EA) for the Onondaga Lake NRDAR.

5.1 ASSESSMENT OF ENVIRONMENTAL CONSEQUENCES

In order to ensure the appropriateness and acceptability of the proposed restoration alternatives, the Trustees evaluated each alternative against a suite of restoration criteria. Ten factors are listed within the NRDA regulations as considerations when evaluating a preferred alternative (43 CFR § 11.82(d)):

- Technical feasibility,
- The relationship of the expected costs of the proposed actions to the expected benefits from the restoration, rehabilitation, replacement, and/or acquisition of equivalent resources,
- Cost effectiveness,
- The results of actual or planned response actions,
- Potential for additional injury resulting from the proposed actions, including long-term and indirect impacts, to the injured resources or other services,
- The natural recovery period,
- Ability of the resources to recover with or without alternative actions,
- Potential effects of the action on human health and safety,

- Consistency with relevant Federal, state, and tribal policies, and,
- Compliance with applicable Federal, state, and tribal laws.

Additionally, actions undertaken to restore natural systems are expected to have beneficial and/or adverse impacts to the physical, biological, socio-economic, and cultural environments. In order to determine whether an action has the potential to result in significant impacts, the context and intensity of the action must be considered, as provided in 40 CFR 1508.27. Context refers to area of impacts (local, state-wide, etc.) and their duration (e.g., whether they are short- or long-term impacts). Intensity refers to the severity of impact and could include factors such as the timing of the action (e.g., more intense impacts would occur during critical periods like wildlife breeding/rearing, etc.), the effect on public health and safety, and cumulative impacts. Intensity is also described in terms of whether the impact would be beneficial or adverse.

In the analysis below, the Trustees examine the likely beneficial and/or adverse impacts of Alternatives A and B on the quality of the human environment. If the Trustees conclude that the actions associated with the preferred alternative will not lead to significant adverse impacts, then the Trustees will issue a finding of no significant impact (FONSI). If significant impacts are anticipated, the Trustees will proceed with an EIS to evaluate a reasonable range of restoration alternatives and the environmental consequences of those alternatives. The Trustees will continue to evaluate environmental impacts as specific projects are implemented. The following sections assess anticipated environmental consequences of the restoration alternatives in light of the ten NRDAR factors listed above.

5.2 EVALUATION OF ALTERNATIVE A: NO ACTION / NATURAL RECOVERY

The No Action / Natural Recovery Alternative would not initiate any restoration action outside of currently funded programs. Instead, the ecosystem would attenuate to background conditions based on natural processes only, with no assistance from active environmental restoration. Although the lack of action makes this Alternative technically feasible and cost effective, this Alternative:

- Does not restore injured resources to baseline. Remediation is expected to include years of monitoring after sediment removal actions are completed, but lack of restoration beyond remedial actions will reduce the potential for resources to fully recover to baseline conditions.
- Does not compensate the public for interim losses. Habitat quality would not be improved above baseline, wildlife would continue to be injured due to mercury and other COCs, and fishing and boating opportunities would not improve or increase.
- Is not consistent with Federal and state policies and laws. Under this Alternative, the available settlement monies that are meant to be directed toward NRDA restoration actions would not be spent.

While the No Action Alternative does not *create* additional adverse impacts to the environment, it also does not provide the ecological, recreational, and socio-economic benefits described under Alternative B. Given the long time frame until natural attenuation of COCs is achieved once sediment removal actions conclude, under the No Action Alternative adverse environmental consequences from mercury and other contaminants (i.e., ecological and human use injuries) are expected to continue into the future and would not be mitigated through restoration actions. That is, the No Action Alternative may result in adverse impacts to fish and other wildlife, as well as reductions in the ecological and human use services provided by lacustrine, riverine, wetland, and upland habitats, due to the lack of additional habitat functionality resulting from the absence of NRDAR-related restoration and/or preservation actions in the assessment area. Therefore, the No Action Alternative is not a favorable restoration alternative when evaluated against the NRDAR factors. This Alternative serves as a point of comparison to determine the context, duration, and magnitude of environmental consequences resulting from the implementation of Alternative B.

5.3 EVALUATION OF ALTERNATIVE B: RESTORATION THAT SATISFIES SITE-SPECIFIC CRITERIA

Alternative B, "Restoration that Satisfies Site-Specific Criteria," is expected to provide relevant natural resource services through timely implementation of projects within the Onondaga Lake watershed, with a strong emphasis in and around Onondaga Lake. Under this alternative, project types include habitat creation, restoration, and enhancement; habitat preservation; and recreational enhancement projects.

To provide a direct comparison to Alternative A, the Trustees evaluated Alternative B for consistency with the DOI NRDA restoration factors, provision of natural resource services at or above baseline, compliance with relevant regulations, and net environmental consequences.

