An Integrated Assessment of Torch Lake Area of Concern

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Funding provided by Michigan Sea Grant

This is Contribution No. 53 of the Great Lakes Research Center
at Michigan Technological University

Calumet & Hecla operations in Lake Linden ca 1940. In the foreground are the Calumet and Hecla stamp mills with the stacks of the power house. Photo courtesy of Michigan Tech Archives.

Acknowledgments

The authors thank Michigan Sea Grant for funding to enable this integrated assessment. Without the support, insights, historical knowledge and perspectives offered by Sharon Baker, MDEQ site coordinator for many years, this project would not have been possible. We also owe tremendous thanks to the two students, Ankita Mandelia and Emma Schwaiger-Zawisza, whose thesis research contributed major parts of this report. Other people who have contributed to our understanding of the site and its history are too numerous to mention individually, but include state and federal agency personnel, colleagues at MTU and the Keweenaw National Historic Park, TLPAC members, and community members. Administration and staff members at Sea Grant were very helpful in administering the grant, creating and maintaining a web site for the project (http://www.miseagrant.umich.edu/torchlake/), and facilitating compilation of the final report. The assessment was greatly improved thanks to the contributions of eight anonymous reviewers representing agency, scientist, and local citizen viewpoints.

Ruins of Quincy powerhouse. Photograph by Todd Marsee, Michigan Sea Grant, 2012.

Acronyms and Symbols

AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirement
ATSDR	Agency for Toxic Substances and Disease Registry
BUI	Beneficial Use Impairment
CbPEC	Consensus-based Probable Effects Concentration
CbTEC	Consensus-based Threshold Effects Concentration
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
C&H	Calumet and Hecla Mining Company
DMG	Daily Mining Gazette
DOC	dissolved organic carbon
EPA	Environmental Protection Agency
ERL	Effect Range – Low
ERM	Effect Range – Medium
FDA	Food and Drug Administration
FOLK	Friends of the Land of the Keweenaw
GLEC	Great Lakes Environmental Center
GLLA	Great Lakes Legacy Act
GLRI	Great Lakes Restoration Initiative
GLWQA	Great Lakes Water Quality Agreement
Hg	mercury
HRS	Hazard Ranking System
IA	Integrated Assessment
IADN	Integrated Atmospheric Deposition Network
IJC	International Joint Commission

ISQG	Interim Sediment Quality Guideline
KBIC	Keweenaw Bay Indian Community
KLT	Keweenaw Land Trust
LEL	Lowest Effects Level
LLRP	Lake Linden Recreation Park
MDCH	Michigan Department of Community Health
MDPH	Michigan Department of Public Health
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MET	Medium Effects Threshold
MeHg	methyl mercury
MRC	Metals Reserve Company
MS	Master of Science
MTU	Michigan Technological University
NPL	National Priority List
NRCS	National Resource Conservation Service, U.S. Department of Agriculture
O&M	Operation and Maintenance
OGL	Office of the Great Lakes, MDEQ
OU	Operable Unit
PAC	Public Action Council
PAH	Polycyclic Aromatic Hydrocarbon
Pb	lead
PCB	Polychlorinated Biphenyl
PEC	Probable Effects Concentration
PEL	Probable Effects Level

PRP	Principal Responsible Party
QMC	Quincy Mining Company
RAP	Remedial Action Plan
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RRD	Remediation and Redevelopment, MDEQ
SB	Senate Bill
SEL	Severe Effect Level
SF	Superfund
SPAC	(Michigan) State Public Advisory Council
SPMD	Semi-permeable Membrane Device
TEC	Threshold Effects Concentration
TEL	Threshold Effects Level
TET	Toxic Effect Threshold
TL	Torch Lake
TLPAC	Torch Lake Public Action Council
TMDL	Total Maximum Daily Load
TU	Trout Unlimited
UOP	Universal Oil Products
UP	Upper Peninsula (of Michigan)
USGS	Unites States Geological Survey

