The Michigan Department of Environmental Quality
Biennial Remedial Action Plan Update
For the
Torch Lake Area of Concern

Mason Sands Superfund Site area two years after Superfund remedial activities completed.

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Acknowledgements

This document is the product of many individuals working toward a common purpose, that purpose being to restore the Torch Lake Area of Concern (AOC). This partnership includes technical staff in the Michigan Department of Environmental Quality (MDEQ) and the U.S. Environmental Protection Agency (U.S. EPA), and members of the Torch Lake Public Action Council (PAC) forming the Torch Lake AOC Technical Committee (TLTC). Additional "Committee" partners include technical staff in the Michigan Department of Natural Resources (MDNR), the Michigan Department of Community Health (MDCH), the U.S. EPA, Great Lakes National Program Office (GLNPO), the U.S. EPA Superfund (SF) Section, and the U.S. Fish and Wildlife Service. The Great Lakes Commission, the International Joint Commission (IJC), and other Great Lakes States' Agencies, the Statewide Public Advisory Council for Michigan's AOC program, and members of many local AOC gave freely of their time and also provided the critical interagency and public perspective in the development of the Guidance for Delisting Michigan's Great Lakes AOC document (Guidance) (MDEQ, 2006a). The Guidance formed the path to the development of this Remedial Action Plan (RAP) update.

Cover: The cover shows the Mason Sands SF Site Area located along the south western shore of Torch Lake, Houghton County, Michigan two years after the completion of the SF recommended remedial action (covering with topsoil and vegetating to prevent erosion by wind or water into nearby waterbodies). These particular "sands" or process wastes are comprised of water quenched slags. These slags are the result of cooling the parent rhyolitic materials with water after separating them from the copper after the smelting process. The picture below is a different view of the Mason sands before the remediation.

Executive Summary

Many actions have occurred within the Torch Lake (AOC) over the past 40 years which have greatly improved water quality and clarity. The original purpose of this RAP Update document, developed by the TLTC, was to determine the potential for delisting Torch Lake as an AOC. Developed through that process, this RAP Update addresses the current status of the three Beneficial Use Impairments (BUIs) identified for the AOC by the state and the U.S. EPA. These BUIs are: Fish Tumors or Other Deformities, Restrictions on Fish and Wildlife Consumption, and Degradation of Benthos (MDNR, 1987; MDEQ 2006a).

- Fish Tumor or Other Deformities BUI: Based on the findings during the delisting discovery process related to status of this BUI, the state and the Torch Lake AOC PAC recommended the removal of this BUI (MDEQ, 2007). The U.S. EPA concurred with this recommendation and now considers this BUI removed (U.S. EPA, 2007).

- Restrictions on Fish and Wildlife Consumption BUI: Torch Lake fish have consumption advisories related to mercury and polychlorinated biphenyls (PCBs) (MDCH, 2004a). The mercury found in Torch Lake fish is not statistically significantly different than the concentration found in Lake Superior fish, and therefore, the state's guidance for removing the BUI is met relative to mercury (MDEQ, 2006a and MDEQ, 2006b). The PCB levels are higher in Torch Lake than in Lake Superior at a statistically significant level. The Torch Lake fish consumption advisory related to PCBs does not meet the state criteria for removing the BUI (MDEQ, 2006a and MDEQ, 2006b). In 2005, the Water Bureau (WB) assessed the levels of PCBs using semi-permeable membrane devices (fish tissue surrogates) (MDEQ, 2006c) and corresponding sediment samples (U.S. EPA, 2006). Also in 2006, WB assessed earlier Remediation and Redevelopment Division (RRD) sediment samples (MDEQ, 2006d). These results indicated that surrogates and sediments on the western side of the lake show elevated levels of PCBs when compared to levels on the east side and controls. Further source identification studies are planned for the summer of 2007 to hopefully define whether there is a discrete source for the PCB contamination or if the distribution is ubiquitous for that area from past mining activities. These studies will determine whether any remedial actions are necessary.

- Degraded Benthos BUI: Under Michigan's Guidance, this BUI would be considered ready for removal when all sources are controlled and remedial actions have been completed (MDEQ, 2006a). The known sources have been controlled through the U.S. EPA SF remedial actions (U.S. EPA, 1992a; U.S. EPA, 1994a; U.S. EPA, 1994b). The chosen remedy for Operable Unit (OU) 2, Torch Lake by SF was natural attenuation. Under the SF Record of Decision (ROD), Torch Lake was automatically eligible for SF delisting once remedial actions on the uplands began. The lake was delisted from the SF National Priorities List (NPL) in April, 2004. The remedial action for the Torch Lake SF Site, OU 1, the uplands, was completed in the fall of 2005. The removal of the Degraded Benthos BUI now only awaits the determination if remedial actions are needed in association with the PCB source identification study underway for the Restrictions on Fish and Wildlife Consumption BUI.

Additional investigations into potential PCB sources within the watershed are needed before the Torch lake AOC can be considered for delisting.

Introduction

The intent in the development of this document by the TLTC was to examine the current status of the Torch Lake AOC's BUIs to determine the potential for delisting the AOC during 2006 as requested by the Torch Lake PAC at a joint meeting with the U.S. EPA and state staff held in August of 2005. The BUI status determination would be made based on criteria for each BUI from the Guidance for Delisting Michigan's Areas of Concern (MDEQ, 2006a).

In 2005, using the 1987 Torch Lake AOC RAP, the MDEQ staff identified three BUIs for the Torch Lake AOC as described under Annex 2 of the 1987 Great Lakes Water Quality Agreement (GLWQA) and further described in the IJC's *Guidelines for Recommending the Listing and Delisting of Great Lakes Areas of Concern* (IJC, 1997). These BUIs are Fish Tumors or Other Deformities, Restrictions on Fish and Wildlife Consumption, and Degradation of Benthos (MDEQ, 2006a). On June 12, 2006, the Torch Lake PAC voted to adopt the state's delisting criteria for the Fish Tumor or Other Deformities BUI (Attachment D). Through discussions with the Torch Lake Technical Committee representing the PAC, the PAC has not reached a decision on whether to use the state's criteria or develop local criteria for the remaining two BUIs.

Based on the Technical Committee's work it became apparent that the AOC could not be delisted at this time. Therefore, though originally intended as the delisting determination document, this document is now considered the Torch Lake AOC Biennial RAP Update. It identifies the specific quantitative or qualitative criteria and information which the TLTC used to determine the current status of the BUIs. This RAP Update describes the historical setting, restoration goals, status of remedial actions, and status of each BUI. It describes how remedial actions and current conditions have addressed or met Michigan's re-designation criteria following Michigan's Guidance. This document integrates information compiled through discussions between the TLTC and agency staff, based on current and historical information.

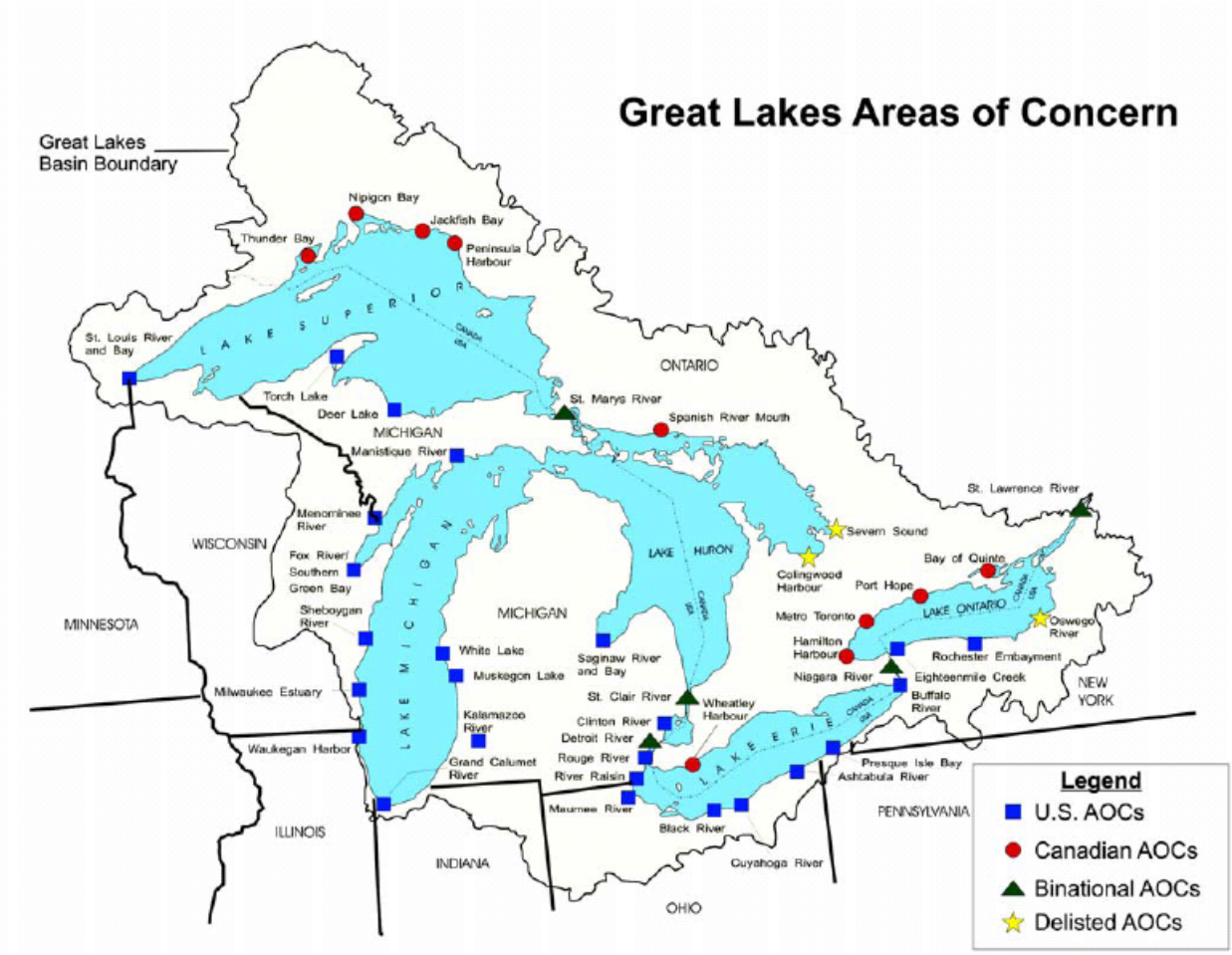
AOC Background/History

The 1985 AOC designation was based on the fish consumption advisory issued by the Michigan Department of Public Health (MDPH) (MDCH, 1983), now the Michigan Department of Community Health (MDCH). The designation was driven by the presence of gross external and internal tumors in older sauger and walleye and also concerns related to contaminated sediments (MDNR, 1986a; MDNR, 1987). The cause of the tumors was never determined (Black et al., 1982; Black and Evans, 1986; MDNR, 1987).

In 1987, amendments to the GLWQA were adopted by the federal governments of the United States and Canada. Annex 2 of the amendments listed 14 different BUIs caused by a detrimental change in the chemical, physical, or biological integrity of the Great Lakes system (IJC, 1987). It directed the two countries to identify AOCs that did not meet the objectives of the GLWQA. The RAPs addressing the BUIs were to be prepared for all AOCs (SIAC, 1985). The BUIs provided a tool for describing effects of the contamination, and a means for focusing remedial actions. The 1987 Torch Lake AOC RAP (MDNR, 1987) was prepared by the MDNR (MDNR, 1986a).

The scope of the AOC program is based on the concept that each AOC has had at least one BUI that was or is an extraordinary problem, one that sets the area apart from other sites with lesser contamination that are not AOCs. For the Torch Lake AOC that identifying issue was the excessive number of tumors found in the sauger and walleye (Tomljanovich, 1974; Wright et al., 1975; Black et al., 1982; Constanza and Oakes, 1984; Markham, 1984; Spence, 1986) Michigan has fourteen AOCs (see Figure 1), each having unique problems and contamination sources.

Figure 1: AOCs in the Great Lakes-St. Lawrence River Basin from the U.S.EPA-GLNPO website.



When the Great Lake's AOCs (Figure 1) were originally designated in the late 1980s, no specific quantitative criteria for listing or delisting these areas were developed. The IJC issued general listing criteria in 1991 (IJC, 1991), and the United States Policy Committee issued general guidance on the process for AOC delisting in 2001 (U.S. EPA, 2001). These efforts, however, were not specific enough for use in determining restoration of individual Beneficial Uses by either the state of Michigan or the United States federal government.

In January 2006, the MDEQ finalized the Guidance for Delisting Michigan's Great Lakes Areas of Concern (Guidance). "The purpose of the document was to: 1) provide guidance to AOC communities about the state's process for delisting AOCs; and 2) identify specific quantitative or qualitative criteria which the state will use to determine when BUIs have been restored" (MDEQ, 2006a).

As part of the Guidance development, the MDEQ staff identified 3 BUIs as described under Annex 2 of the 1987 GLWQA (IJC, 1987) for the Torch Lake AOC. These BUIs are: Fish Tumors or Other Deformities, Restrictions on Fish Consumption, and Degradation of Benthos as agreed to through discussions with the Torch Lake PAC, the U.S. EPA and the state of Michigan. As the recognized impairments, these will be officially addressed in this document. Other BUIs were assumed or mistakenly added to the Torch Lake informational material through the years including Restrictions on Dredging, Degradation of Phyto- or Zooplankton Populations, Degradation of Fish and Wildlife populations, Degradation of Fish and Wildlife Habitat, and perhaps others. These impairments were not documented. The state had not

officially requested the U.S. EPA to add any additional BUIs to the Torch Lake AOC. Table 1 summarizes the current status of the identified BUIs.

Table 1. Torch Lake BUI Removal Status Matrix

Beneficial Use Impairment	Beneficial Use Remains Impaired	Assessment in Status Review In Progress	Draft Removal Document In Review Process	BUI - Removed
Restrictions on fish and wildlife consumption	x	x		
Fish Tumors or Other Deformities				x
Degradation of Benthos	x	x		

Geographic/Geologic/Hydrogeologic Setting

The Torch Lake AOC is located on the Keweenaw Peninsula within Houghton County on the northwestern shore of Michigan's Upper Peninsula and on Lake Superior's southern shore. The region is locally known as "Copper Country." Deposits of both native (elemental) copper and copper sulphide, called chalcocite, are found in the Portage Lake Lava series and Nonesuch Shales, respectively. These geologic formations extend from the tip of the Keweenaw Peninsula southwest to the Michigan-Wisconsin border covering a distance of over one hundred miles. The lava series are steeply pitching seams whereas the shale's are relatively flat seams occurring at the southwest end of the district. In the Torch Lake area only the native copper was extracted from ores within the Portage Lake Lava Series. These series consisted of both dark-gray basalts, and conglomerates consisting of sands with a high amount of red to purple rhyolitic pebbles and cobbles (MDNR, 1970; LeDuc and Lee, 1976; Warburton, 1986; Whiton, 2006; Johnson, 2007).

Several small communities are located on the western shore of Torch Lake, the largest of which are Lake Linden, Hubbell/Tamarack City, and Mason. Two large cities, Houghton and Hancock, are located on the south and north side of Keweenaw Waterway respectively. The villages of Calumet and Laurium are located 5 miles north of Torch Lake (See Figure 2).

Torch Lake is an oligotrophic dimictic lake which exhibits thermal stratification. Torch Lake has a surface area of approximately 2,700 acres, a maximum depth of 105 feet, and a volume of 5.2 trillion cubic feet (MDNR, 1970). The watershed covers approximately 121 square miles and has an average retention time of one year (Wright et al., 1973). The average annual snowfall for the area lies between 180 and 200 inches which sometimes results in extremely flashy rivers and streams at snowmelt. Wetlands are located on the east portion of the former Lake Linden stamp sand pile, on the eastern edge of the former Hubbell stamp sand pile, and on the eastern shore of Torch Lake. These stamp sands have been remediated and will be discussed later in this document.