First, Alternative B is consistent with the restoration factors outlined in the NRDA regulations. For example, habitat and wildlife restoration and public use projects within the Onondaga Lake watershed are technically feasible, cost effective, and would be specifically targeted to benefit multiple, relevant natural resources that utilize aquatic and associated upland habitat. There are many restoration options within and along Onondaga Lake itself, as well as in the tributaries and adjacent habitat. The Trustees plan to apply methods that have been successful in other locations to increase the probability of project success, building on remedial-related actions completed to-date.

Second, projects under Alternative B have the potential to compensate the public for natural resource injuries by providing additional, similar services in the future. Projects may either allow resources to more rapidly achieve baseline, or may improve resource conditions such that the habitat or resource provides services above and beyond baseline. For example, habitat creation and restoration activities provide natural resource services similar to the assessment area's baseline services. Restored wetlands and riparian areas provide habitat for spawning fish and migratory birds, improve water quality by filtering sediments and pollutants from the water column, reduce erosion, and export detritus. These actions influence increased production of forage fish populations, which provide prey for piscivorous fish, birds, reptiles, and mammals. Preservation actions such as land acquisition and conservation easements protect ecologically important habitat from current and future land development. Restoration of wetland, upland, and riparian habitats has the potential to increase habitat connectivity throughout the restoration area, which is important in providing ecological services similar to those lost.

Finally, the cumulative environmental consequences of Alternative B are expected to be beneficial to natural resources. Below, the Trustees assess the potential environmental consequences of each of the proposed project types. Adverse impacts to environmental justice and/or socio-economic factors are expected to be minimal at most, and may be mitigated during project selection. Any unavoidable adverse impacts would be minimized through individual project plans, and are expected to be far outweighed by the beneficial impacts of projects under this Alternative. Additional project-specific NEPA analysis would be completed if a proposed project has expected adverse effects beyond the scope of those analyzed here.

5.3.1 HABITAT CREATION, RESTORATION, AND ENHANCEMENT

Habitat creation, restoration, and enhancement modify existing areas to improve the quality of ecological services provided.

Wetland area near Onondaga Lake

Habitat creation in this case would involve converting low quality habitat to vernal pools, a unique habitat type that has been degraded due to a number of threats such as development, forest fragmentation, and climate change. Vernal pools are wetlands with a seasonal cycle of flooding and drying**.** For example, some vernal pools flood in the spring with water from melting snow, rain, or high groundwater and then typically dry by summer's

end.


Vernal pool

Creation of vernal pools would result in direct and indirect, short-term, localized, major impacts on natural resources such as soil, sediment, and vegetation. Existing habitat would be substantially modified to create the hydrology, grade, soil type, and vegetation necessary for the successful development of vernal pools. This would likely involve the use of heavy machinery and construction equipment, which may include soil compaction, emissions from heavy equipment, removal or crushing of understory vegetation, and increased soil erosion in the immediate area of construction operations. However, the long term direct and indirect benefits expected from this type of restoration activity outweigh the potential adverse impacts. Amphibian and reptile diversity and population densities around Onondaga Lake remain lower than in surrounding areas (Ducey 2014). The creation of vernal pools within the Onondaga Lake watershed would provide significant benefit to these and other species. For example, vernal pools provide key breeding habitat for amphibians whose tadpoles and larvae are especially vulnerable to fish predation (fish cannot survive in vernal pools). These pools also provide prey for species such as turtles, birds, small mammals, and predatory insects.

Habitat restoration would include restoration of a variety of habitat types, such as in-lake habitat, wetlands, and grassland. In-lake habitat projects would involve installation of habitat structures on the lake bottom, consistent with actions taken under the remedy. The installation may cause minor, short-term, indirect impacts (e.g., emissions, noise) as a result of the machinery necessary to transport the structures over water and deploy them. However, the long-term direct and indirect benefits of these structures outweigh the potential adverse impacts. For example, habitat structures provide cover to increase survival of juvenile fish, spawning habitat to improve reproductive success, and complex substrate for colonization by benthic organisms (Bolding et al. 2004). These benefits to the invertebrate and fish communities result in indirect benefits to their predators within the aquatic and shore-based food webs. These structures are specifically designed to remain in place for decades, thereby providing ecological benefits throughout that extensive time period.

Wetland restoration creates the desired elevation, and hydrology for wetland vegetation and fish habitat. Action may include planting, revegetation, site re-grading, bank restoration, use of herbicides, and erosion reduction. These actions are expected to cause minor, short-term, localized impacts to existing resources and resource services, and

result in moderate long-term benefits across a broad geographic scope. For example, wetland and riparian planting may cause short-term, localized impacts to existing vegetation at the restoration site (e.g., as existing vegetation is trampled or removed). During planting, which may last for multiple seasons, the resource services provided by that area are likely to be reduced through physical disturbance. Herbicides will be restricted to those allowed for use in aquatic environments and they will be applied by certified applicators. However, long-term, moderate beneficial impacts to water resources and associated flora and fauna would occur due to the reduced erosion and increased shelter provided by wetland plants. "Wetland planting activities would [also] result in beneficial impacts by restoring or creating wetland and/or shallow-water habitats that provide areas for feeding and shelter for fish, as well as nutrient cycling and carbon sequestration and storage capacity…Minor beneficial impacts related to socioeconomic resources may result from increased tourism opportunities that could develop around an improved resource." (NOAA 2015 p.156)