Table of Contents

List of Figures

List of Tables

Summary

Introduction

Torch Lake has been an EPA Superfund site and Great Lakes Area of Concern for over thirty-five years. Remediation has been slow and incomplete. The industrial site of copper ore processing that produced stamp sands (tailings), slag, chemical pollutants such as polychlorinated biphenyl compounds (PCBs), and dramatic ecosystem changes during 100 years of mineral processing and reclamation, Torch Lake remains a polluted environment. Remediation has focused upon coverage and vegetation of the stamp sands that extend into Torch Lake and a few emergency actions to remove metals, asbestos, and PCBs at specific locations. What remains to be remediated are the lake sediments rich in copper and trace metals that prevent a healthy benthos, and the western shoreline of Torch Lake where many processing facilities once existed. The purpose of this report is to document the history of pollution at Torch Lake and to make available the findings of ongoing research and data collection in a form that benefits the community, government agencies, and researchers who continue the work of improving the Torch Lake ecosystem and eliminating exposure to major pollutants. This Summary attempts to synthesize the entire report and may be read as a stand-alone document; however, for documentation of information sources and rationales for opinions expressed in the summary, the reader must refer to the chapters of the full report.

In 2011 Michigan Sea Grant funded researchers at Michigan Technological University (MTU) to perform an Integrated Assessment of the Torch Lake Area of Concern (TL AOC). The original objectives of the project were: 1) to gather and to summarize existing information regarding conditions in the AOC; 2) to communicate with stakeholders about the status of the site as well as stakeholders' ideas for and visions of future conditions in the AOC; and 3) to identify and to begin to evaluate potential remedial actions that could mitigate any remaining undesirable conditions. This report summarizes the project findings related to the first objective and summarizes the actions taken to meet the second objective. The third objective was dropped as the project evolved, and no evaluation of potential remedial actions was performed. This project was funded for the period 2/1/2012-1/31/2014, but we included actions through 12/2014 within the report. Actions subsequent to that date are briefly summarized in the Epilogue.

The report is organized into several sections, some of which include multiple chapters. After an introduction to the scope of the Integrated Assessment in Chapter 1, Chapters 2-5 discuss the development of mineral processing and waste production at Torch Lake, the government study and remediation efforts through the Superfund and AOC programs, and the role of community participation. Chapters 6-9 address the major problems including the three AOC beneficial use impairments: fish tumors, fish consumption restrictions, and degraded benthos. In addition, Chapter 9 summarizes other problems not addressed to date, and offers some general observations and recommendations. This Summary does not summarize each chapter, but rather discusses the key points from the Integrated Assessment of most benefit to community members and those needing an overview of the status of Torch Lake pollution and remediation.

Figure 1. Beached remains of Quincy Dredge #2, Mason, Michigan. Photograph by Todd Marsee, Michigan Sea Grant, 2012.

Industrial History

Conditions at Torch Lake today are the result of over 100 years of mining-related activities and the subsequent 45 years of remedial actions. The mining industry released wastes to the atmosphere, to the lake and its tributary streams, and to the land around the lake. A unique feature of this project was the application of research into the industrial history to clarify the genesis of, the specific components of, and the spatial and temporal distributions of the "problems" at the site. The historical research included extensive review of materials from the MTU archives as well as interviews with local residents with memories of the industrial activities and the post-industrial period of reclamation. This investigation uncovered a complex picture of copper milling and processing along the western industrial shoreline of Torch Lake. The multiple sub-processes involved in copper production resulted in differing waste streams. Additionally, as technology changed during one hundred years of processing, the character, size, and location of waste streams changed.

Figure 2. Photograph of Calumet and Hecla dredge with Hecla stamp mill in background. Photo courtesy of Michigan Tech Archives.