The Torch Lake watershed is the head waters of what is referred to as the Keweenaw Waterway. This waterway bisects the Keweenaw Peninsula and is open at both the north and south ends allowing, depending on wind direction, flows into Lake Superior in either direction. Lake Superior seiches can also "push" water essentially flowing into Torch and Portage Lakes causing the lake levels to rise. Torch Lake is used for fishing, boating, limited contact recreation (swimming, jet skis, and water skis), non-contact cooling water supply, treated municipal waste assimilation, and wildlife habitat.

Figure 2: Portion of the Keweenaw Peninsula, Upper Peninsula, Michigan. Torch Lake is connected to Lake Superior through Portage Lake and the Keweenaw Waterway.

Map from United States Geological Survey "TopoZone" Mapping System.

Area Background/History

Copper-bearing ore on the Keweenaw Peninsula contains copper in its native or natural metallic form (Markham, 1985) and not in the sulfides or oxidized ores found in other districts. This native copper was found by native peoples in "floats" on the surface. For this reason, it has been a source of copper for area peoples for thousands of years.

The Keweenaw Peninsula, "Copper Country," saw production of 14 billion pounds of copper (Johnson, 2007) involving mining, milling, dredging, leaching, and smelting operations. Large scale operations began in the 1840s and continued for more than one and half centuries until all mining and related operations ceased in 1992. The last copper production operation at the western end of the "copper country" shut down in 1992. The Torch Lake area provided 10.5 billion pounds of copper with operations ceasing in 1968. It is the process byproducts from these industrial operations of the mined copper bearing ore which created environmental concerns. These industries generated large quantities of stamp sands, slags, poor rock, and other process wastes. An estimated 200,000,000 tons of stamp sands and slags were distributed directly into Torch Lake or along the shoreline filling approximately 20 percent of the volume of the lake (Markham, 1985; MDNR, 1987; Albee, 1999). These processes also left behind process waste materials that were deposited either on the surface of the surrounding landscape or in adjacent lakes and streams. The stamp sands and slags are highly erodible through wind or water driven processes.

Mined materials considered waste or "poor rock" were piled near abandoned mines. Stamp sands were disposed of in lakes and waterways adjacent to the mills (ore processing plants)

with minor amounts located near the old mine sites (Markham, 1985). Slag piles are found at old smelter sites also located along nearby lakes and waterways. Poor rock piles were once prominent on the landscape but have decreased in volume since the mines closed because the rock is a valuable construction material.

The milling process involved crushing and grinding mined ore to remove the copper, which produced a waste byproduct called “stamp sands” or “tailings.” In the milling process, two things were necessary, an abundance of clean water and room for the disposal of the waste tailings.

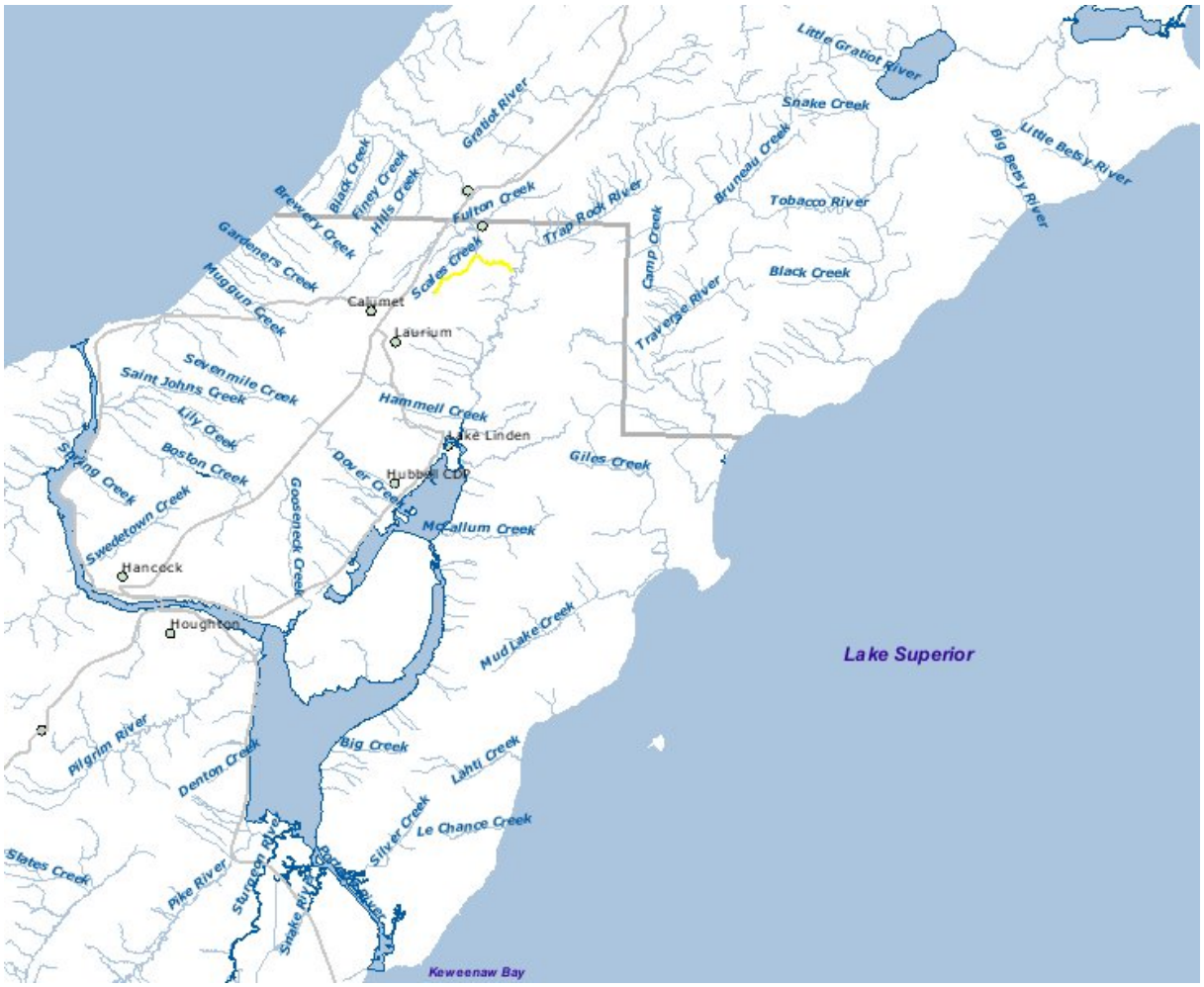
Many of the copper producing companies operating during the 1800s also had stamp mills near the mining operations. These mills used adjacent streams or rivers as water sources (Figure 3). These industries generated large quantities of stamp sands, slags, and other process wastes. Companies would build long sluices also called launders, to discharge the waste tailings downstream or down slope from the mill buildings. Essentially, all companies found it difficult to maintain ore milling at the mine sites due to processing increasing amounts of ore resulting from increased mining efficiencies and the consolidation of mining companies. This led to the lakes being a major attraction for the gravity deposition of stamp sands and a ready source for the required large volumes of water. Consequently many mills were moved to the shores of Keweenaw Waterway, Portage Lake, Torch Lake, and Lake Superior.

The tailings dumped into the west arm of Portage Lake, however, began to impede Great Lakes shipping traffic. Therefore, by the end of the 1800s, companies were required to cease milling operations where tailing infringed on the ship canal and move to either Torch Lake or Lake Superior (Nordberg, 1996). Torch Lake was particularly desirable as a milling site because of its depth and proximity to mining and shipping operations. The channel between Torch and Portage Lakes at one time was maintained for navigational use by commercial shippers by dredging. The channel is no longer maintained for commercial use and is now designated for recreational use.

It is estimated that more than 10.5 billion pounds of copper were produced in the Copper Country between the mid-1840s and 1968. Half of this output was processed at sites scattered across the Copper Country landscape. The remainder was processed along the western shoreline of Torch Lake. Approximately 200 million tons of copper ore tailings were deposited in Torch Lake, displacing about 20 percent of the lake’s original volume (Markham, 1985; Warburton, 1986; MDNR, 1987).

The early milling process, which consisted of crushing copper rich ore in stamp mills to remove the copper, was relatively inefficient and considerable copper was discharged with the stamp sands. As reclamation and reprocessing technologies improved, sediment dredging for copper recovery operations was conducted in Torch Lake beginning in 1915 using floatation processes to extract copper from previously discarded stamp sands. For the floatation process, mined ore and recovered tailings were ground finer to further liberate the copper. These processes were used along with mechanical gravity concentration to separate copper from the previously by-passed copper-bearing stamp sands. Then leaching processes used biodegradable chemicals for leaching, including ammonium carbonate (ammonia), floatation with oils, creosotes, and xanthates, and other copper concentrating chemicals. These chemicals went with the copper concentrate to the smelter where most of the chemicals were incinerated while the remainder was redeposited into the lake along with the reprocessed stamp sands and slags (Markham, 1985 and MDNR, 1987).

Figure 3. Map of Portage Lake, Keweenaw Waterway, Torch Lake, and the Trap Rock River Watershed. Go to the Michigan MiSwims website for site specific water quality information
https://www.michigan.gov/egle/about/organization/water-resources/glwarm/my-waterway



These process wastes, which included creosotes and xanthates, were suspected as the causative agents responsible for tumor induction in Torch Lake sauger and walleye (Markham, 1985; Leddy, 1986; Stensland and Bowen, 1986). They have not been found in the lake due to their rapid degradation (Dorie, 1986 and MDNR, 1987). A direct link with tumor formation was never established (Markham, 1976; MDNR, 1987; MDNR, 1990) though studies of rainbow trout by LeDuc and associates at the Sir George Williams Campus of Concordia University in Montreal found that xanthates and other mining flotation reagents caused necrotic effects to the liver, egg degeneration in the ovaries, and a decrease in yolk deposition in the eggs which would decrease fry viability (Markham, 1976; Leddy, 1986; Stensland and Bowen, 1986).

Eventually, most of the stamp sands previously deposited into Torch Lake were removed from the lake by dredging, reprocessed to remove the copper, and discharged back into the lake as much finer materials. The use of this recovery technology allowed the Copper Country's industrial base to eventually branch into the secondary copper market by recycling materials. With the growing demand for copper just prior to and during World War II, the technology was adapted to process copper-bearing scrap and expended armament brought to the plants by rail (Markham, 1976).

Following the war, copper-bearing scrap continued to be processed and the secondary copper market became a significant part of the industrial process. The local industry, now called

Peninsula Copper, Inc. (PCI), a small manufacturing firm in the old industrial district on the western shoreline of Torch Lake, retrofitted its leaching plant and branched into the manufacture of copper-based chemicals for agricultural and industrial uses. The Peninsula Copper Company utilizes an improved chemical technology through a leaching process to convert scrap copper metal into cupric oxide (CuO) (PCI, 2000 and MDEQ-National Pollutant Discharge Elimination System [NPDES], 2006). The production facility is currently permitted to discharge non-contact cooling water (MDEQ-NPDES, 2006). It does not use any local source of copper in its processes.

A lengthy work stoppage halted the copper mining and processing operations beginning in 1968 and led to the cessation of all copper mining and processing operations in the Houghton County area in 1968 (Markham, 1986; MDNR, 1987, Albee, 1999). Subsequently, the copper production infrastructure was dismantled. Only a historical legacy remains today which includes structures and foundations that housed the industrial activities. These remnants including the mounds of poor rock, slag and stamp sand piles, tailings, and their sediments in the lake and stream bottoms are all that remain of the once thriving mining and copper recovery industry. The Peninsula Copper Company, the only remaining remnant of that industry, continues to produce copper based materials for agricultural and industrial users.

Besides the actions resulting from the extraction of copper from mined ores and reclaimed stamp sands, the neighboring densely populated communities also used Torch Lake or it's tributaries to directly deposit raw sewage (Williams, 1973 and Wright et al., 1973).

There has been local concern that the discharge of copper leaching liquor which occurred sometime between 1971 and 1972 when the Lake Linden leaching plant was being dismantled for salvage (MDNR, 1973 and Wright et al., 1973) was a potential strong source of contaminants to the lake. An estimated 27,000 gallons copper leaching liquor (cupric ammonium sulfate) was discharged. This spill was determined by the Michigan Water Resources Commission (MWRC) staff of the MDNR to be an insignificant source of copper concentrates to Torch Lake (MWRC, 1973 and Wright et al.) when compared to other sources. In 1973 Wright et al. reported in Water Quality Alteration of Torch Lake, Michigan by Copper Leach Liquor. Proceedings 16th Conference, Great Lakes Research states that this spill did cause an impact on both the water chemistry and phytoplankton community of the lake, shifting the phytoplankton community to different species. Though the causal mechanisms were not clear, there was a definite decrease in water quality at that time through conversion of ammonia nitrogen to nitrate nitrogen. This might have been a factor in the observed oxygen depletion in the lake.

Each of the above actions resulted in increased water turbidity, increased suspended fines, deposited process wastes, or deposited waste into the lake. These historic anthropogenic actions resulted in decreased water quality and clarity in Torch Lake and directly contributed to the contaminant loadings to Torch Lake (MDNR, 1987).

Many actions have occurred within the watershed prior to and since the area was designated as an AOC which have had a positive impact on both water quality and clarity within the watershed. Dredging and milling process waste discharges ceased in 1968, before the 1985 AOC designation. Contaminated industrial discharges ceased, and only non-contact cooling water is currently discharged. The area's wastewater treatment plants were updated by the early eighties ending direct discharge of raw sewage to the lake or the lake's tributaries. The local municipalities historically used the lake's edge as a repository for municipal and industrial solid and liquid waste by piling the waste at the water's edge and pushing it into the lake. This use ceased in the 1980s.

The bottom of Torch Lake remains contaminated with the remnants of these past historical industrial and municipal activities. The lake bottom in some places has collected deposits of

heavy metals in toxic concentrations which are separated from the water column by a layer of naturally deposited sediments.

Other significant remedial actions were taken along Torch Lake and in the upper watershed of the Trap Rock River along Scales Creek by the U.S. EPA, MDEQ, and the Natural Resources Conservation Service. These actions were recommended in the U.S. EPA's Record of Decision (ROD) (discussed above) and were intended to slow water and wind driven erosional actions which contributed significant contaminate loadings to the lake. These remedial actions were achieved by stabilizing old mine dewatering basins, stabilizing streambanks, grading and stabilizing stamp sands and slags deposits through engineered plans which also incorporated soil and vegetative cover and implementing other nonpoint source best management practices.

2007 Information

The summer 2007 MDEQ Bathymetric Survey preformed by the MDEQ SF Staff (MDEQ, 2007d) found that the lake bottom does not conform to the expected natural bottom found in lakes. The bottom configuration is crisscrossed by the old dredging paths made for the copper reclamation processes. Some of these dredging channels were described as deep and others shallow, with no discernable pattern. Where these dredging paths cross they can form deeper pockets in the bottom sediments. Staff also found that the bottom is littered with many barrels and other metal debris in single, small, and large groupings. The locations of larger groupings were specifically identified during the mapping process. Due to falling lake levels additional expanses of stamp sands previously underwater are becoming exposed. During this same survey, the MDEQ staff walked an extensive portion of the remediated areas to determine the difference between the edge of the remediated areas and the new lake edge due to the lowered lake levels. Lake levels are expected to drop still further.

What's in a Name?

For nearly 30 years, the name "Torch Lake" has been used to describe three different but related concepts; Torch Lake the geographic entity, the Torch Lake AOC, designated under the GLWQA, and "Torch Lake SF Site under the United States Clean Water Act-Comprehensive Environmental Resource, Compensation, and Liability Act, 1980 PL96-510" SF, which includes numerous environmentally impacted areas of Houghton County, Michigan including the entire AOC.