Wetland area near Onondaga Lake

Regrading a portion of a restoration area may include the following actions: moving soil or sediment and placing the material either within the restoration area or at a disposal site, contouring the area to satisfy hydrologic and/or vegetative goals, and amending the area with topsoil or other capping material. Depending on the scope and scale of regrading, sediment or soil may be moved by non-motorized methods (e.g., shovels) or by earth-moving diggers and other equipment. These actions are expected to result in moderate,

short-term, localized impacts to the re-graded area and any area that receives sediment or soil as a result of the physical movement of material and corresponding disturbance of existing habitat, and minor, short-term localized impacts resulting from the noise and exhaust from construction vehicles. However, these impacts are outweighed by the major, long-term, localized and broader benefits expected as a result of regrading. For example, likely benefits include, but are not limited to, improved hydrological conditions that would support high quality habitat and re-establish connections between habitats (e.g., wetland and riparian areas) and topography that would support native vegetative communities and corresponding biota.

Grassland restoration typically involves removal of existing vegetation through physical, chemical or mechanical means, replanting native grassland species, and conducting frequent maintenance (i.e., mowing) to ensure the grassland does not convert to a more shrub-dominated or forested habitat type. The adverse impacts of these actions are expected to range from direct, short-term, localized, minor impacts to indirect, long-term, localized, minor impacts. For example, the short-term impacts associated with revegetation are similar to those described for wetland replanting above. The long-term minor impacts are associated with the continued maintenance of the habitat (e.g., emissions, noise from mowing). However, the long-term direct and indirect benefits of grassland restoration outweigh the potential adverse impacts. Grasslands are increasingly threatened by agriculture and development, yet are a crucial habitat for birds and other wildlife. For example, migratory songbirds such as bobolinks and savannah sparrows rely on grassland habitat for foraging and nesting during the summer, and small mammals such as voles and mice make their homes in grassland areas, and are an important food source to many birds of prey.

Restored grassland in New York

Cultural and historic resources and land use could experience indirect, long-term, minor adverse impacts resulting from habitat restoration. The land use in the floodplain, including any potential culturally sensitive areas, would change as the water resources in the floodplain changed (e.g., as a result of wetland restoration). Because land use would stabilize in the floodplain over time, the impact is expected to be minor (NOAA 2015).

5.3.2 HABITAT PRESERVATION

Conservation actions are expected to cause indirect, long-term, moderate to major beneficial impacts to natural resources that utilize the conserved area, providing ecological and human use services. “These impacts would result from new management

of land and water resources and would prevent development of other degrading activities from taking place on the project site." (NOAA 2015 p.156) Beneficial impacts to natural resources "may occur from such restoration activities due to improved access to coastal areas and habitats, the creation of buffer zones between sensitive resources, altered or managed timing of water withdrawals, and other factors that could impact such resources. Depending on the nature of the land acquisition or protection action, land use overall could directly and moderately benefit over the long term, as fewer adverse environmental impacts occur at the project site. Recreational opportunities and land use practices would largely be improved as natural areas and ecosystems are preserved (e.g., through fee simple purchase of tracts of land or of water flows in rivers). Cultural and historic resources, if located on a protected parcel, would benefit from not being disturbed by development or other degrading activities that might otherwise occur." (NOAA 2015 p.157)

5.3.3 RECREATIONAL ENHANCEMENT PROJECTS

Improvements to existing recreational access areas and creation of new access areas within the Onondaga Lake watershed would provide compensation for reduced recreational opportunities associated with Site-related contamination. Compared to the No Action alternative, the environmental impacts of potential projects are anticipated to be minor and in many cases beneficial. Potential sites range from existing formal and informal access areas to historic parks to new access opportunities. Improvements to roads, parking lots, trails, and boat ramps may cause minor short-term impacts to the environment as a result of construction activities but would help to reduce erosion, promote bank stabilization, reduce impacts to riparian vegetation, and improve user safety. Negative impacts would primarily be associated with increased use, which can result in minor increases in traffic, noise, and litter.

This project type has the potential to positively impact the local economy. By increasing fishing access, it is likely that recreation in the area would increase, resulting in corresponding long-term benefits to the recreation, accommodation and food services industries. In addition, additional fishing access would provide increased opportunities for local urban populations to participate in recreational activities -- opportunities that may not have been previously available.

Erie Canalway trail

5.4 PREFERRED RESTORATION ALTERNATIVE

The Trustees evaluated two restoration alternatives. Of these, Alternative B addresses natural resource injuries and service reductions resulting from the release of COCs within the assessment area. Based on the Trustees' evaluation of the environmental consequences of Alternatives A and B, the NRDA restoration factors described in 43 CFR § 11.82(d), and the potential for greater restoration project opportunities, including specifically within and around Onondaga Lake and its associated tributaries and habitats, the Trustees propose Alternative B as their Preferred Alternative.

After this draft RP/EA is finalized, the Trustees will begin to identify and evaluate specific project options based on Alternative B, or the restoration alternative the Trustees select in the final RP/EA. Each project will be evaluated against the same restoration priorities and factors described above, and, if needed, a further review of environmental consequences will be conducted. Any selected projects that are expected to have non-negligible impacts will be subject to a project-specific NEPA analysis prior to implementation. In addition, a Section 7 consultation (under the Endangered Species Act) will be completed for restoration projects that may affect threatened or endangered species and Section 106 of the National Historic Preservation Act will be followed for each restoration project that will be implemented.

The Trustees will continue to inform the public of restoration project plans and progress.

Jetties at Onondaga Lake outlet

REFERENCES

Albers, P.H., M.T. Koterba, and R. Rossman, W.A. Link, J.B. French, R.S. Bennett and W.C. Bauer. 2007. Effects of Methylmercury on Reproduction of American Kestrels. *Environ. Toxicol. Chem*. 26 (9): 1856 – 1866.

Basu, N., A.M. Scheuhammer, S.J. Bursian, J. Elliott, K. Rouvinen-Watt, and H.M. Chan. 2007. Mink as a sentinel species in environmental health. *Environ. Research* 103:130-144.

Bengtsson, B.E. 1980. Long-term effects of PCB (Clophen A50) on growth, reproduction, and swimming performance in the minnow, *Phonixus phonixus*. *Water Res.* 14:681-687.

Beyer, W.N., E. Cromartie, and G.B. Moment. 1985. Accumulation of Methylmercury in the Earthworm, *Eisenia foetida*, and its Effect on Regeneration. *Bull. Environ. Contam. Toxicol.* 35:157-162.

Bills, T.D., L.L. Marking, and W.L. Mauck. 1981. Polychlorinated Biphenyl (Aroclor 1254) residues in rainbow trout: effects on sensitivity to nine fishery chemicals. *North American Journal of Fisheries Management* 1: 200-203.

Bolding, B., S. Bonar, and M. Divens. Use of Artificial Structure to Enhance Angler Benefits in Lakes, Ponds, and Reservoirs: A Literature Review. *Reviews in Fisheries* Science 12:75-96.

Burton, G.V., R.J. Alley, G.L. Rasmussen, P. Orton, V. Cox, P. Jones, and D. Graff. 1977. Mercury and behavior in wild mouse populations. *Environmental Research* 14:30-34.

Cohen, J. and A. Chaudhary. 2014. Avian Community Composition and Blood Mercury and Chromium in Onondaga Lake Waste Beds. Submitted to U.S. Fish and Wildlife Service, Cortland, NY. State University of New York College of Environmental Science and Forestry. January.

Dillon, T., N. Beckvar, and J. Kern. 2011. Residue-based mercury dose-response in fish: An analysis using lethality-equivalent test endpoints. *Environ. Toxicol. Chem*. 29(11): 2559-2565.

Domske, H. and O'Neill, C.R. 2003. Invasive Species of Lakes Erie and Ontario. Fact Sheet Prepared by New York Sea Grant Institute. Information accessed in June 2016 at the following link: http://www.seagrant.sunysb.edu/ais/pdfs/AIS-LErieOnt.pdf.

Ducey, P.K., W. Newman, K.D. Cameron, and M. Messere. 1998. Herpetofauna of the Highly-polluted Onondaga Lake Ecosystem, Onondaga County, New York. *Herpetological Review* 29(2):118-119.

Ducey, P.K. 2014. Analysis of amphibians and reptiles of the Onondaga Lake ecosystem, 1994-2012. State University of New York at Cortland, Cortland, NY 13045.

Eisler, R. 2000. Handbook of Chemical Risk Assessment, Health Hazards to Humans, Plants, and Animals. Three volumes. Lewis Publishers. Boca Raton.

EPA. 2000. Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs, Appendices. EPA-823-R-00-001. February.

Evers, D.C., L.J. Savoy, C.R. Desorbo, D.E. Yates, W. Hanson, K.M. Taylor, L.S. Seigel, J.H. Cooley, M.S. Bank, A. Major, K. Munney, B.F. Mower, H.S. Vogel, N.Schoch, M. Pokras, M.W. Goodale, and J.Fair. 2008. Adverse effects from environmental mercury loads on breeding common loons. *Ecotoxicology* 17:69-82.

FWS (United States Fish and Wildlife Service). 2005. Natural Resource Damages Preassessment Screen for Onondaga Lake Onondaga County, New York. November.

FWS. 2015. Mercury in Northern Green Frogs and Snapping Turtles from Onondaga Lake, New York. Prepared for the Onondaga Lake NRDAR Trustee Council. September.