This confusing status is found in MDNR, MDEQ, U.S. EPA, and IJC documents as well as in the 1987 Torch Lake RAP itself and is used when referring to both the Torch Lake AOC and the Torch Lake SF Site. As a consequence, the name Torch Lake is frequently used not to specify a body of water, but rather to refer to the entire area impacted by waste generated by processing ore, tailings and scrap to extract copper in Houghton County and can be found in both program's materials. References made to Torch Lake will designate the program (AOC or SF) being referred to within this document.

Additionally, SF Site decisions related to remedial activities within Torch Lake have directly impacted the status of BUIs in the Torch Lake AOC.

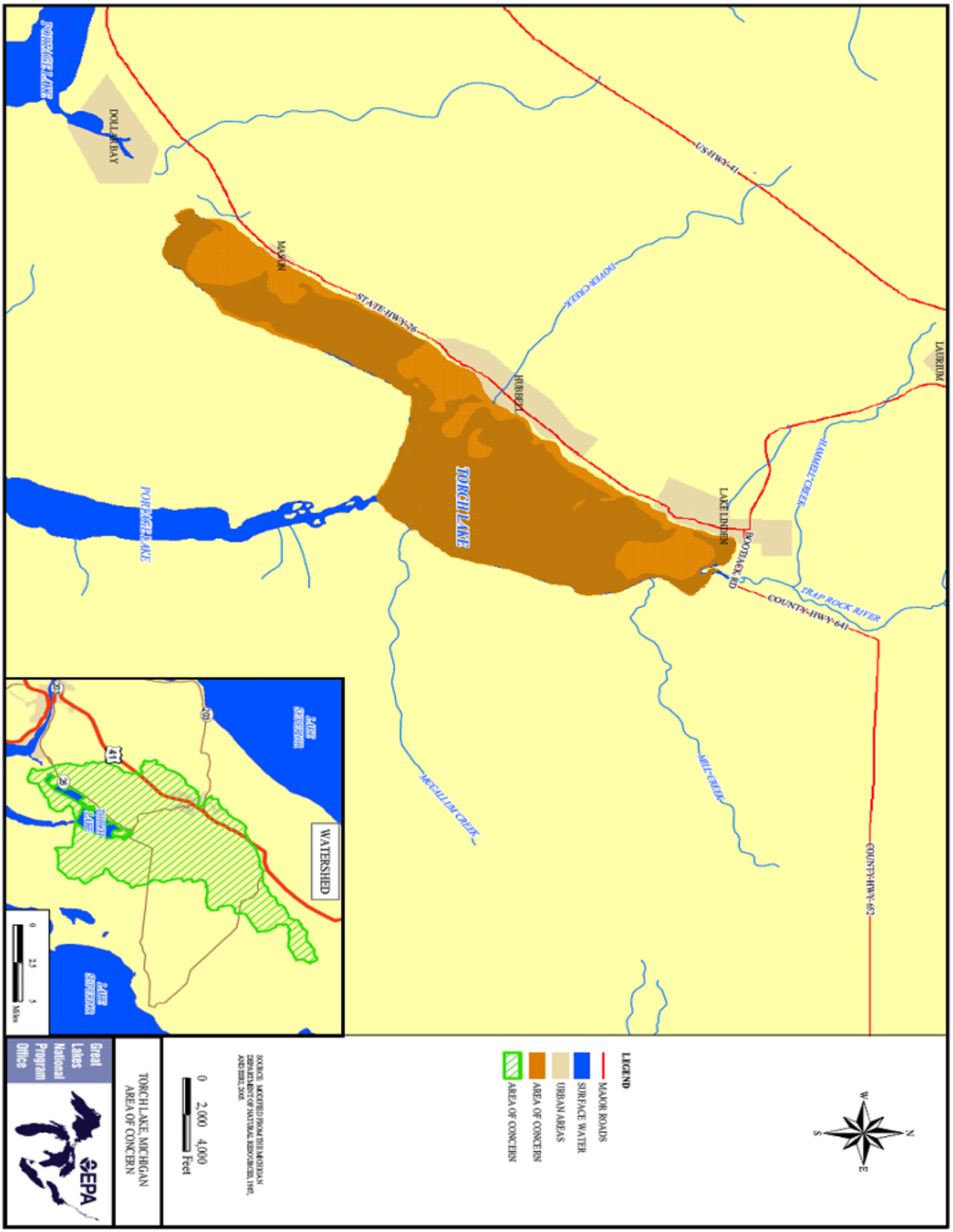
All three concepts, Torch Lake the geographic entity, Torch Lake the SF Site, and Torch Lake the AOC must be understood to grasp the scope of the problem.

AOC Boundary

The Torch Lake AOC boundary was described in the 1987 Torch Lake RAP as "…..Torch Lake and its immediate environs" (Fig. 3) (MDNR, 1987). Immediate environs can be described as those areas along the shore of Torch Lake proper where wastes from the production of copper contributed directly to the contaminate loadings of Torch Lake. These areas had stamp sands and water quenched slags dumped on the shore and into the lake during the copper production process in many places reconfiguring the lakes shoreline. The AOC boundary was formally agreed to between the PAC, U.S. EPA, and state of Michigan in 2006.

The U.S. EPA's Delisting Principles (U.S. EPA, 2001a) and the MDEQ's Delisting Guidance (MDEQ, 2006a) documents have indicated that BUIs must lay within the AOC boundary. If the contaminant source(s) for the BUIs lay outside of the boundary, but within the watershed, they are considered source areas and must be addressed before delisting can occur. AOCs are not responsible for sources which lie outside their watershed.

Figure 4. Torch Lake AOC Boundary Map from the U. S. EPA AOC Website developed in cooperation with the MDEQ and Torch Lake PAC.



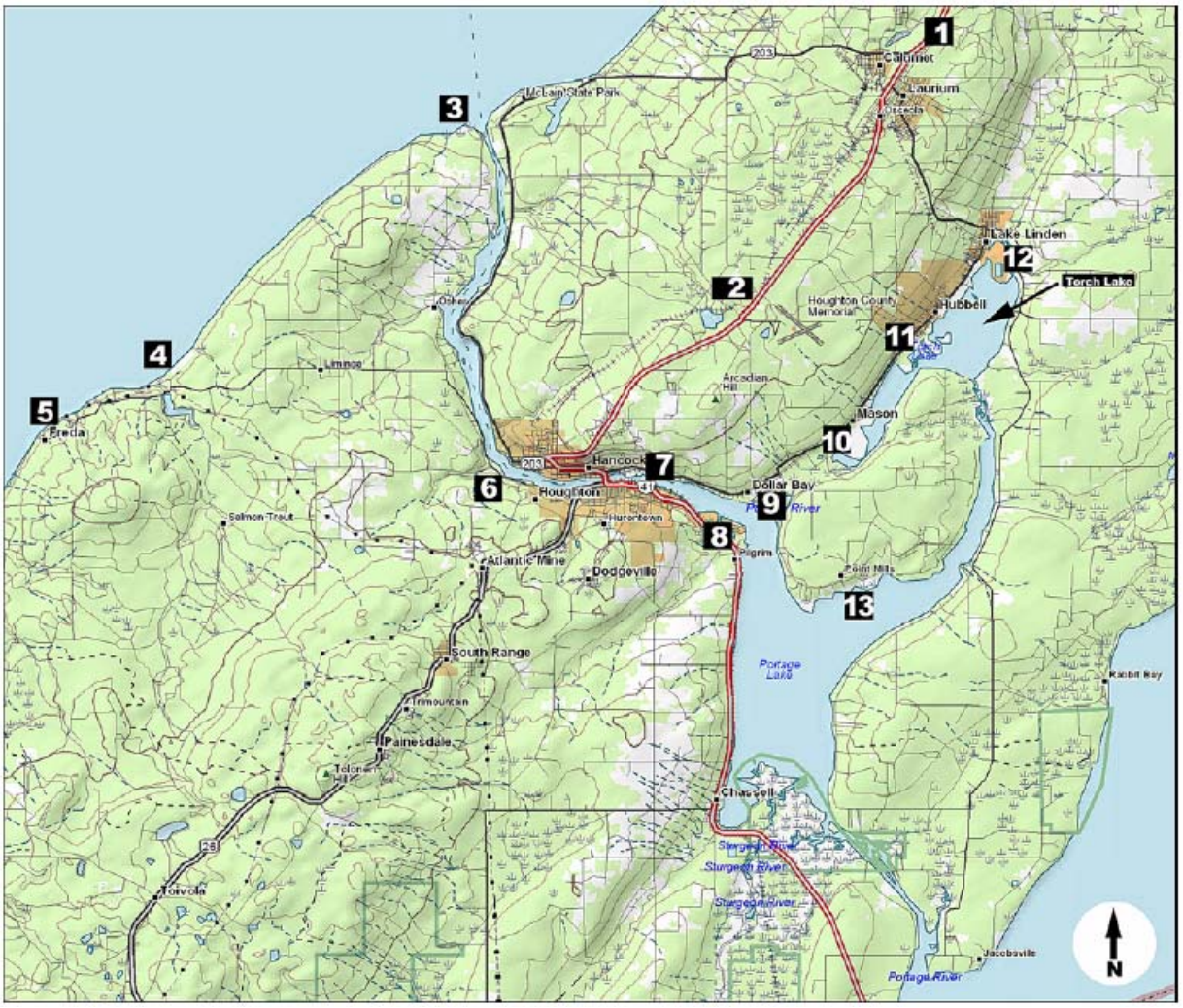
Torch Lake Superfund Site Remedial Activities

Superfund Site Background

Because of the high incidence of fish tumors, in 1983 the MDPH issued a Fish Consumption Advisory for sauger and walleye (MDPH, 1983). In 1984, the Hazard Ranking System was applied to the Torch Lake Site, which was defined as Torch Lake, Portage Lake, and North Entry, because at these locations the copper concentrations were significantly above background levels (U.S. EPA, 1989 and U.S. EPA, 1990). In 1986, 14 areas were included in an area designated as a CERCLA SF site within the Keweenaw Peninsula of Houghton County, Michigan commonly referred to as the Torch Lake SF Site and were placed on the NPL (U.S. EPA, 1986). The NPL is the list of all of the SF sites in the country.

Of these 14 areas, four lay within the Torch Lake AOC and one within the Torch Lake Watershed (Figure 5). These other areas had similar concerns to the Torch Lake AOC but were less in magnitude. In 1992 and 1994, Records of Decision for OUs 1, 2 and 3 and Final Remedy Position Paper for OU 2 specified remedial requirements for these SF areas (U.S. EPA 1992a; U.S. EPA 1994a; U.S. EPA, 1994b). These areas consist of not just bodies of water, but rather areas of various sizes impacted from the deposition of process by products resulting from the processing of ores, reclaimed stamp sands, and scrap to extract copper.

Figure 5: Torch Lake Superfund Sites.



The Torch Lake SF site was also impacted by various drums which were disposed of on land and in the water from area industrial processes. The firm of Geraghty and Miller, working for the responsible parties as identified in the U.S. EPA's Order of Consent (GMI, 1992) removed and tested some of the drums. There were 808 barrels identified from the lake bottom, with 20 overpacked and removed. There were 83 barrels removed terrestrially, 72 of which were removed from a slope descending into Torch Lake near Lake Linden. After removing the top layer, other layers were found underneath, with rusted drum carcasses and stained soils. These carcasses and associated soils were overpacked and removed to the staging area and additional cuts were made into the bank to insure that no additional barrels were missed (GMI, 1992).

A total of 103 barrels were sent to the staging area for analysis. A sub-set of 16 drums from the 103 total were selected for analysis to represent visually the materials found within the 103, eight from the water and eight from the terrestrial. The results of the analysis indicated that four of the barrels were Resource Conservation and Recovery Act (RCRA) hazardous waste due to heavy metals and were disposed of in an approved landfill. Thirteen of the 16 had some minor levels of Volatile Organic Compounds (VOCs) and ten of the 16 had detectable levels of Semi-VOCs which classified them as non-hazardous under RCRA (GMI, 1992).

Environmental impacts identified within Torch Lake have also historically been recognized to exist throughout much of the Keweenaw Waterway, including its watershed, and along the Keweenaw Peninsula's Lake Superior shoreline (Tomljanovich, 1974; Laarman, 1976; Kraft, 1979; Kraft and Sypniewski, 1981; Hesse, 1983; Black, 1986; Donohue, 1988; U.S. EPA, 1992g; Kerfoot, 1998). Further work by Michigan Technological University (MTU) researchers also documented 15 square miles of impaired benthos along the Lake Superior shoreline due to stamp sand contamination of its near shore waters as well as contaminated sediments within the Keweenaw Waterway itself (Kraft, 1979; Kraft, 1981; Kerfoot, 1998; Kerfoot et al., 2004).

Superfund Remedial Investigation/Feasibility Studies

Superfund Operable Units

The U.S. EPA SF divided these areas into three Operating Units (OUs). Of the three OUs identified, OU1 and OU 2 pertain to the Torch Lake AOC (U.S. EPA, 1990; U.S. EPA, 1992a; U.S. EPA, 1994a) and OU 3 pertains to all other sites (U.S. EPA, 1992 and U.S. EPA, 1992a). Four of the SF remedial actions were located along the west shore of Torch Lake and one within the upper watershed (Figure 5).

- Operable Unit 1 includes the stamp sands, water quenched slags and other mining wastes deposited along the Torch Lake shoreline. See Fig. 4, Sites 10, 11, and 12.
- Operable Unit 2 includes ground water, surface water and submerged stamp sands and sediments in Torch Lake, Portage Lake, the Keweenaw Waterway/Portage Ship Canal, the Lake Superior Shoreline from south of the North Entry to Freda/Red Ridge, Boston Pond and Calumet Lake. See Fig. 4.
- Operable Unit 3 includes stamp sands and water quenched slag deposits along the Lake Superior shoreline, Keweenaw Waterway/Portage Ship Canal, Michigan Smelter, Quincy Smelter, Isle Royal, Calumet Lake, Boston Pond and Grosse Point/Point Mills. See Fig. 4, for the remainder of the 14 sites.

Remedial investigations were completed for all three OUs. The Remedial Investigation/ Feasibility Study (RI/FS) report for OU 1 was completed in November 1990 (U.S. EPA, 1990) and the Baseline Risk Assessment (BRA) was finalized in July 1991 (U.S. EPA 1991). The OU 3 RI/FS report was completed in 1992 (U.S. EPA, 1992b) and BRA report (U.S. EPA, 1992c) was finalized in February, 1992. The OU 2 RI/FS report was completed in 1992 (U.S. EPA, 1992d and U.S. EPA, 1992e), the OU 2 BRA report was completed in March 1992 (U.S. EPA

1992f), the OU 2 Final Remedy Position Paper (U.S. EPA, 1994b) which was submitted in February 1994, and the OU ROD was completed in March 1994 (U.S. EPA, 1994a). The Ecological Assessment for the Torch Lake SF site was finalized in May 1992 (U.S. EPA, 1992g). The Ecological Assessment provides an integrated ecological assessment for the SF site and supplements all of the RIs and supplemental health evaluations prepared separately for this site (U.S. EPA, 1992g).

Human Health Risks

Legislated at the Federal level, the SF Program was required to perform human health assessments at all CERCLA, sites within one year. In order to accomplish this federal mandate, the MDCH used an abbreviated evaluation, following the ASTDR Guidance to meet the federal legislative mandates. Therefore a full human health assessment was not completed for the Torch Lake SF site (MDCH, 2007).

Several human health risk assessment exposure scenarios were evaluated under the SF investigations including scenarios related to current and future on-site residents, and construction workers. All human health risks were estimated to be within acceptable levels for each scenario evaluated by the U.S. EPA SF staff (U.S. EPA, 1992a; U.S. EPA, 1992g; U.S. EPA, 1992f).