Henny, C.J., E.F. Hill, D.J. Hoffman, M.G. Spalding and R.A Grove. 2002. Nineteenth Century Mercury: Hazard to Wading Birds and Cormorants of the Carson River, Nevada. *Ecotoxicology* 11: 213 – 231.

Honeywell. 2009. Onondaga Lake Remedial Design Elements for Habitat Restoration. Draft. November.

IEc (Industrial Economics, Incorporated). 2012. Onondaga Lake Natural Resource Damage Assessment Plan Addendum. Final. Prepared for U.S. Department of the Interior Fish and Wildlife Service, New York State Department of Environmental Conservation, and Onondaga Nation. September.

Jackson, A., Evers, D.C., Etterson, M.A., Condon, A.M., Folsom, S.B., Detweiler, J.,Schmerfeld, J. and D.A. Cristol. 2011. Mercury Exposure Affects the Reproductive Success of a Free-living Terrestrial Songbird, the Carolina Wren. *Auk* 128: 759-769.

LaManche, K. 2007. The current state of aquatic invasive species in central New York. Report Prepared by Central New York Regional Planning and Development Board. March.

Lane, O., Edmonds, S.T., Atwood, J., Regan, K., Buck, D., and D. Evers. Assessment of Mercury in Birds at Onondaga Lake: 2008-2009 Breeding Season Final Report. 2012. Report BRI 2011-17 submitted to U.S. Fish and Wildlife Service, Cortland, NY. Biodiversity Research Institute, Gorham, Maine.

Lock, K. and C.R. Janssen. 2001. Ecotoxicity of mercury to *Eisenia fetida*, *Enchytraeus albidus* and *Folsomia candida*. *Biol. Fertil. Soils*. 34:219-221.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. *Arch. Environ. Contam. Toxicol.* 39:20-31.

Matta, M.B., J. Linse, C. Carincross, L. Francendese, and R.M. Kocan. 2001. Reproductive and transgenerational effects of methylmercury or Aroclor 1268 on *Fundulus heteroclitus*. *Environ. Toxicol. Chem.* 20(2):327-335.

Mayer, F.L., P.M. Mehrle, and H.O. Sanders. 1977. Residue dynamics and biological effects of polychlorinated biphenyls in aquatic organisms. *Arch. Environ. Contam. Toxicol.* 5: 501-511.

National Oceanic and Atmospheric Administration (NOAA). 2010. Adapting to Climate Change: A Planning Guide for State Coastal Managers. NOAA Office of Ocean and Coastal Resource Management. Accessed June 2016 at: https://coast.noaa.gov/czm/media/adaptationguide.pdf.

NOAA. 2015. Programmatic Environmental Impact Statement. NOAA Restoration Center. June.

Normandeau Associates. 1996. Onondaga Lake Natural Resource Damage Assessment Plan. Report Prepared for New York State Department of Environmental Conservation. November.

NYSDEC (New York State Department of Environmental Conservation). 1994. Preassessment Screen Determination for the Onondaga Lake Watershed in the Vicinity of Syracuse, New York. Prepared by the Trustee for Natural Resources. September.

NYSDEC. 2015a. Proposed Remedial Action Plan. NM – Syracuse Erie Blvd. MGP. Site No. 734060.

NYSDEC. 2015b. New York State Aquatic Invasive Species Management Plan. July.

NYSDEC. 2016a. Impacts of Climate Change in New York. Information accessed in June 2016 at the following link: http://www.dec.ny.gov/energy/94702.html.

NYSDEC. 2016b. Onondaga Lake and Watershed. Information accessed in June 2016 at the following link: http://www.dec.ny.gov/lands/72771.html.

NYSDEC/AECOM. 2012. Environmental Database for Onondaga Lake.

NYSDEC/TAMS. 2002a. Onondaga Lake Baseline Ecological Risk Assessment. Syracuse, New York.

NYSDEC/TAMS. 2002b. Onondaga Lake Remedial Investigation Report. Syracuse, New York.

NYSDEC, Onondaga Nation, and the U.S. Department of the Interior. 2008. Interim memorandum of agreement among the New York State Department of Environmental Conservation, Onondaga Nation, and United States Department of the Interior regarding the assessment of natural resource damages related to the Onondaga Lake Superfund Site.

NYSERDA (New York State Energy Research and Development Authority). 2014. Climate Change in New York State. Final Report 14-26. September.

OCDWEP (Onondaga County Department of Water Environment Protection). 2008. Onondaga Lake Fishery: 2007-2008 Fact Sheet. Information accessed in June 2016 at: http://www.ongov.net/wep/images/FishFactSheet2007_2008.pdf.

Onondaga Lake Watershed Partnership (OLWP). 2016. Onondaga Lake and Watershed. Information accessed in June 2016 at: http://www.olwp.org/lake--watershed.html.

Onondaga Nation. Site updated 2015. Data extracted May 11, 2016. http://www.onondaganation.org/

Parsons. 2014a. Construction Completion Report for the Geddes Brook Interim Remedial Measure Site Number NYD986913580 Onondaga County, New York. Prepared for Honeywell. November. http://www.dec.ny.gov/docs/regions_pdf/gbirm.pdf

Parsons. 2014b. 2013 Annual Monitoring and Maintenance Report Geddes Brook/Ninemile Creek Solvay, New York. Prepared for Honeywell. December. http://www.dec.ny.gov/docs/regions_pdf/gbmt2013.pdf.

SUNY ESF (State University of New York College of Environmental Science and Forestry). 2016. Tully Mudboils Technical Advisory Panel Report. Final Report. Prepared in collaboration with the technical advisory panel. October 6.

Syracuse-Onondaga County Planning Agency. 1998. The 2010 Development Guide for Onondaga County.

Syracuse-Onondaga County Planning Agency. 2003. Map Gallery. Watersheds in Onondaga County. Information accessed in June 2016 at: http://www.ongov.net/planning/map_gallery.html.

Terrestrial Environmental Specialists, Inc. (TES). 2013a. Onondaga Lake Herpetological Investigations, Results of 2011 Studies at Onondaga Lake and Reference Areas. Prepared for Onondaga Lake Natural Resource Damage Assessment and Restoration Trustee Council.

Terrestrial Environmental Specialists, Inc. (TES). 2013b. Onondaga Lake Herpetological Investigations, Spring 2012 Supplement. Prepared for Onondaga Lake Natural Resource Damage Assessment and Restoration Trustee Council.

Trustees and Honeywell. 2009. Cooperative Assessment and Funding Agreement Regarding the Assessment of Natural Resource Damages Related to the Onondaga Lake Superfund Site, New York.

Unrine, J.M. and C.H. Jagoe. 2004. Dietary mercury exposure and bioaccumulation in southern leopard frog (*Rana sphenocephala*) larvae. *Environ. Toxicol. Chem.* 23(12): 2956-2963.

Unrine, JM, CH Jagoe, WA Hopkins and HA Brant. 2004. Adverse effects of ecologically relevant dietary mercury exposure in southern leopard frog (*Rana sphenocephala*) larvae. *Environ. Toxicol. Chem.* 23 (12): 2964-2970.

US Census Bureau. 2016. American Community Survey. http://factfinder.census.gov/

US Department of Labor. 2016. Bureau of Labor Statistics "Economy at a Glance" Syracuse, NY. Data extracted on May 10. http://www.bls.gov/eag/eag.ny_syracuse_msa.htm

NPS (United States National Park Service). 2016. National Register of Historic Places Program. Data extracted on May 11. https://www.nps.gov/nr/research/

USEPA and NYSDEC. 2015. Record of Decision. Operable Unit 2 of the General Motors Inland Fisher Guide Subsite of the Onondaga Lake Superfund Site.

Yates, D., S. Angelo, T. Divoll and D. Evers. 2012. Assessment of Mercury Exposure to Bats at Onondaga Lake, New York: 2009 Field Season. Submitted to U.S. Fish and Wildlife Service, Cortland, NY. Biodiversity Research Institute, Gorham, Maine.

APPENDIX A THREATENED AND ENDANGERED SPECIES OF ONONDAGA COUNTY

GROUP	COMMON NAME	SCIENTIFIC NAME	STATE PROTECTION STATUS [1]	FEDERAL PROTECTION STATUS [2]
Mammals	Indiana Bat	*Myotis sodalis*	Endangered	Endangered
	Northern Long-eared Bat	*Myotis septentrionalis*	Threatened	Threatened
Birds	Black Tern	*Chlidonias niger*	Endangered	None
	Peregrine Falcon	*Falco peregrinus*	Endangered	None
	Short-eared Owl	*Asio flammeus*	Endangered	None
	Bald Eagle	*Haliaeetus leucocephalus*	Threatened	None
	Common Tern	*Sterna hirundo*	Threatened	None
	Henslow's Sparrow	*Ammodramus henslowii*	Threatened	None
	Least Bittern	*Ixobrychus exilis*	Threatened	None
	Northern Harrier	*Circus cyaneus*	Threatened	None
	Pied-billed Grebe	*Podilymbus podiceps*	Threatened	None
	Sedge Wren	*Cistothorus platensis*	Threatened	None
	Upland Sandpiper	*Bartramia longicauda*	Threatened	None
Reptiles	Bog Turtle	*Glyptemys muhlenbergii*	Endangered	Threatened
	Eastern Massasauga	*Sistrurus catenatus catenatus*	Endangered	Candidate
	Blanding's Turtle	*Emydoidea blandingii*	Threatened	None
	Timber Rattlesnake	*Crotalus horridus*	Threatened	None
Fish	Lake Chubsucker	*Erimyzon sucetta*	Threatened	None
	Lake Sturgeon	*Acipenser fulvescens*	Threatened	None
	Longear Sunfish	*Lepomis megalotis*	Threatened	None
Flowering Plants	American Waterwort	*Elatine americana*	Endangered	None
	Angled Spikerush	*Eleocharis quadrangulata*	Endangered	None
	Bear's-foot	*Smallanthus uvedalius*	Endangered	None
	Broad-lipped Twayblade	*Listera convallarioides*	Endangered	None
	Button-bush Dodder	*Cuscuta cephalanthi*	Endangered	None
	Calypso	*Calypso bulbosa var. americana*	Endangered	None
	Carey's Smartweed	*Persicaria careyi*	Endangered	None
	Cloud Sedge	*Carex haydenii*	Endangered	None
	Cooper's Milkvetch	*Astragalus neglectus*	Endangered	None
	Cranefly Orchid	*Tipularia discolor*	Endangered	None
	Eastern Prairie Fringed Orchid	*Platanthera leucophaea*	Endangered	Threatened
	Fairy Wand	*Chamaelirium luteum*	Endangered	None
	Field Dodder	*Cuscuta campestris*	Endangered	None