The shallow groundwater associated with OU 2 which comes into contact with stamp sands exhibits inorganic contamination which results in unacceptable potential future risks; however these risks are only applicable if, in the future, the stamp sands are developed for residential use and drinking water is taken from the shallow groundwater. The practice in the region is to drill drinking water wells into the sandstone aquifer which underlies the stamp sands. Since the sandstone aquifer has been found to be unaffected by stamp sand contamination, any future risk from contaminated groundwater is unlikely.

The Houghton County Health Department and the MDPH regulate the installation of drinking water wells in the vicinity of the site. These local authorities have been alerted to the potential future threat and currently have permitting programs and well site development review procedures in place which provide further assurances against future public exposure to stamp sand-affected groundwater. Thus, treatment of groundwater to permanently and significantly reduce the toxicity, mobility, and volume of contaminants was not found to be necessary to protect human health (U.S. EPA, 1992a and U.S. EPA, 1992f).

Ecological Health Risks

The continuous release of slag and stamp sands through wind, surface water runoff, and wave erosion represented unacceptable and actionable sources of ecological risk. The most severe impact is the degradation of benthic communities (bottom dwelling organisms) associated with contaminated sediments in Torch Lake and other water bodies of the Site. The benthic community is an integral part of the complex food web in aquatic systems and a severely degraded benthic community would impact the entire food web. Toxic effects due to metals (especially copper) appear to have impacted the sediments due to pore space dynamics and seem not to have significant water column impacts.

In the 1994 ROD for OU 2, the U.S. EPA determined that contamination associated with Torch Lake sediments poses an ecological threat (U.S. EPA, 1992g and U.S. EPA, 1994a). Much of the lake bottom sediment consists of stamp sands and slags which were deposited in the lake over many years of active copper ore milling and smelting operations. Levels of contamination (primarily copper) in these sediments are sufficient to create an inhospitable lake bottom habitat and thus suppress the organisms which are normally expected to inhabit lake sediments. The consistency of these sediments in some areas is highly flocculent and at other areas exhibits a

pudding like consistency which, even if these sediments were not toxic, would still not provide suitable benthic invertebrate habitat (MDEQ, 1999). However, given the wide distribution (the lake covers 2,700 acres) and large volumes (approximately 200,000,000 tons) of stamp sands deposited in Torch Lake, remediation of the lake bottom was deemed not practical, feasible, nor, in the long run, necessary. The U.S. EPA believes that implementation of the remedy for OUs 1 & 3 prevents further erosion of the stamp sands which will allow the sediments to recover naturally with time through natural sedimentation processes. The remedy for OUs 1 & 3 was to stabilize the eroding materials, cover with clean soils, and vegetate. At this time, from the SF perspective, the U.S. EPA does not anticipate any construction work to be done in the future to remove stamps sands and potentially contaminated sediments from the lake or any water body of the site.

The U.S. EPA's site contractor, the National Resources Conservation Service (NRCS) has estimated that the exposed stamp sands eroded into Torch Lake at a rate of 19 to 22 tons per acre per year, which correlates to < 0.1" per year (U.S. EPA 1992f and NRCS-Petersen 1999). Significant ecological risks were determined to be from exposure of aquatic, terrestrial and wetland species to tailings, slag, and sediment.

Remedial Actions Selected For OU 1 and OU 3

The Record of Decision for OU 1 and 3 was signed on September 30, 1992 (U.S. EPA, 1992a), while the ROD for OU 2 was signed on March 31, 1994, (U.S. EPA, 1994a). These two RODs present the selected remedies for all three SF OUs. The U.S. EPA provided $15.2 million and the state provided $1.52 million in matching funds in the fall of 1998 to fund remedial actions. The remedial designs for OU 1 and 3 were approved on September 10, 1998.

The selected remedy and actions taken for OU 1 and OU 3, as documented in the RODs, are as follows:

- All areas are subject to deed restrictions to control the use of tailing piles so that tailings will not be left in a condition which is contrary to the intent of the ROD;
- All areas where the remedy was implemented are subject to removal of debris to effectively implement the soil cover with vegetation;
- Areas received a minimum of six inches clean soil (sandy loam) cover stabilized with vegetation:

Remedial project design began in 1998. Construction began in 1999 and was completed by NRCS, the U.S. EPA contractor at all 14 SF sites by September 13, 2005. OU 2 (Torch Lake) and the Lake Linden Parcel were deleted from the NPL of SF sites in 2002. The Hubbell/Tamarack City SF site parcels deleted from the NPL in 2004. The state has yet to accept as complete all of the construction sites because some parcels are still in the follow up phase which allows the establishment of the vegetative cover and ensures that the remedy and project design at that particular site maintains design integrity. Essentially, all that remains is to ensure that everything works well and to repair those areas which do not.

Remedial Actions Selected For OU 2

The 1994 ROD for OU 2 (groundwater, surface water and sediments associated with the site) selected a "No Action" remedy with long-term monitoring. As detailed in the ROD, the U.S. EPA determined that the sediment and surface water contamination associated with OU 2 poses no unacceptable threat to human health. The no action alternative is also sometimes referred to as natural attenuation or natural sedimentation processes.

Monitoring of OU 2 (groundwater, surface water and sediments) was performed as part of the first five year review for OUs 1 & 3 required after remedial activities began. Field sampling was conducted in 1999 and 2000 for this review. Since the effectiveness of the remedy chosen for

OUs 1 & 3 will in part be measured by assessing effects on Torch Lake, the monitoring program developed for OUs 1 & 3 includes groundwater, surface water, sediment, and general ecological monitoring. In addition, the monitoring included an evaluation of the rate and effectiveness of organic sediment build-up and the recovery of the benthic community, as part of the Operation and Maintenance (O&M) plan for OUs 1 & 3. This monitoring provided information on the effectiveness of the remedy and on the extent of environmental impacts, if any. Details on these results are provided in the Baseline Study Report (BSR) prepared by the U.S. EPA in 2001 (U.S. EPA, 2001b).

In May 2003 and May 2004, the U.S. EPA undertook a remedial action at Gull Island that was not specifically laid out in the OU 1 and OU 3 RODs. This was undertaken as a modification of the remedy. Gull Island is an eight acre island located approximately 1,500 feet off the western shore of Hubbell in Torch Lake. Approximately one-third to one-half of the island was already vegetated. However, in response to complaints from local citizens and government officials, the U.S. EPA, with assistance from the MDEQ and NRCS, planted approximately 38,000 individual trees, shrubs and beach grass plants directly into the stamp sands that comprise the island (without the use of clean cover material). The U.S. EPA is monitoring the status of the plants and intends to delete Gull Island from the NPL as part of OU 1.

As previously stated, the U.S. EPA implemented the remedy as detailed in the 1992 ROD and in the area-specific design plans (U.S. EPA, 1998) at Lake Linden, Hubbell/Tamarack City, and Mason.

The suggested remedy consisted of six to ten inches of sandy-loam soil covering the stamp sands and slag, with a vegetative mat to quickly stabilize the soil. The soils used, due to local considerations, were clean soils similar to the recommended sandy loam soils. The vegetative mat was achieved through a seed mix applied directly on top of the sandy-loam soil. The seed mix was applied at approximately 90 pounds per acre on top of the soil. The typical seed mix contained six species of plants, including perennial ryegrass (*Lolium perene*), tall fescue (*Festuca arundinacea*), creeping red fescue (*Festica rubra*), red clover (*Trifolium pratense*), alfalfa (*Medicago falcata*), and birdsfoot trefoil (*Lotus comiculatus*). This mix of plant species was selected because of their rapid growth rate, their relative resilience, and three of the species are nitrogen-fixing legumes. Rapid stabilization of the soil cover material with vegetation is important at the site in order to avoid soil washouts and to accommodate the short growing season in Michigan's Upper Peninsula. Variations of this seed mix were applied to a small number of areas to accommodate landowner preference. Overall, the vegetative growth in most areas is well established and is stabilizing the soil portion of the cover material.

The construction firms under contract with the NRCS identified clean soils borrow areas that met NRCS soils specifications. Since the borrow soils were obtained locally, there is a side-benefit to the remedy. The soils are serving as a seed bank for native species. So as growing seasons come and go, the U.S. EPA is noting the presence of more and more native species on the cover, resulting in more diverse habitats. Species diversity is one of the keys to a healthy, functioning habitat.

Protection was also installed along much of the shoreline where the remedy was implemented. Shoreline protection includes rip-rap (rock averaging about one-foot in diameter in the shape, midway between a sphere and a cube with a specified density and integrity) which protects the remedy from wave erosion. Most of the rock rip-rap was derived from area poor rock piles.

In 1999 and 2000, as part of the remedy requirement for long-term monitoring, the U.S. EPA conducted environmental sampling as a way to establish the environmental baseline conditions of Torch Lake (U.S. EPA, 2001). The results of the sampling efforts are presented in the BSR dated August 2001. In 2004, the MDEQ undertook their first round of long-term monitoring with a detailed sediment sampling program. The 2004 monitoring report is expected in 2007 after

the data from the long term sediment traps has been evaluated and incorporated into the report. The MDEQ will conduct all future long-term monitoring events and the results compared to the 2001 baseline study to identify changes and/or establish trends in lake conditions.

The U.S. EPA SF will oversee the operational and maintenance (O & M) activities at all sites for a minimum of two years post completion of construction and implement all repairs on each individual area of the site. The repairs will be implemented through an Interagency Agreement (IAG) that the U.S. EPA has with the NRCS. After approximately two – three years, post construction completion the MDEQ, NRCS and U.S. EPA will inspect the areas to determine whether each parcel is stable and anticipated to withstand future weathering and erosion in a satisfactory manner. At that time, in concurrence with the MDEQ and in communication with the landowner, the U.S. EPA will delete each area from the SF NPL and the MDEQ will take over O&M responsibilities.

The U.S. EPA has determined that remedial action construction activities have been performed according to specifications and that cover material and shoreline protection installed at the site meets remedial action objectives for the site. For Lake Linden, the U.S. EPA and MDEQ determined that the remedy is functioning as intended and in April 2002, partial deletion of Lake Linden stamp sands and all of OU 2 (groundwater, surface water and sediments) from the SF NPL was finalized. As discussed earlier in this report, the remedy for OU 2 was no action with long-term monitoring. The U.S. EPA, with MDEQ concurrence, deleted Hubbell/Tamarack City stamp sands from the NPL on March 29, 2004. Construction was completed at all the SF sites in the fall of 2005. The anticipated deletion of the remaining sites is expected to be on a case by case basis with the final parcel deletion expected by sometime in 2008 if all of the remedial actions and follow up monitoring satisfy the MDEQ and U.S. EPA expectations related to the remedial action stabilization.

Additional Nonpoint Source Remedial Activities

A U.S. EPA 319 Nonpoint Source Erosion Control Grant funded the Scales Creek “Moonscape” remediation activity completed in 1999. This site was a former mine settling pond and forms a headwater stream Scales Creek, a tributary to the Trap Rock River. Stabilization of sloughing banks of this highly erosional area with poor rock and the application of topsoil and vegetation was the selected management practice. Poor rock from a nearby pile donated by Dave Jukuri, PAC Chair, was used in the project to help stabilize severely eroding banks. Top soil was applied and seeded with a mixture of alfalfa and native grasses (Albee, 1999).

Remaining funds from this grant were used to apply rock to the ice surface along the Lake Linden Park Shoreline to create fish habitat (Albee, 1999). These rock reefs function quite well as fish habitat (MDNR, 2002).

Summary of Inputs/Source Controls/Remedial Actions

Many remedial actions, source control activities, and changes have occurred within the Torch Lake AOC in the past 30 to 50 years which affected water quality and clarity. Historic inputs, remedial actions, and source control activities have been summarized to document these changes:

- Historically, raw sewage was dumped into Torch Lake from numerous public and private outfalls (MDNR, 1987).
- 1860’s: Copper mining and milling activities began in the Keweenaw Peninsula area depositing mine water, and milling and smelting process wastes into the lake (Wright et al., 1973; MDNR, 1987; U.S. EPA, 1989).
- 1915: Dredging of sediments for copper recovery, including reclamation and reprocessing operations began, disturbing sediments and depositing process wastes into the lake (MDNR, 1987). The sediment reprocessing operations used creosotes and

xanthates in the flotation process to separate additional copper from the original process waste materials. Dredging and reprocessing continued through 1968 (MDNR, 1987).

- 1968: Copper production ceased in the AOC (MDNR, 1987 and U.S. EPA, 1989) including mining, milling, and smelting operations.
- 1968: Dredging in Torch Lake related to reprocessing sediments for copper production and associated discharges ceased (MDNR, 1987 and U.S. EPA, 1989).
- 1970: North Houghton County Water and Sewerage Authority was formed which eliminated effluent discharges to the Trap Rock River system and Torch Lake from the communities of Lake Linden, Tamarack, Hubbell, and other local sources (Wright et al., 1973 and MDEQ-NPDES, 2006).
- 1970: Torch Lake Area Sewage Authority found 23 raw sewage outfalls along the Torch Lake shoreline. (Williams, 1973).
- 1971-1972: An estimated 27,000 gallons of copper leaching liquor (cupric ammonium sulfate) were discharged from salvage efforts at the Lake Linden leaching plant (MDNR, 1973 and Wright et al., 1973). This was not considered a significant source of copper to the lake (MWRC, 1973 and MDNR, 1987).
- 1972: Mine dewatering ceased (Wright et al., 1973). Dewatering added high amounts of calcium chloride, other solubles, and suspended solids to the lake.
- 1979: The Torch Lake Area Sewage System-Lake Linden Facility and the Torch Lake Area Sewage System-Tamarack System collection and treatment lagoon systems were put in place ending the discharge of raw sewage into Torch Lake.
- 1989 & 1990: Drums were removed from terrestrial and the lake bottom by the U.S. EPA and Geraghty & Miller, Inc., unknown materials were characterized and disposed of as appropriate to contents. Those with non-hazardous materials were left in place (GMI, 1992).
- 1996: 319 Grant to NRCS stabilization project to control erosion from the "Moonscape," an abandoned mine dewatering basin to the headwaters of Scales Creek, a tributary to the Trap Rock River (Albee, 1999).
- 1999-2005-Implementation of the SF Remediation.
- 2004: The NPDES Permit for the Torch Lake Area Sewage System-Lake Linden Facility and Tamarack systems continue to authorize stabilization lagoons with seepage beds for wastewater treatment (MDEQ-NPDES, 2006).
- 2006: Current discharges to Torch Lake from industrial sources include only noncontact cooling water and storm water from Peninsula Copper Industries copper recovery operation (MDEQ-NPDES 2006).

These combined actions have led to increased water quality and clarity and improvement in the trophic status of the lake.

Torch Lake Area of Concern Beneficial Use Impairments

The Torch Lake AOC Boundary is included within the geographic boundaries of the Torch Lake SF site. The AOC Boundary is described previously. In 2005, using the 1987 Torch Lake RAP, the MDEQ staff identified three BUIs as described under Annex 2 of the 1987 GLWQA (1987 GLWQA) for the AOC. These BUIs are Fish Tumors or Other Deformities, Restrictions on Fish and Wildlife Consumption, and Degradation of Benthos (MDEQ, 2006).

As discussed previously, this RAP Update began as an AOC Delisting Determination Document for the Torch Lake AOC, describing the historical impacts and resulting contamination issues, followed by discussions of the subsequent changes and remedial activities resulting in improving water quality and clarity. As part of this process, the Technical Committee investigated the current status of the identified BUIs. Subsequent to those investigations it was determined that delisting the AOC at this time is not appropriate, though the removal

recommendation for the Fish Tumor and Other Deformities BUI was submitted to the U.S. EPA and subsequently approved.