GROUP	COMMON NAME	SCIENTIFIC NAME	STATE PROTECTION STATUS [1]	FEDERAL PROTECTION STATUS [2]
Flowering Plants	Glomerate Sedge	*Carex aggregata*	Endangered	None
	Golden Puccoon	*Lithospermum caroliniense var. croceum*	Endangered	None
	Goosefoot Corn-salad	*Valerianella chenopodiifolia*	Endangered	None
	Hair-like Sedge	*Carex capillaris*	Endangered	None
	Heart Sorrel	*Rumex hastatulus*	Endangered	None
	Hooker's Orchid	*Platanthera hookeri*	Endangered	None
	Kentucky Coffee Tree	*Gymnocladus dioicus*	Endangered	None
	Large Twayblade	*Liparis liliifolia*	Endangered	None
	Lindley's Aster	*Symphyotrichum ciliolatum*	Endangered	None
	Marsh Valerian	*Valeriana uliginosa*	Endangered	None
	Michigan Lily	*Lilium michiganense*	Endangered	None
	Northern Bog Violet	*Viola nephrophylla*	Endangered	None
	Northern Wild Comfrey	*Cynoglossum virginianum var. boreale*	Endangered	None
	Nuttall's Tick-trefoil	*Desmodium nuttallii*	Endangered	None
	Orange Fringed Orchid	*Platanthera ciliaris*	Endangered	None
	Possum-haw	*Viburnum nudum var. nudum*	Endangered	None
	Puttyroot	*Aplectrum hyemale*	Endangered	None
	Salt-meadow Grass	*Leptochloa fusca ssp. fascicularis*	Endangered	None
	Sartwell's Sedge	*Carex sartwellii*	Endangered	None
	Scarlet Indian-paintbrush	*Castilleja coccinea*	Endangered	None
	Scirpus-like Rush	*Juncus scirpoides*	Endangered	None
	Scotch Lovage	*Ligusticum scothicum ssp. scothicum*	Endangered	None
	Sea Purslane	*Sesuvium maritimum*	Endangered	None
	Seaside Crowfoot	*Ranunculus cymbalaria*	Endangered	None
	Sheathed Pondweed	*Stuckenia filiformis ssp. occidentalis*	Endangered	None
	Shining Bedstraw	*Galium concinnum*	Endangered	None
	Short's Sedge	*Carex shortiana*	Endangered	None
	Slender Marsh-pink	*Sabatia campanulata*	Endangered	None
	Small White Ladyslipper	*Cypripedium candidum*	Endangered	None
	Small Whorled Pogonia	*Isotria medeoloides*	Endangered	Threatened
	Small Yellow Ladyslipper	*Cypripedium parviflorum var. parviflorum*	Endangered	None
	Small's Knotweed	*Polygonum aviculare ssp. buxiforme*	Endangered	None
	Southern Twayblade	*Listera australis*	Endangered	None

GROUP	COMMON NAME	SCIENTIFIC NAME	STATE PROTECTION STATUS [1]	FEDERAL PROTECTION STATUS [2]
Flowering Plants	Spiny Water-nymph	*Najas marina*	Endangered	None
	Spreading Chervil	*Chaerophyllum procumbens*	Endangered	None
	Sticky False Asphodel	*Triantha glutinosa*	Endangered	None
	Stiff Tick-trefoil	*Desmodium obtusum*	Endangered	None
	Straight-leaf Pondweed	*Potamogeton strictifolius*	Endangered	None
	Swamp Smartweed	*Persicaria setacea*	Endangered	None
	Sweet Coltsfoot	*Petasites frigidus var. palmatus*	Endangered	None
	Sweet-scented Indian-plantain	*Hasteola suaveolens*	Endangered	None
	Tall Bellflower	*Campanulastrum americanum*	Endangered	None
	Virginia False Gromwell	*Onosmodium virginianum*	Endangered	None
	Virginia Three-seeded Mercury	*Acalypha virginica*	Endangered	None
	White Basswood	*Tilia americana var. heterophylla*	Endangered	None
	Wild Sweet-william	*Phlox maculata ssp. maculata*	Endangered	None
	Woodland Bluegrass	*Poa sylvestris*	Endangered	None
	Big Shellbark Hickory	*Carya laciniosa*	Threatened	None
	Brown Bog Sedge	*Carex buxbaumii*	Threatened	None
	Cork Elm	*Ulmus thomasii*	Threatened	None
	Creeping Sedge	*Carex chordorrhiza*	Threatened	None
	Dragon's Mouth Orchid	*Arethusa bulbosa*	Threatened	None
	Drummond's Rock-cress	*Boechera stricta*	Threatened	None
	Dwarf Glasswort	*Salicornia bigelovii*	Threatened	None
	Farwell's Water-milfoil	*Myriophyllum farwellii*	Threatened	None
	Glaucous Sedge	*Carex glaucodea*	Threatened	None
	Golden-seal	*Hydrastis canadensis*	Threatened	None
	Great Plains Flatsedge	*Cyperus lupulinus ssp. lupulinus*	Threatened	None
	Knotted Spikerush	*Eleocharis equisetoides*	Threatened	None
	Lake-cress	*Rorippa aquatica*	Threatened	None
	Little-leaf Tick-trefoil	*Desmodium ciliare*	Threatened	None
	Marsh Arrow-grass	*Triglochin palustre*	Threatened	None
	Midland Sedge	*Carex mesochorea*	Threatened	None
	Mountain Death Camas	*Anticlea elegans ssp. glaucus*	Threatened	None
	Nodding Pogonia	*Triphora trianthophora*	Threatened	None
	Northern Bog Aster	*Symphyotrichum boreale*	Threatened	None
	Ohio Goldenrod	*Oligoneuron ohioense*	Threatened	None
	Pink Wintergreen	*Pyrola asarifolia ssp. asarifolia*	Threatened	None
	Purple Cress	*Cardamine douglassii*	Threatened	None

GROUP	COMMON NAME	SCIENTIFIC NAME	STATE PROTECTION STATUS [1]	FEDERAL PROTECTION STATUS [2]
Flowering Plants	Ram's-head Ladyslipper	*Cypripedium arietinum*	Threatened	None
	Red Pigweed	*Chenopodium rubrum*	Threatened	None
	Reflexed Sedge	*Carex retroflexa*	Threatened	None
	Rock-cress	*Draba arabisans*	Threatened	None
	Rough Avens	*Geum virginianum*	Threatened	None
	Saltmarsh Aster	*Symphyotrichum subulatum var. subulatum*	Threatened	None
	Schweinitz's Sedge	*Carex schweinitzii*	Threatened	None
	Seabeach Amaranth	*Amaranthus pumilus*	Threatened	Threatened
	Seaside Bulrush	*Bolboschoenus maritimus ssp. paludosus*	Threatened	None
	Seaside Gerardia	*Agalinis maritima var. maritima*	Threatened	None
	Seaside Plantain	*Plantago maritima var. juncoides*	Threatened	None
	Showy Aster	*Eurybia spectabilis*	Threatened	None
	Slender Blue Flag	*Iris prismatica*	Threatened	None
	Small Bur-reed	*Sparganium natans*	Threatened	None
	Small Floating Bladderwort	*Utricularia radiata*	Threatened	None
	Smooth Bur-marigold	*Bidens laevis*	Threatened	None
	Stargrass	*Aletris farinosa*	Threatened	None
	Swamp Lousewort	*Pedicularis lanceolata*	Threatened	None
	Terrestrial Starwort	*Callitriche terrestris*	Threatened	None
	Troublesome Sedge	*Carex molesta*	Threatened	None
	Twin-leaf	*Jeffersonia diphylla*	Threatened	None
	Wild Pink	*Silene caroliniana ssp. pensylvanica*	Threatened	None
	Woodland Agrimony	*Agrimonia rostellata*	Threatened	None
	Yellow Giant-hyssop	*Agastache nepetoides*	Threatened	None
	Yellow Wild Flax	*Linum sulcatum*	Threatened	None
Conifers	Creeping Juniper	*Juniperus horizontalis*	Endangered	None
Ferns and Fern Allies	Climbing Fern	*Lygodium palmatum*	Endangered	None
	Common Moonwort	*Botrychium lunaria*	Endangered	None
	Mingan Moonwort	*Botrychium minganense*	Endangered	None
	Prairie Dunewort	*Botrychium campestre*	Endangered	None
	Rugulose Grape Fern	*Botrychium rugulosum*	Endangered	None
	Blunt-lobe Grape Fern	*Botrychium oneidense*	Threatened	None
	Hart's-tongue Fern	*Asplenium scolopendrium var. americanum*	Threatened	Threatened
	Marsh Horsetail	*Equisetum palustre*	Threatened	None

Data Sources: [1] NYSDEC, [2] FWS