Beneficial Use Impairment Issues

The U.S. EPA determined in their Baseline and Ecological Risk Assessments completed as part of the SF ROD as shown in remedial investigations which led to the development of the individual RODs for OU 1, OU 2, and OU 3 that the Torch Lake SF Site has environmental problems associated with past human activities. The U.S. EPA determined that once the recommended remedial action of stabilizing the stamp sands and vegetative cover was in place for OU 1 and OU 3 the major human and ecological concerns for the site would be addressed through the stabilization of the wind blown erosional materials. The U.S. EPA determined that human health concerns related to placing restrictions on the source water for private drinking water wells would be covered adequately by local ordinances related to well placement and aquifer location permitting requirements (U.S. EPA, 1992a and U.S. EPA, 1994a). The U.S. EPA also determined in the RODs, that other than the need to resolve the remaining issues surrounding the PCBs and mercury issues related to the Fish Consumption Advisories, there were no other significant human health concerns for the community.

The historic environmental impacts have been extensive and are described in greater detail previously in this document as well as in the 1987 Torch Lake RAP (MDNR, 1987), the Torch Lake SF documentation discussed here earlier, as well as in the U.S. EPA's 2001 BSR (U.S. EPA, 2001b). These documents also describe actions which have improved water quality and clarity.

The west side of Torch Lake has a severely impacted benthic community (MDNR, 1987; U.S. EPA, 1992f; U.S. EPA, 1992g; 2001b; MDEQ, 2007a). The U.S. EPA's 2001 Baseline Study and MDEQ Monitoring Report essentially found very few macroinvertebrates in the samples taken from the west side of the lake. The benthic community gradually develops as you move toward the eastern shore, but the macroinvertebrate populations are still low and consist mainly of pollution tolerant species. Though the populations improved along this gradient, the populations are still considered impaired, because the populations densities were low and comprised of pollution tolerant species (U.S. EPA 2001b and MDEQ, 2007a).

A 1991 MDEQ biological survey indicated biotic communities are impaired below stamp sand erosional areas within the Trap Rock River Watershed (MDNR, 1991). Discussions with Mr. William Taft, MDEQ Aquatic Biologist who conducted these field investigations in the local stream, indicated that the eroding stamp sands make the benthic habitat inhospitable to aquatic organisms (MDEQ, 1999) and in particular the abrasive quality of these sands abrade the carapace of the organisms. Mr. Taft proposed that nonpoint source remedial activities would greatly improve the habitat for benthic organisms and that natural colonization and invertebrate drift mechanisms would help populate downstream areas once the significant stamp sand erosion was controlled. A biological survey conducted on Kearsarge Creek after stamp sands stabilization activities, under a U.S. EPA Federal Section 319 Grant, indicated substantially improved benthic communities (MDEQ, 2002).

The fish in this system can freely travel between Lake Superior, the Keweenaw Waterway, Portage Lake, and Torch Lake.

Fish Consumption Advisories exist in Torch Lake for mercury and PCBs.

Criteria for Restoration of Beneficial Use Impairments

The Guidance criteria are Michigan's position on what constitutes restoration of the BUIs, and any AOC that meets these criteria will be considered restored by the state. The state's

Guidance is the minimal goal that the state will accept when an AOC establishes goals for a particular BUI (MDEQ, 2006a). The BUI removal guidelines are based on existing state and federal criteria (U.S. EPA, 2001a) and programs and incorporate existing monitoring programs and monitoring cycles. Local PACs may offer alternate criteria that will be reviewed by the state and may be approved if functionally equivalent to, or more stringent than Michigan's criteria. The Guidance has the U.S. EPA's concurrence (U.S. EPA, 2006b).

On June 12, 2006, the Torch Lake PAC voted to adopt the state's delisting criteria for the Fish Tumor or Other Deformities BUI. No decision on whether to use the state's criteria or develop local criteria has been reached by the Torch Lake PAC related to the remaining BUIs. The Torch Lake PAC has been encouraged to accept the states criteria for these BUIs. Locally based delisting criteria goals will need to be developed by the local PAC and accepted by the state by the end of 2008. This deadline was agreed to by members of the Great Lakes Regional Collaboration in 2005.

Using the state Guidance, the state, with technical support from the Torch Lake PAC Technical Committee has developed the following documentation related to the states restoration criteria for the three BUIs identified for the Torch Lake AOC to determine the current status of each BUI.

A fundamental assumption of the statewide restoration criteria is that sources of pollutants within the AOC watershed which cause any of the BUIs must be controlled before a BUI can be removed and an AOC delisted. Assessment of this step is determined by results from site-specific monitoring of remedial actions or other monitoring in the AOC. If a beneficial use is impaired only due to contaminants originating from sources outside the AOC watershed, it will not preclude removal of BUI and delisting of an AOC.

In some circumstances, monitoring may indicate that full restoration of a BUI has not occurred (i.e., does not meet the criteria), even when all remedial actions to address the problem and control sources of pollutants in the AOC have been completed. This could be due to two factors: 1) sources of contaminants are external to the AOC watershed; or 2) the resources affected are still recovering from historical (pre-remediation) effects of contamination or habitat loss. This affects the Torch Lake Degradation of Benthos BUI in particular.

In addition, the MDEQ will take into account the time of recovery for some resources when evaluating restoration success. For some BUIs, the affected resource may take many years to recover after remedial actions are complete. Full restoration of the impairment may not be required in all cases prior to delisting, if the MDEQ determines the resource is showing consistent improvement after all necessary remedial actions have been completed. This affects the Torch Lake Degradation of Benthos BUI in particular.

Fish Tumors or Other Deformities

Removal Recommendation

The Fish Tumor or Other Deformities BUI is related to the tumors of undetermined origin found historically on sauger and walleye. This BUI is now considered restored by the PAC, state of Michigan, and U.S. EPA. The recommendation for removal documentation was presented to the U.S. EPA, GLNPO by the MDEQ on March 14, 2007, with the support of the Torch Lake PAC. The MDEQ received the U.S. EPA's approval and removal confirmation on April 5, 2007 (U.S. EPA, 2007).

Restoration Criteria/Beneficial Use Impairment Goal

On June 12, 2006, the Torch Lake PAC voted to adopt the state's delisting criteria for the Fish Tumor or Other Deformities BUI. Under the Michigan criteria selected for this BUI by the Technical Committee this BUI would be considered restored when no reports of fish tumors or deformities due to chemical contaminants which have been verified through observation and analysis by the MDNR or MDEQ for a period of five years.

Historical Significance

This BUI was only concerned with fish tumors. Deformities were not listed as a concern. Large external and internal fish tumors were found by local fishermen on older sauger and walleye and reported to the MDNR district staff beginning in the late 1960s and studied by David Tomljanovich for his 1973 Masters Thesis at MTU (Tomljanovich, 1973; MDNR, 1979; MDNR, 1986b; MDNR, 1987). The 1983 fish consumption advisory was issued by the MDCH because of the tumors found in the sauger and walleye (Tomljanovich, 1973; Black et al, 1982a; Black et al, 1982b). The advisory was issued for the protection of human health.

These fish tumors initiated an extensive study running from 1985 through 1986 of the Torch Lake area by researchers at MTU resulting in a combined series of reports titled Torch Lake Study, A Project Completion Report, prepared for the MDNR, August 1986 (MDNR, 1986b). This limited series of reports began to document the extent of the incidence of the fish tumors, type of fish tumors, which fish had the tumors, potential cause of tumors, studied whether xanthates or creosotes were carcinogens to fish, whether creosotes and xanthates were still present or how long they had remained in the water column, developed a copper budget for the lake, estimated flow rates, researched the mining history related to the chemical reagents used in the area, estimated airborne effects from stamp sands, and determined whether the chemical reagents used for the mining were still present in the lake (MDNR,1986b).

Environmental Improvements/Remedial Activities

The cessation of the historic copper mining, cessation of dredging to support the copper recovery practices, and the improvements to the area's sewerage handling combined to drive improvements in water quality and clarity are discussed in greater detail in the background section. These environmental improvements likely led to the decreasing frequency of tumors documented in the MDNR 1990 Report. The 1990 report's recommendation to the MDCH to remove the tumor related consumption advisory resulted in the removal of the Tumor Consumption Advisory in 1993 (MDNR, 1987 and MDNR, 1990).

At one time the sauger in Torch and Portage Lakes were so abundant that special limits were put in place which allowed creel limits higher than those usually allowed in the state. The record sauger at that time was reported from Torch Lake (MDNR, 1986b). At the time of the 1990 MDNR Report, with the improvements in water clarity, the sauger were no longer found in the system (MDNR, 1990). The assumption was made that, as sauger prefer murky waters, they

sought other, more congenial habitat (Ali et al. 1977; Nerenberg, 1998, Madison, 2006a). Through the MDNR stocking efforts in Portage and Torch Lakes, the walleye populations have improved. The fish in this system can freely travel between Lake Superior, Keweenaw Waterway, Portage Lake, and Torch Lake systems (MDNR, 2007).

Fisheries Specific Activities/Status Assessment

The following information summarizes the fisheries specific information, activities and events presented chronologically which provided the basis for the Fish Tumor or Other Deformities BUI listing and document the removal recommendation:

- 1960s and 1970s: Large external and internal tumors regularly reported to the MDNR (specifically sauger and walleye) (Tomljanovich, 1973 and MDNR, 1986b).
- 1973: Report on Cupric Ammonium Carbonate Spill released indicated that though this chemical is known to cause increased tumors in fish in the laboratory, no connection was determined for the fish in Torch Lake (MDNR, 1973).
- 1973: Tomljanovich found undetermined, yet high number of sauger and walleye with neoplasms (Tomljanovich, 1973).
- 1979: Michigan Department of Conservation fish collection summary data sheet notes: all sauger were heavily infected by internal and external parasites (MDNR, 1979a).
- 1979 and 1980: Internal and external fish tumors identified on old sauger and walleye (Markham, 1984; MDNR, 1986b; MDNR, 1987).
- 1982: First published study of the tumors (Black et al., 1982) found:
    - 100 percent of saugers affected with liver neoplasms and epizootic neoplasms
    - 13 percent of walleye with liver neoplasms
    - Noted that sauger were old
    - External tumors were “highly visible”
- 1983: The MDPH issued tumor based consumption advisory on sauger and walleye (MDPH, 1983) to be protective of human health, without a specific causative agent identified, though the suspected agents were creosotes and xanthates used in the mining floatation processes (MDNR, 1986b and MDNR, 1987).
- 1983: Constanzo and Oaks collected many fish, mostly non-target species. The data showed 56 were sauger. The information in the MDNR 1990 report did not list any neoplasms for these fish. Twenty-eight walleye were collected with four reported to have neoplasms (Constanzo and Oaks, 1983).
- 1984: Constanzo and Oaks collected many fish, including small mouth bass, northern pike, and sucker. The data showed 72 were sauger with 72 reported neoplasms and 45 walleye were collected with two reported to have neoplasms (Constanzo and Oaks, 1984; MDNR, 1986b; MDNR, 1990).
- 1984: Markham reported catching fewer target fish. Examining nine sauger, and finding nine with neoplasms and 18 walleye and only one with neoplasms (Markham, 1984 and MDNR 1990).
- 1983-1984: Black and Evans collected a total of 434 fish of which 64 were sauger and 34 had neoplasms, and of the 113 walleye collected four had neoplasms (Black and Evans, 1986 and MDNR, 1990).
- 1985: Spence examined 10 sauger finding 9 with neoplasms and 25 walleye reporting none with neoplasms (Spence, 1986 and MDNR, 1990).
- 1986. Torch Lake Study-A Project Completion Report Prepared for the MDNR by MTU, Houghton, Michigan. August 1986. The MTU Study completed on Torch Lake was designed to document and understand the abnormal growths exhibited by saugers. MTU staff was led by Leddy, D.G. Project Coordinator. Principal Investigators: Bagley, S.T., Bornhorst, T.J., Bowen, S.H., Dharland, W.W., Dorie, L.D., Erbish, F.H., McDowell, D.S., Rose, W.L., Spence, J.A. (MDNR 1986b).
- 1987: The MDNR began stocking walleye from rearing ponds into Torch Lake. Stocking continued through 2004, with over 400,000 walleye fingerlings planted (MDNR, 2006c).

- 1988: The MDNR collected 458 fish. The fish were tested for contaminants and sampled for tumors. Saugers were no longer available to be collected (Ali et al., 1977 and Markham, 1984). Forty-seven of the fish collected were walleye. Of the walleye that were collected, no neoplasms reported, 1990 and Markham, 1984).
- 1992: The U.S. EPA SF remedial investigation report found very high levels of PCBs and polycyclic aromatic hydrocarbons, known to induce tumors in fish. However, they were only detected in one small area of the 2700-acre lake, the "hot spot" just off PCI. The U.S. EPA determined that this small area is quite unlikely to cause the frequency of the tumors found in the 1970s and 1980s (U.S. EPA, 1992e).
- 1993: The MDCH removed the fish consumption advisory for tumors based on the 1990 report (MDNR, 1990). This is a comprehensive study of fish tissue residues and the occurrence of internal and external tumors. The conclusions of the report related to fish tumors are:
    - No internal or external growth anomalies were observed among 458 fish collected in 1988 by Black and Evans (MDNR, 1990).
    - Saugers disappeared from the lake due to increasing clarity in the lake after cessation of mining activities and building sewerage treatment facilities (Nelson and Walberg, 1977; Ali et al., 1977; MDNR, 1998; MDNR, 2006a).
    - Bioassays of water and sediments do not indicate the presence of carcinogenic substances (U.S. EPA, 1992e).
    - The report documented the environmental fate of creosotes and xanthates as reported in the 1986 Torch Lake Study, A Project Completion Report prepared for the MDNR by researchers at MTU (MDNR, 1986b).
    - 1998 and 2006: Sauger were no longer present in the system (Ali et al., 1977; MDNR, 1998; and MDNR, 2006a). Data collected in the 1979 fisheries survey by the MDNR staff indicated that the fish surveyed were older fish (7+ years) and natural recruitment of young fish was not occurring (MDNR, 1979a and MDNR, 1986b).
- 1998: The MDNR notes no reports of tumors in more than five years. Note that MDNR asks specifically about tumors at public meetings (MDNR, 1998).
- 2000: MDNR-Edward Pearce observed black goo like substance on anchor and tracked all over personal watercraft after night fishing offshore of the pilings at PCI.
- 2001: Michigan Fish Contaminant Monitoring (FCMP) Report (fish collected 1998 - 2000), no tumors were noted in the report. The inference is that no tumors were observed (MDEQ, 1995 and MDEQ, 2001):
    - MDEQ, Water Bureau (WB), Surface Water Assessment Section (SWAS), Procedure No. 31 describes the procedure used to process fish samples (MDEQ, 1995).
    - MDEQ, WB, SWAS, Procedure No. 31 states "anomalies such as tumors or lamprey marks. . . " should be noted on the fish processing data sheets (MDEQ, 1995).
    - Since no mention was made in the 2001 report of fish anomalies, then it can be inferred that none were noted.
    - Ms. Baker participated in both the fish collection and processing events for Torch Lake fish specifically to observe gross external and internal tumors. None were observed.
- 2003 and 2004: Two In-Fisherman Professional Walleye Trail Tournament Championships sponsored by Mercury Motor Sports were held and drew the top 51 North American fisherman competing for the championship title. No tumors were reported by participants. The tournament was run out of Portage Lake.
- 2006: In-Fisherman Professional Walleye Trail Tournament was held. One of four Super-Pro Tournaments sponsored by Mercury Motor Sports in which 30 top regional walleye fisherman compete for the right to participate in the championship tournament

mentioned above. No tumors were reported by participants. The tournament was run out of Portage Lake.

- 2006: Memo from the MDNR, Fisheries Division, indicates that fish tumors had not been reported nor observed (again) for more than five years (Madison, 2006)).
- 2006: The MDEQ held a public meeting to discuss the proposed Tumor BUI Removal and a 30-day public comment period to obtain input related to the proposal. The MDEQ did not receive any tumor reports related to the proposed tumor removal from the public.
- 2006: The Large Lakes Assessment Field Protocol used by the MDNR when collecting fish clearly states the presence/absence of lymphocystis on walleye and lymphosarcoma on pike and muskie will be noted. This information supports "no tumors were observed nor noted" in the 2001 FCMP report.
- 2006: The MDNR creel census manuals indicate that reports of tumors must be noted when fish are collected for the FCMP. This information supports "no tumors were observed nor noted" in the 2001 report.

Analysis

This BUI meets the states delisting criteria and is considered restored because no reports of fish tumors or deformities due to chemical contaminants have been verified through observation or analysis by the MDNR or MDEQ for a period of five years.

Recommendation/Actions/Results

The Torch Lake Technical Committee determined that this BUI was ready for a Removal Recommendation. The formal recommendation to remove this BUI was made by the MDEQ to the U.S. EPA, GLNPO with the full support of the PAC on March 14, 2007. The U.S. EPA approved our request to delist this BUI in a letter from Mary Gade, Great Lakes Regional Program Manager (U.S. EPA, 2007).

- 2007: March 14, 2007. Fish Tumor or Other Deformities Removal Request submitted to U.S. EPA, GLNPO by the MDEQ.
- 2007: April 5, 2007. The MDEQ received the U.S. EPA Region 5's approval to remove the Fish Tumors or Other Deformities BUI.

Restrictions on Fish and Wildlife Consumption

Restoration Criteria/Beneficial Use Impairment Goal

The Torch Lake PAC discussed the state's criteria for restoring this BUI but has yet to make a decision related to accepting the state's criteria or to develop their own criteria. Past PAC discussions have determined that the Fish Consumption Advisory for the AOC should be similar to those specified for Lake Superior as the selected reference lake which is similar to the state's Guidance for this BUI (MDEQ, 2006).

Fish Consumption Advisories-Historical Significance

This BUI is only concerned with fish consumption advisories. No wildlife consumption advisories exist (MDNR, 1987). The original fish consumption advisory, driven by the presence of gross external and internal tumors in older sauger and walleye, was issued by the MDCH in 1983 (MDPH 1983) and removed in 1993 (MDCH, 1993 and MDNR, 1993) and is discussed extensively in the AOC Background, the previous Tumor BUI section, and the 1987 RAP. The cause of the tumors was not determined (1987 RAP and MDNR 1990).

Fish Consumption Advisories-Current

Check the most current fish consumption advisory carefully before consuming fish at *(The link provided was broken and has been removed)* (MDCH, 2003 and MDCH 2004).

Consumption advisories were established in 1998 due to elevated levels of PCBs and mercury in fish tissue. These advisories were developed after the MDCH adopted new PCB trigger levels based on the establishment of new federal guidelines related to PCB and mercury levels. For the mercury fish consumption advisory, based on the states Guidance being "fish consumption advisories in the AOC are the same or less restrictive than the associated Great Lake or appropriate control site," the walleye meet this definition. The walleye do not meet this definition in relation to the data available for PCBs.

General Population Fish Advisories

There is a special advisory for all inland lakes of Michigan because of the possibility of mercury accumulation from eating fish (MDCH 1997, Public Health News). Advisories due to mercury exist for both Torch and Portage Lakes. These advisories are at least as restrictive as the Lake Superior advisory, but no more restrictive than the Inland Lakes Advisory for mercury. The advisory for Portage Lake brown trout due to PCBs is more restrictive than the advisory for Lake Superior brown trout.

Torch Lake AOC Specific Fish Advisories

There is a current fish consumption advisory specific for Torch Lake based on mercury and PCBs. The MDCH recommends that the no one eat more than one meal per week of walleye greater than 22 inches, and that women of childbearing age and children less than 15 years of age eat no more than one meal per week of walleye 14-22 inches, and no more than one meal per month of walleye greater than 22 inches. The MDCH recommends no one eat more than one meal per week of smallmouth bass greater than 18 inches, and that women of childbearing age and children less than 15 years of age eat no more than one meal per week of smallmouth bass 14-18 inches, and no more than one meal per month of smallmouth bass greater than 18 inches. The MDCH recommends no one eat more than one meal per week of northern pike greater than 30 inches, and that women of childbearing age and children less than 15 years of

age eat no more than one meal per week of northern pike 22-30 inches, and no more than one meal per month of northern pike greater than 30 inches (MDCH 2004).

Table A.-History Torch Lake Fish Consumption Advisories. The following table was developed from MDNR and MDCH Fish Consumption Advisories and information found in the 1987 Torch Lake AOC RAP. Please observe that the Tumor Consumption Advisory was removed in 1993. The General Mercury Advisory suggests limiting fish consumption for the general population to one meal per week and limiting fish consumption to one meal per month for women of childbearing age or children under 15 for walleye, northern pike, largemouth bass, smallmouth bass, and muskellunge of all lengths and crappies, yellow perch, and rock bass, greater than 9 inches.

Date	Species Specific Consumption Advisory In Place For:	Tumors Advisory	Mercury Advisory	PCBs Advisory
1979 & 1980	walleye and sauger tumor reports (no advisory)			
1983	walleye & sauger	X		
1989	walleye & sauger	X		
1990 - 1992	walleye, sauger, smallmouth bass	X	X	
1993			X	
1994 - 1998			X	
1999 - 2001	walleye, smallmouth bass		X	X
2002 - present	walleye, smallmouth bass, northern pike		X	X

Environmental Concerns/Improvements/Remedial Actions

For detailed information related to the historical concerns, environmental improvements, and remedial activities within the AOC which have impacted this BUI (see previous discussions within this document in the SF Remedial Activities section and also in the Fish Tumors or Other Deformities BUI section).

Assessment Activities and Results

Walleye were chosen as the representative species for the AOC as the sauger are no longer found in the system (see Tumor discussion). The committee compared the fish tissue data from the FCMP for Torch Lake fish with that of fish from Lake Superior and Portage Lake, the controls.

For mercury, the data indicate that the Torch Lake walleye were not statistically significantly different from the controls, which would, if this were the only advisory, allow this BUI to be removed under Michigan's Guidance. However, when comparing the fish tissue data available for PCB's, there was a statistically significant difference.

This prompted a small study during the fall of 2005 using semi-permeable membrane devices (SPMDs) to help determine whether the PCBs were ubiquitous within Torch Lake or if there was a higher concentration in any one area. The SPMDs, though not fish, can act as surrogates for fish tissue when determining mercury uptake in fish tissue (MDEQ, 2006c). At the same time that the SPMDs were put in place, the U.S. EPA had the contractor take sediment samples at the same locations (U.S. EPA, 2006a) for analysis for PCBs.

The SPMD's and the U.S. EPA's sediment samples showed similar trends, though the numbers were not the same. The data indicated that both had higher concentrations of PCBs from those samples taken along the west shore than from the controls and the pattern of distribution was similar (MDEQ, 2006; U.S. EPA, 2006) between the two. It had been speculated that the PCBs

might be ubiquitous around the lake and similar to the controls in Lake Superior's Huron Bay, yet the sampling indicated that the higher concentrations were on the western edge and the highest off the western edge just south of Peninsula Copper Industries.

In 2006, through a previous economy of the MDEQ, RRD SF Section, sediment samples from the area in question and around the lake were also available for analysis which had been in cold storage since their 2004 field season sampling. It was assumed that since PCBs are not mobile in sediments that these samples would be confirmational in nature for the 2005 sampling. These samples would provide many more sites within the lake and specifically in the area in question. Analysis of these samples also displayed a distribution of PCBs similar to the concentrations found in the previous sampling analysis in 2005 (MDEQ, 2006d).

Analysis

Under the state's Delisting Guidance and the U.S. EPA's Delisting Principles all sources need to be identified and controlled or at least in recovery. Because the source of the PCBs driving the PCB Fish Consumption Advisory has not been identified cannot recommend this BUI is not yet ready for removal. The TLTC has determined that this BUI needs additional assessment (MDEQ, 2006a and U.S. EPA, 2001a).

Recommendations

The TLTC recommends the identification and remediation, if possible, of the PCB source or sources driving the Fish Consumption Advisories.

Additional assessment planning began in the winter of 2006-2007, with preliminary scoping work preceding the 2007 field season. This work will help the TLTC determine if contaminated sediments are the source of the PCBs. If it is determined that sediments are the source, then the next decision will be whether sediment remediation will be necessary or if the U.S. EPA's SF ROD natural attenuation/natural sedimentation for Torch Lake with monitoring is adequate to address this issue over time.

Actions:

- 2007- June-Sidescan Sonar/Bathymetric Survey
    - map sediment types and distribution
    - map debris locations and estimate size
    - map change in lake edge due to drop in lake level
        - estimate exposed stamp sands which were recently sediments
- 2007-August-Sediment Sampling
    - target sediment sampling efforts using information from Sidescan Sonar/Bathymetric Survey,

Degraded Benthos

Restoration Criteria/Beneficial Use Impairment Goal

The Torch Lake PAC has discussed the state's criteria for restoring this BUI but has yet to make a decision related to accepting the states criteria or to develop their own criteria. Past PAC discussions have determined that the goal for the AOC was that the Degraded Benthos BUI will be considered restored when all remedial actions for known contaminated sediment sites with degraded benthos are completed (except for minor repairs required during O&M) and monitored according to the approved plan for the sites. Remedial actions and monitoring are conducted under authority of state and federal programs, such as SF, Resource Conservation and Recovery Act, Great Lakes Legacy Act, or Part 201 of Michigan's National Resource and Environmental Protection Act (NREPA) of 1994. This is generally the same as the state's Guidance criteria, which essentially requires that all remedial actions for known contaminated sediment sites with degraded benthos are completed (except for minor repairs required during operation and maintenance) and monitored according to the approved plan for the site (U.S. EPA, 2001a and MDEQ, 2006a).

Historical Significance

The bottom of Torch Lake is degraded (Malueg et al., 1984a; Malueg et al.,1984b; U.S. EPA 1991b). The degradation of the benthos was primarily caused by historic copper mining, milling, smelting, and leaching operations and the discharge of those operations byproducts into Torch Lake. Additional impairments to water quality were caused by the historic discharge of raw sewage into the lake. For detailed information related to the historical concerns, environmental improvements and remedial activities within the AOC which have impacted this BUI see previous discussions within this document in the SF Remedial Activities section and in the Fish Tumors or Other Deformities BUI section.

Remedial Actions

Under the ROD for the Torch Lake SF Site for OUs 1, 2, and 3 described earlier in the SF Section and also described in the 1987 Torch Lake AOC RAP, natural attenuation was the selected remedy for OU 2 which includes Torch Lake, ground water, surface water, submerged stamp sands, and sediments. The SF recommended remedial action for OUs 1 & 3 included recontouring the land surface, covering stamp sands and slags with six inches of sandy loam top soil and seeding to prevent erosional activity, was completed in September 2006.

The stamp sands erosion concerns related to both wind and water have been addressed through an U.S. EPA SF led partnership with the MDEQ through the U.S. EPA's IAG with the NRCS and through a 319 Nonpoint Source Grant for Scales Creek. These remedial activities include covering erosional areas with seeded down topsoil and other associated best management practices, including rock riprap and geo-textile to stabilize these covering soils. A compromise was reached between the U.S. EPA Project Manager and the NRCS, to substitute clean soils instead of sandy loam top soils due to the lack of a good local source of sandy loam top soils and also at a reasonable cost.

As part of the ROD specifications, OU 2 was deleted from the NPL when site remedial design plans were accepted for funding in the fall of 1998. When sites are deleted through the SF, they still require O&M. Continued monitoring occurs as part of the O&M to insure that the selected SF remedial action functions as predicted and environmental conditions improve over time. If the monitoring information gathered indicates human risks, environmental health risks, or physical failure of the remedy, the remedy will be reassessed and appropriate actions taken.

The SF ROD for OU 2 called for natural attenuation which is essentially a no action alternative. Natural attenuation or sedimentation allows the area to heal itself over an indeterminate time period. The healing is through depositional processes resulting from particulate and organic materials carried into the waterbody by rain or wind erosion and deposited along the bottom of the waterbody or by the decomposition of wastes from the life cycles of littoral zone, planktonic or pelagic species. In streams and rivers these materials will become suspended moving downstream and will fall out of suspension as the water velocity slows. These depositional actions form distinct sediment layers. For this area a significant layer would be laid down after snow melt in the spring due in part to the large amounts of snow which can accumulate over the winter within the watershed, up to 300 inches. Add to that, the fact that in the spring and fall, lakes "turn over" due to natural hydrologic processes powered by wind action, which thoroughly mix the lakes and distributes sediments. This mixing occurs in deeper lakes, while shallow lakes mix continuously (Horne, 1994). Torch Lake exhibits fall and spring turnovers (MDNR, 1986b).

These sediments form distinct layers and these layers can be analyzed for depositional rate and composition (Long, 2001). The structure of the sediment cores removed and analyzed during the Long study for the U.S. EPA found in Appendix B of the U.S. EPA's baseline study (U.S. EPA, 2001b) indicate:

- The top 10 centimeters of sediments were brown in color and relatively firm in texture and were comprised of sand/silts/particulates.
- Below 10 cm the sediments were watery, and pinkish to purple in color.
- The cores did not reach background copper concentrations.
- Sediment copper concentrations up to 5,500 parts per million (ppm) were found at depth.
- Current surface sediment copper concentrations range from 1,600 to 2,200 ppm.
- There is a spatial variation in sediment concentration profiles for copper.
- At two sites in the central area of the lake, copper concentrations are clearly higher in the top brown sediments than in the lower pink sediments.
- At one site in the northern area of the lake, copper concentrations in the top brown sediments are higher than the lower pink sediments, but have very high peak copper concentrations at about 10 cm in depth.
- At one site in the southern area of the lake, copper concentrations generally decrease towards the surface, but at about 10 cm from the surface increase to values similar to those in the lower pink sediments.
- Recent sediment chronologies for copper among the three dated cores are similar.
- Copper concentrations show an increasing trend in recent sediments.

Due to the vast amount of tailings deposited in the lake and the high toxicity and slush like consistency of the contaminated sediments (U.S. EPA 1991b and Long, 2001), the technology and scale needed to safely remove or stabilize these sediments without causing environmental harm doesn't currently exist. It was deemed too difficult and expensive to attempt to remove and remediate them (U.S. EPA, 1992d; U.S. EPA. 1992g; U.S. EPA. 1994a). The ROD calls for natural sedimentation (natural attenuation) to occur instead (U.S. EPA. 1994a). It was determined that covering the shoreline tailings six inches of sandy loam soils and vegetation will aid the natural sedimentation process by cutting down on the amount of tailings being deposited in the lake through erosional processes. No estimate has been made for the amount of time for natural remediation to occur at OU 2. The ROD also calls for long term monitoring of OU 2 to evaluate the no action decision. The U.S. EPA is responsible for the baseline monitoring, and the long term monitoring needed to determine the success of the remedial actions is the responsibility of the state, as part of their match for the federal funds. If the long term monitoring determines that this remedial option has not progressed as anticipated, a reevaluation will take place (U.S. EPA. 1994a).

Assessment

The current status of the benthos is degraded, but Torch Lake has a natural attenuation remedial alternative to active remedial actions selected through SF processes. For the Degraded Benthos BUI, under Michigan's Delisting Guidance, all sources must be controlled and all remedial actions must be completed. The recommended source control for the terrestrial SF Sites under SF Program Authorities has already been accomplished. Operable Unit 2, the Lake has been delisted from the NPL. Under the SF Program, monitoring will continue at 5 year intervals to determine remedy success. This meets Michigan's delisting criteria Guidance.

There are current Fish Consumption Advisories related to PCBs. See the discussion under the Restrictions on Fish or Wildlife Consumption BUI. Because there is an undetermined source of PCBs potentially within the lake sediments, until the source can be identified and remediated if possible, this BUI cannot move through the removal process.

Recommendations

Identification and remediation, if possible, of the PCB source or sources driving the Fish Consumption Advisory will allow the removal of this BUI as it will then meet the Michigan Delisting Guidance Criteria. The MDEQ is moving forward with source identification efforts during the summer of 2007. If no specific source can be identified and remedial actions are not necessary, under Michigan's Delisting Guidance, this BUI is ready for removal and appropriate steps under Michigan's Guidance will be taken.

Appendix A

Acronyms/Glossary

The Agency for Toxic Substances and Disease Registry (ATSDR) - a federal public health agency- The ASTDR ‘s mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. The ATSDR is not a regulatory agency. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-422-8737 or visit http://www.atsdr.cdc.gov.

Areas of Concern (AOC) - geographic area that fails to meet General or Specific Objectives of the GLWQA where such failure has caused or is likely to cause impairment of beneficial use or the area’s ability to support aquatic life.

Beneficial Use Impairments (BUI) - those impairments defined in Annex 2 of the November 1987-GLWQA (see table a Section 2.3 at the end Introduction section). Impairment to a beneficial use means a change in the chemical, physical, or biological integrity of the Great Lakes System preventing or restricting the use.

Benthos- refers to the community of organisms that lives on the bottom of lakes, ponds, and streams.

Boundary Waters Treaty - treaty between the United States and Great Britain Relating to Boundary Waters and Questions Arising between the United States and Canada signed in Washington on January 11, 1909.

Comprehensive Environmental Response, Compensation,Liabilty, and Recovery Act – (CERCLA) SF provides a Federal “SF” to clean up uncontrolled or abandoned hazardous-waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. Through the Act, the U.S. EPA was given power to seek out those parties responsible for any release and assure their cooperation in the cleanup. The U.S. EPA cleans up orphan sites when potentially responsible parties cannot be identified or located, or when they fail to act. Through various enforcement tools, the U.S. EPA obtains private party cleanup through orders, consent decrees, and other small party settlements. The U.S. EPA also recovers costs from financially viable individuals and companies once a response action has been completed.

Colloidal materials - very small solid, liquid, or gaseous non-diffusible particles that remain in suspension in a surrounding solid, liquid, or gaseous material.

Conglomerate - compacted and cemented gravel that a river deposited millions of years ago.

Dimictic - dimictic lakes are lakes in which the water mixes twice during the year, once in the spring during ice out and once during fall. During these mixing events, the complete water column in the lakes mixes, creating isometric conditions throughout. For example, following this mixing, temperatures, dissolved oxygen concentrations, and pH levels throughout the water column will be the same. The two mixing events within these lakes create a set of chemical and biological characteristics in these lakes which differ from those in monomictic (mix once during the year) or polymictic (mix frequently during the year) lakes. A typical feature is the exhaustion of dissolved oxygen at the bottom of the lake during the summer months.

Dissolved oxygen - the oxygen that is free and available in the water column. This oxygen exists in the water as a dissolved gas and does not include the oxygen that is bound within other molecules, such as the oxygen that makes up the water molecule (H_2O). Dissolved oxygen in the water is measured in milligrams per liter. Dissolved oxygen levels of 5 mg/l or greater are optimal water conditions for fish and other biologic components of the lake. Dissolved oxygen levels below 3 mg/l are not sufficient to support fish for prolonged periods of time. Water with dissolved oxygen levels below 1 mg/l are considered hypoxic (without oxygen). Hypoxic conditions at the bottom of the lake are common to dimictic lakes and are a result of thermally stratified water within the lake.

Floats - large free form pieces of elemental copper found scattered on the landscape and buried within the mines.

Flocculation - a process or treatment which causes fine colloidal material to aggregate into a denser mass when deposited in a fluid such as water.

Great Lakes Water Quality Agreement (GLWQA) - an agreement between the United States and Canada, signed in 1978 and amended in 1989, which lays out the commitment by the two countries to cooperate in the management of their shared water resources. The Amended 1989 Protocol described, among other things, Lakewide Management Plans (LaMPs), Areas of Concern (AOC), and BUI.

Impaired Designated Uses - those use impairments identified by the 1987 Torch Lake RAP document following U.S. EPA guidance.

International Joint Commission (IJC) -formed by the 1909 Great Lakes Boundary Waters Treaty between the United States and Canada as the independent body overseeing the treaty with Commission appointees from both governments.

Keweenaw Waterway - (see figure 1) a waterway traversing the Keweenaw Peninsula that includes bodies of water designated as Portage Lake, North Entry, Portage River, Portage Entry, Torch Lake Canal, Cuts, and Torch Lake.

Milling - the process of grinding and extracting minerals from mined ore yielding a mineral concentrate and stamp sands or tailings.

Natural attenuation or sedimentation - allows that the area should heal itself, over an indeterminate period, through natural sedimentation (deposition) processes providing an unimpacted barrier between the water column and the contaminated sediments. It is essentially a “no action alternative.”

Oligotrophic lakes – lakes that typically have low levels of nutrients which limit the growth of aquatic vegetation and algae. Water clarity in oligotrophic lakes is very good with light transparency, light penetrating deep into the lake, due to the low levels of algae present in the lakes. These lakes are often cold, deep and have relatively high levels of dissolved oxygen distributed from their surface to the deep water. The deep waters in the lake may hold relatively high amounts of dissolved oxygen through the summer due in part to their low productivity. These lakes support cold water fisheries including species such as walleye and lake trout.

Parcels – Herein refers to portions of the SF Operable Units

Phytoplankton - plant component of the plankton (algae).

Plankton - minute animal and plant life found floating in the open water area of a body of water.

Polychlorinated biphenyls (PCBs) - a mixture of individual chemicals have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they don't burn easily and are good insulators. The manufacture of PCBs was stopped in the United States in 1977 because of evidence they build up in the environment and can cause harmful health effects. Health effects that have been associated with exposure to PCBs include acne-like skin conditions in adults and neurobehavioral and immunological changes in children. PCBs are known to cause cancer in animals. Polychlorinated biphenyls are mixtures of up to 209 individual chlorinated compounds (known as congeners). There are no known natural sources of PCBs. PCBs are either oily liquids or solids that are colorless to light yellow. Some PCBs can exist as a vapor in air. PCBs have no known smell or taste. Many commercial PCB mixtures are known in the United States by the trade name Aroclor.

Polycyclic aromatic hydrocarbons (PAHs) - organic compounds consisting of three or more condensed aromatic rings, where certain carbon atoms are common to two or three rings. PAHs include hundreds of compounds, which have attracted much attention because many of them are carcinogenic, especially those PAHs containing four to six aromatic rings.

Resource Conservation and Recovery Act (RCRA) - enacted as an amendment to the Solid Waste Disposal Act of 1965. The RCRA is a combination of the first solid waste statutes and all subsequent amendments. The RCRA authorizes the U.S. EPA to regulate waste management activities. The RCRA authorizes states to develop and enforce their own waste management programs, in lieu of the federal program, if a state's waste management program is substantially equivalent to, consistent with, and no less stringent than the federal program.

Slag - vitrified or glassy-like material discarded as waste from the process of fire refining the concentrates received from the mill.

Smelting - the process of extracting the mineral from mill concentrates using fire refining methods.

Stamp sands - a type of tailings material produced in a milling process that uses stamp and roll mills to pulverize rock into sand sized particles from which higher value minerals (e.g. metallic copper) are recovered by hydraulic separation (non chemical leaching).

Tailings - a finer sized component of the stamped rock or material that was subsequently ground in mills to a finer size and deposited as waste following removal of most of the copper content.

Thermal stratification - the presence of a relatively warm layer of water (epilimnion) over a deeper colder layer of water (hypolimnion). A third layer of water (thermocline), characterized by rapid temperature change, often occurs between these two layers. Besides temperature, the epilimnion and hypolimnion also differ in density, with the colder waters in the hypolimnion being denser than the warmer waters in the epilimnion. These differences in densities, if great enough, can limit the exchange of water between these two layers. The exchange of dissolved gasses, compounds in solution, and other things in the water can also be limited. As a result, chemical and biological differences between the surface and bottom waters can become established and pronounced the onset and maintenance of stratification within the lake. Thermal stratification may be broken down at different times of the year depending upon prevailing climate, physical properties of the lake, and other factors. When these stratified layers are broken down

and mixed, similar measures of temperature, dissolved oxygen, pH, and other parameters may be seen throughout the water column.

Transparency or clarity - a measure often used to describe water quality. Transparency in lakes is measured using a Secchi disk - a black and white disk that is lowered into the lake until it can be no longer seen. The deeper the disk can be seen, the greater the transparency of the lake, and the better the water quality.

Unconsolidated unflocculated clay-like material (UCM) - extremely fine material from the milling process that has not been treated to allow flocculation when deposited in water. This material when reaching a settled state in water, after considerable time, appears gelatinous or greasy when disturbed.

Watershed - all of the land area, which drains into a particular waterbody.

Zooplankton - animal life component of the plankton consisting of animals such as protozoans, copepods, and rotifers.

Appendix B
References

Albee, S.I. 1999. A Profile of the Trap Rock River Watershed With Findings and Recommendations for Erosion Sites Along Scales Creek and Other Environmentally Related Issues Identified in the Watershed. Prepared by the Houghton/Keweenaw Conservation District, Hancock, Michigan as the final report to meet the Federal pass through 319 Grant requirements for the Michigan Department of Environmental Quality (MDEQ) administered grant.

Ali, M.A., et al., 1977. Photoreceptors and Visual Pigments as Related to Behavioral Responses and Preferred Habitats of Perches *(Perca spp.)* and Pike-perches *(Stizostedion spp.)*. Journal of Fisheries Research Board Can. 34:1475-1480.

Black, John J., et al., 1982a. Epizootic Neoplasms in Fishes From a Lake Polluted by Copper Mining Wastes, Journal of the National Cancer Institute, Vol. 69:915-926, No. 4, October 1982.

Black, J. J. and Evans, E.D. 1986. Environmental Carcinogenesis Studies in a Copper Polluted Lake. Draft report to the Unite State Environmental Protection Agency (U.S. EPA) National Programs Office. U.S. EPA Grant R005726-01.

Costanzo, J.P. and J.W. Oakes. 1983. Torch Lake Field Study Report. Michigan Technological University (MTU). Part of the 1986 MTU Torch Lake Study for the Michigan Department of Natural Resources (MDNR).

Costanzo, J.P. and J.W. Oakes. 1984. Torch Lake Field Study Report. MTU. Part of the 1986 MTU Torch Lake Study for the MDNR.

Dorie, L D. 1986. Laboratory studies on the stability of xanthates and analysis of lake sediment extracts for creosote compounds. Torch Lake: A Project Completion Report. MTU. pp. 59-87.

Geraghty and Miller, Inc., 1992. Final Drum Removal Report, Torch Lake Drum Removal Report, Houghton County, Michigan, March, 24, 1992. Prepared for Universal Oil Products Co. Inc., Quincy Mining Company, Quincy Development Corp., Houghton County Department of Public Works, Superior Crafts, and Rudolf Kump as required under the 1991 Administrative Order by Consent with the U.S. EPA in cooperation with MDNR.

Great Lakes Regional Collaboration (GLRC). 2005. The Strategy to Restore and Protect the Great Lakes. For details go to http://www.glrc.us.

Great Lakes Water Quality Agreement (GLWQA), 1987. IJC. November 1987. Annex 2 of the 1987 Revisions to the 1978 GLWQA.

Hesse, J.L. 1983. Memorandum to Gloria R. Smith, Director, MDPH. Subject: Fish Consumption Advisory Torch Lake, Houghton County. April 22, 1983.

Horne, A.J. and C.R. Goldman. 1994. Limnology, Second Edition. McGraw-Hill. NY. Pp. 18-19.

International Joint Commission (IJC). 1987. United States and Canada. Reprint 1994. Revised GLWQA of 1978. Agreement with Annexes and Terms of Reference, between the United States and Canada signed Ottawa, November 22, 1978, and Phosphorous Load

Reduction Supplement signed October 16, 1983, as amended by Protocol November 18, 1987. Office Consolidation IJC United States and Canada. p.25.

IJC. 1991. Guidelines for Recommending the Listing and Delisting of Great Lakes Areas of Concern (AOC).

Johnson, Allan 2007. Personal communication between Dr. Johnson, Mineral Sciences professor emeritus at MTU, and Ron Whiton, Torch Lake Public Action Council (PAC) member and Torch Lake AOC Technical Committee (TLTC) member.

Juetten, R. 1979. Torch Lake Fisheries Survey. MDNR-Surface Water Quality Division (SWQD). p. 74

Kerfoot, W.C. 1998. Conversation of Matt Cavalieri with Charles Kerfoot, Feb. 6, 1998. Dr. Kerfoot of Michigan Tech studies the Lake Superior ecosystem.

Kerfoot, W.C., et al. 2004. Local, Regional, and Global Implications of Elemental Mercury in Metal (Copper, Silver, Gold, and Zinc) Ores: Insights from Lake Superior Sediments. 2004. J. of Great Lakes Res. 30 (Supplement 1):162-184, Internat. Assoc. Great Lakes Res., 2004.

Kraft, K.J. 1979. Pontoporeria distribution along the Keweenaw shore of Lake Superior affected by copper tailings. J. Great Lakes Res., Internat. Assoc. Great Lakes Res. 5(1):28-35.

Kraft, K.J. and Sypniewski, R.H. 1981. Effect of sediment copper on the distribution of benthic macroinvertebrates in the Keweenaw Waterway. J. Great Lakes Res., Internat. Assoc. Great Lakes Res. 7(3): 258-263.

Laarman, P.W. 1976. The sport fisheries of the twenty largest inland lakes. Fisheries Research Report No. 1843. MDNR.

Leddy, D G. 1986. The environmental fate of xanthates and creosotes. Torch Lake: A Project Completion Report. MTU. pp. 47-48.

Leduc, G. and G. Lee. 1976. Environmental Chemistry of Copper in Torch Lake, Michigan. Water, Air, and Soil Pollution. 8:37.

Leopold, L.B. and M.G. Wolman. 1964. Fluvial processes in geomorphology. W.H. Freeman. San Francisco. pp 134-135.

Lind, O. 1985. Handbook of Common Methods in Limnology, Second Ed. Kendall/Hunt Publishing Company, Dubuque, Iowa.

Long, D.T., J. Fett, and S. Simpson. 2001. Temporal and Spatial Distributions of Copper in Sediments of Torch Lake, Upper Peninsula, Michigan. Found as Appendix B of the U.S. EPA Baseline Study Report, 2001.

Malueg, K.W., et al. 1984a. Toxicity of Sediments from Three Metal Contaminated Areas. Environmental Toxicology and Chemistry, Vol. 3:279-291.

Malueg, K.W., et al. 1984b. Laboratory Sediment Toxicity Tests. Sediment Chemistry and Distribution of Benthic Macroinvertebrates in Sediments from the Keweenaw Waterway. MI Environmental Toxicology and Chemistry. Vol. 3:233-242.

Markham, T. 1985. Stamp Sands and Chemical Reagents of Torch Lake Mills-September 1985. Part of the Torch Lake Study: A Project Completion Report, Prepared for the MDNR, by staff of MTU. August 1986. pp. 233-261.

Markham, T. 1984. Torch Lake Fish Study Field Report-September & October 1984. Part of the 1986 MTU Torch Lake Study for the MDNR.

MDPH. 1983. The MDPH, now the Michigan Department of Community Health (MDCH), issued a fish consumption advisory on sauger and walleye in for Torch Lake, Houghton County based on fish tumors of unknown origin.

MDCH. 1993. Fish Consumption Advisory based on fish tumors removed for Torch Lake.

MDCH. 1998. Michigan Fishing Guide, 1998. Contains charts of specific consumption advisories for fish based on length and specific watershed.

MDCH. 2003. 2003 Michigan Fish Consumption Advisory. (https://www.michigan.gov/mdhhs then click on Statistics and Reports).

MDCH. 2004. Michigan Family Fish Consumption Guide: Important Facts to Know if You Eat Michigan Fish. (The link provided was broken and has been removed)
Certain kinds and sizes of fish from the Great Lakes, and some Michigan lakes and streams, contain levels of toxic chemicals that may be harmful if those fish are eaten too often. The MDCH advises caution about eating Michigan fish for the general population, women of childbearing age, and children under 15 years old.

MDCH. 2007. Personal communication between Lynn Dykema, MDCH and Sharon Baker MDEQ.

MDEQ. 1995. Fish Contaminant Monitoring Program (FCMP) - Fish Collection Procedures (4/22/87) REVISED 1/31/95 Revised Great Lakes Environmental Assessment Section (GLEAS) Procedure #31 FCMP Fish Collection and Processing Procedure

MDEQ. 1996. A Biological Survey of St. Louis Creek, Houghton County, Michigan, July 12, 1996. MI/DEQ/Surface Water Quality (SWQ)-96/153

MDEQ. 1997. A Biological Survey of St. Louis Creek, July 12, 1996. MDEQ, Surface Water Quality Division (SWQD). February 1997.

MDEQ. 1998. Michigan FCMP 1998 Annual Report. Established new mercury and PCB consumption advisories based on newly established U.S. EPA trigger levels. No fish tumors were noted. Report number MI/DEQ/SWQ-99-091.

MDEQ. 1999. Personal communication. William Taft, Aquatic Biologist, GLEAS, SWQD.

MDEQ 2001. Michigan FCMP 2001 Annual Report. No fish tumors were noted. Report number MI/DEQ/SWQ-02-035.

MDEQ. 2002. A biological survey of selected tributaries located north of the Portage Ship Canal along the Keweenaw Peninsula, Houghton and Keweenaw Counties, June 6, 2000, and June 18-27, 2001. MI/DEQ/SWQ-02/005.

MDEQ. 2006a. Guidance for Delisting Michigan's Great Lakes AOC. MI/DEQ/WB-06/001.

MDEQ 2006b. Bohr, J. and J. Zbytowski. 2006. Michigan FCMP: 2005 Annual Report. MDEQ-WB Report #MI/DEQ/WB-06/091
(The link provided was broken and has been removed)

MDEQ 2006c. Bohr, J. Polychlorinated biphenyl (PCB) Concentrations in Torch Lake Using Semi Permeable Membrane Devices, Houghton County, Michigan, October 20-November 18, 2005. Water Bureau (WB) Document MI/DEQ/WB-06/032.

MDEQ 2006d.-RRD samples from 2004. Lab data set.

MDEQ- National Pollutant Discharge Elimination System (NPDES). 2006. Review of current status permits in the NPDES database by Judith Woodcock, Permits Section, WB, MDEQ.

MDEQ. 2007a (Draft) Monitoring Report, Torch Lake SF Site, Houghton County, Michigan. Prepared for MDEQ-Remediation & Redevelopment Division-SF by MACTEC Engineering and Consulting of Michigan, Inc. as part of the SF Operation and Maintenance. Project 3293046030.

MDEQ. 2007b. Fish Tumor or Other Deformities Removal Recommendation. Document sent by MDEQ-WB Richard Powers, Chief, to U.S. EPA Region 5 Great Lakes National Program Office (GLNPO) Gary Gulezian on March 14, 2007.

MDEQ. 2007c. Michigan's FCMP 2006 Annual Report. WB Document MI/DEQ/SWQ-07-053.

MDNR. 1970. Ground Water and Geology of Keweenaw Peninsula, Michigan, Geological Survey, Water Investigation 10, MDNR, 1970.

MDNR. 1973. Michigan Water Resources Commission (MWRC) now WB. An Evaluation of a Cupric Ammonium Carbonate Spill into Torch lake, Houghton County, Michigan, September 29, 1972. Michigan Water Resources Commission, Bureau of Water Management, MDNR. February 7, 1973. Filed under: Torch Lake, Houghton County, Calumet, Hecla (Mining Company). SWAS Database Report #063670.

MDNR. 1979a. Juetten, R. Torch Lake Fisheries Survey. Michigan Department of Conservation now MDNR-SWQD. p. 74 .

MDNR 1986a. Interoffice Communication. *Strategy for Developing RAPs for AOCs in Michigan's Great Lakes Waters*. Richard Powers, Chief, GLEAS. Sept. 4, 1986.

MDNR 1986b. Leddy, D.G., Project Coordinator. Principal Investigators: Bagley, S.T., Bornhorst, T.J., Bowen, S.H., Dharland, W.W., Dorie, L.D., Erbish, F.H., McDowell, D.S., Rose, W.L., Spence, J.A. 1986. Torch Lake Study-A Project Completion Report Prepared for the MDNR by MTU, Houghton, Michigan. August 1986.

MDNR 1987. MDNR Remediation Plan for Torch Lake AOC. Surface Water Quality Division, GLEAS. Lansing, MI.

MDNR 1990- MDNR-SWQD, Staff Report, March 1990, Fish Growth Anomalies in Torch Lake and Portage Lakes 1974-1988, Houghton County, Michigan . The 1990 Report is assigned the WB document number MI/DNR/SWQ-90-029.

MDNR 1991. A Biological Survey of the Trap Rock River and Its Tributaries, July 29-30, 1991, Houghton County, Michigan. Report by William Taft. Report Number MI/DRN/SWQ-92/040.

MDNR. 1991. Toxicity Assessment of the Trap Rock River and Tributaries Houghton County, Michigan August 23-30, 1991. MI/DNR/SWQ-91/305.

MDNR. Taft, W. 1992. MDNR SWQD August 1992 Staff Report: A Biological Survey of the Trap Rock River and Its Tributaries, July 29-30, 1991, Houghton County, Michigan. Report # MI/DNR/SWQ-92/040.

MDNR. 1992. Toxicity Assessment in the Development of Site-Specific Water Quality Criteria for Copper in Portage Lake Houghton County, Michigan January 29 - February 5, 1992 March 6-15, 1992. MI/DNR/SWQ-92/280.

MDNR. 1993. FCMP 1993 Annual Report. Fish Tumor Consumption Advisory removed for Torch Lake, Houghton County, MI. Report number MI/DNR/SWQ-93-059.

MDNR. 1998. MDNR Vern Nerenberg. Electronic and personal communication between Sharon Baker MDEQ, Torch Lake AOC Contact and Vern Nerenberg, Fisheries Biologist, Fisheries Division, Baraga, MI, February 5, 1998. He had not had reports nor seen evidence of fish tumors for more than five years. Sauger are no longer found in the lake due to the increases in water clarity.

MDNR/Pearce. 2000. Pearce, Edward. Personal communication to Sharon Baker. Pearce observed a tar like substance on anchor while fishing area offshore of Peninsula Copper Industries among old pilings and near discharge pipe. This was communicated to the U.S. EPA and MDEQ SF Project Managers.

MDNR. 2006a. Madison, G. 2006c. MDNR Fisheries Division, Escanaba, MI, Personal communication. February 5, 1998. Electronic and personnel communication between George Madison, Fisheries Division, MDNR, and Sharon Baker, Torch Lake, MDEQ, AOC Contact. Sauger discussions agreed with earlier assumption that sauger are no longer present in the system due to greater water clarity as sauger prefer murky waters.

MDNR. 2006b. Madison, G. Electronic and personnel communication between George Madison, Fisheries Division, MDNR, and Sharon Baker, Torch Lake, MDEQ, AOC Contact. He had not had any reports nor seen evidence of fish tumors for more than five years.

MDNR. 2006c. MDNR Fisheries Division Stocking Report. Walleye stocking in Torch Lake. 400,000+ walleye stocked since 1987. For further details go to the MDNR Stocking Report website at http://www.michigandnr.com/fishstock/ and select Houghton County, Torch Lake, Walleye, 1979 through 2006 data.

MDNR. 2007. MDNR-Unpublished data from the summer 2007 Torch Lake / Portage Lake Large Lake Sampling Event. The MDNR sampled Torch Lake and Portage Lake fish populations and habitat as part of the MDNR's statewide effort to evaluate large lakes. Tagged fish were caught that were tagged on the Canadian shoreline, a fish that was tagged in this sampling event was caught a week later in the Ontonagon system.

Nelson, W.R. and C.H. Walberg. 1977. Population Dynamics of Yellow Perch, *Perca flavescens,* Sauger*, Stizostedion canadense,* Walleye*, Stizostedion. vitreum vitreum* in four main stem Missouri Reservoirs. Journal of Fisheries Research Board Can. 34:1748-1763.

Natural Resources Conservation Service (NRCS)/Peterson. 2000. NRCS/Peterson, Bruce. . Conversation. Characterized the agricultural sector in the Torch Lake watershed.

Nordberg, Erik. 1996. Milling practices in the Lake Superior copper region. Personal communication. MTU Archives. Houghton, MI.

PCI. 2000. Troy Eddy personal communication. Peninsula Copper Industries.

SIAC. 1985. U.S. EPA Guidance for Preparing an Area of Concern (AOC) RAP developed for the U.S. EPA-GLNPO. (SIAC-U.S. EPA Contractor).

Spence, J A. 1986. Tumor incidence and parasite survey of perch, *Perca flavescens*, walleye, *Stizostedion vitreum*, and sauger, *S. canadense* from Torch Lake, Houghton County, Michigan. In: A project completion report. MTU. pp. 88-118.

Stensland, T. and S. Bowen. 1986. Tumor Induction Study: Exposure of *Orzyias latipes* to Potassium-isopropyl Xanthate and Potassium-isopropyl Creosote Combinations in the Presence of Torch Lake Sediment: Effect on Liver Histology. MTU.

Tomljanovich, D.A.. 1974. Growth Phenomena and Abnormalities of the Sauger *Stizostedion canadense* (Smith), of the Keweenaw Waterway. M.S. Thesis, MTU, Houghton, MI. 102 pp.

U.S. EPA. 1986. Comprehensive Environmental Response, Compensation, and Liability Act National Priorities List.

U.S. EPA. 1989. Volume 1A, Final Work Plan, Torch Lake, Remedial Investigation/Feasibility Study, Houghton County, Michigan, June 1989, U.S. EPA Contract 68-W8-0093. Donohue & Associates, Inc.

U.S. EPA. 1989. Ground Penetrating Radar Survey, Torch Lake, Houghton County, Michigan May 9-11, 1989.

U.S. EPA. 1990. Volume 1, Final Remedial Investigation Report, Operable Unit 1, Torch Lake, Remedial Investigation/Feasibility Study, Houghton County, Michigan, November 1990. U.S. EPA Contract 68-W8-0093. Donohue & Associates, Inc.

U.S. EPA 1991a. Baseline Risk Assessment OU 1.

U.S. EPA 1991b. U.S.EPA, Environmental Response Division, prepared by David W. Charters, "Final Report for Torch Lake," Nov 26. 1991. Purpose of the study was to determine the acute and toxic effect levels of the sediment in Torch Lake.

U.S. EPA. 1992a. U.S.EPA SF Record of Decision: Torch Lake Operable Units 1 & 3, Houghton County, MI, 09/30/1992. EPA R05-R92-215, 1992.

U.S. EPA 1992b. Final Remedial Investigation OU 3 Vol. 1 Ap. 1992.

U.S. EPA 1992c. Baseline Risk Assessment OU 3 Vol. 1 Ap. 1992.

U.S. EPA. 1992d. Volume 2, Appendices A, B, and C, Final Remedial Investigation Report, Operable Unit 2, Torch Lake, Remedial Investigation/Feasibility Study, Houghton County, Michigan, January 1992. U.S. EPA Contract 68-W8-0093. Donohue & Associates, Inc.

U.S. EPA. 1992e. Addendum No. 1, Final Remedial Investigation Report, Operable Unit 2, Torch Lake, Remedial Investigation/Feasibility Study, Houghton County, Michigan, March. U.S. EPA Contract 68-W8-0093. Donohue & Associates, Inc.

U.S. EPA. 1992f. Volume 3, Appendix D: Final Baseline Risk Assessment, Remedial Investigation Report, Operable Unit 2 Torch Lake, Remedial Investigation/Feasibility Study, Houghton County, Michigan, March 1992. U.S. EPA Contract 68-W8-0093. Donahue and Assoc.

U.S. EPA. 1992g. (Draft) Ecological Assessment, Torch Lake Remedial Investigation/Feasibility Study, Houghton County, Michigan, January 1992. Finalized in May 1992. U.S. EPA Contract 68-W8-0093. Donahue and Assoc.

U.S. EPA, 1993b. Region V, Record of Decision Summary, Torch Lake SF Site, OU II, Houghton County, Michigan. Prepared by U.S. EPA Region 5. March 1993.

U.S. EPA. 1994a. U.S. EPA SF Record of Decision: Torch Lake Operable Unit 2, Houghton County, MI, 03/31/1994. U.S. EPA R05-R94-264, 1994.

U.S. EPA. 1994b. Torch Lake SF Site, Operable Unit 2, Final Remedy Position Paper, February 1994.

U.S. EPA, 2001a. GLNPO. December 2001. Restoring United States Great Lakes AOC Delisting Principals and Guidelines, Adopted by the United States Policy Committee.

U.S. EPA. 2001b. SF Division. July 2001. Baseline Study Report, Torch Lake SF Site, Houghton County Michigan. July, 2001.

U.S. EPA. 2006a Torch Lake Sediment Sampling Data, Unpublished. Data done in concurrence with MDEQ Semi-Permeable Membrane Devices sampling.

U.S. EPA. 2006b. Concurrence letter from Gary Gulezian to MDEQ related to Michigan Delisting Guidance received

U.S. EPA. 2007. Concurrence letter from Gary Gulezian to MDEQ related to MDEQ Request to Remove the Tumor BUI. Received April 2007.

Warburton, W.L. 1986. Copper Budget for Torch Lake. Torch Lake Study-A Project Completion Report Prepared for the MDNR by MTU, Houghton, Michigan. August 1986.

Whiton, R. 2006. Authored part of text based on his mining technical expertise.

Williams, S. 1973. MTU study, part of which described the number of untreated outfalls which directly discharged to Torch Lake. Described by Dr. Robert Baillod, MTU Professor and PAC Technical Committee.

Wright, T.D., D.G. Leddy, D.J. Brandt, and T. Virnig. 1973. Water Quality Alteration of Torch Lake, Michigan by Copper Leach Liquor. Proceedings 16th Conference, Great Lakes Research. Pages 329-344. International Association of Great Lakes Research.

Wright, T.D., D.J. Tomljanovich, H.E. Otto. 1975. A High Incidence of Unusual Tumors and Abnormalities of *Perchid* Fish in a Copper-Rich Area of Michigan. Unpublished Manuscript. 35 pp. MTU.

Whiton, Ron. 2003. Personal communication. Member TLPAC. Mr. Whiton provided vast historical knowledge and past mining expertise to the development of this document.

Appendix C
Relevant Websites

- United States Environmental Protection Agency (U.S. EPA)-Areas of Concern (AOC) website at http://www.epa.gov/glnpo/aoc/index.html

- U.S. EPA-Torch Lake SF website at *(The link provided was broken and has been removed)*

- Great Lakes Commission-AOC/Statewide Public Advisory Council Website at https://www.glc.org/work/spac/

- International Joint Commission-Great Lakes Water Quality Agreement at https://www.ijc.org/en/what/glwqa-ijc

- MDCH- Fish Consumption Advisories at https://www.michigan.gov/en/mdhhs/safety-injury-prev/environmental-health/topics/eatsafefish

- MDEQ-AOC information and the Delisting Guidance document at (The link provided was broken and has been removed)