The western shoreline of Torch Lake provided a site for milling facilities for the mines of Calumet and Hecla (C&H) and Quincy mining companies. The first mills, located in Lake Linden, had access to water (needed to produce steam and to separate metal-rich and –poor components of the ore) and to a water body to deposit waste tailings. When the US government established harbor lines that prevented further dumping from mills operating in Portage Lake, several companies moved their mills to Torch Lake. A total of eight mills operated at different times along the shoreline between 1860 and 1970, producing the large volume of stamp sands that were deposited into the lake (~1.5×10^8 m^3 or ~200 million metric tons). These stamp sands became the object of reclamation beginning in the 1910s and continuing through the 1950s, adding a new dimension to processing in the district. The original stamp sands were dredged, re-ground, and then treated in leaching and flotation units installed in Lake Linden and Tamarack City, and a flotation unit at Mason; this processing used chemicals including ammonia and xanthates, and created new wastes in the form of metal-rich sludges and finer tailings that were re-deposited into the lake. Electrical power replaced steam power such that by 1940 most industrial facilities along the western shoreline were powered by a single coal-fired power plant located in Lake Linden, augmented by steam. A smelter located in Hubbell was operated by Calumet and Hecla for nearly one hundred years, and two large coal-handling facilities were built at Hubbell (C&H) and Mason (Quincy). Auxiliary buildings such as sub-stations and chemical laboratories added to the infrastructure and potential waste disposal in and around the lake. The original sole focus on production of copper metal was broadened to include production of secondary copper chemicals, and this also brought new waste streams.

Figure 3. Photograph of Ahmeek stamp mill located in Tamarack City, Michigan. Photo courtesy of Michigan Tech Archives.

Mineral Processing and their Waste Products

Two types of ores, amygdaloid basalt and conglomerate, were processed near the lake with only conglomerate ore being processed at the north end of the lake (Lake Linden), only amygdaloid basalt at the south end (Mason), and both types in the middle. Only some basalt ores contained arsenic, and hence arsenic enrichment is not found in stamp sands processed at the northern end of the lake. Conglomerate-derived stamp sands were easier to reclaim, and reclamation included both flotation and ammonia-leaching; all leaching was performed at the Lake Linden and Tamarack reclamation plants, and the metal-rich slimes/sludges produced by this process are likely confined to these areas.

Composition of slag, a major byproduct of smelting, changed tremendously as technology developed. Early slags (pre-1914) were generated at lower temperatures, and had higher metal content and probably higher leachable metal content. The locations where these slags were deposited remain to be clarified. Use of coal pulverization (beginning around 1914) increased the efficiency of metal separation from slag and resulted in a more vitrified slag; these slags are less likely to leach metals than the earlier slags. Beginning in 1929, slag was ground and subjected to flotation to extract copper; in the 1930s and 1940s, slag was granulated (fractured by depositing in water) and then pumped to be re-extracted. These later slags are likely to have lower metal content and to pose less environmental hazard than earlier slags. Beginning in 1905, amendments were added to the smelters to draw arsenic from the molten copper into the slag. In the late 1940s, arsenic-rich slags were reground and leached (Lake Linden reclamation plant) to extract the arsenic; it remains unknown what was done with the arsenic-rich leachate but arsenic enrichment is observed in north basin lake sediments and soils in the Calumet and Hecla processing areas.

Vast amounts of coal burning were required to support the mills, smelter, and electricity generating facilities, a dimension that has not been considered previously. Considerable quantities of fly and coal ash were generated; the coal ash was deposited with the stamp sands into the lake, although for some period after World War II, the coal ash was subjected to metal reclamation. The leaching plant at Lake Linden produced metal-rich sludges/slimes as a by-product. The complete extent of this material remains to be determined, although some was identified and removed in a Superfund emergency removal in 2007. Reclamation of scrap materials resulted in additional toxic waste generation in the area. Specifically, lead- and zinc-rich wastes were produced, and PCBs were volatilized and deposited in soils through burning of copper wire insulation. The present-day distribution of lead-enriched sediments and soils shows the locations of disposal of reclamation wastes.

Electrification of the mining industry was accompanied by use of PCB-containing transformers along the length of the shoreline. The specific locations of installation of many of these transformers have been identified. However, the fate of the transformers and PCBs following demolition of sites has not been determined. One significant insight from our historical investigation of mineral processing is that many of the contaminants that remain in the landscape today originated from specific locations and industrial processes. The types of waste remaining at the site and their disposal locations identified by this type of research can guide further remediation efforts.

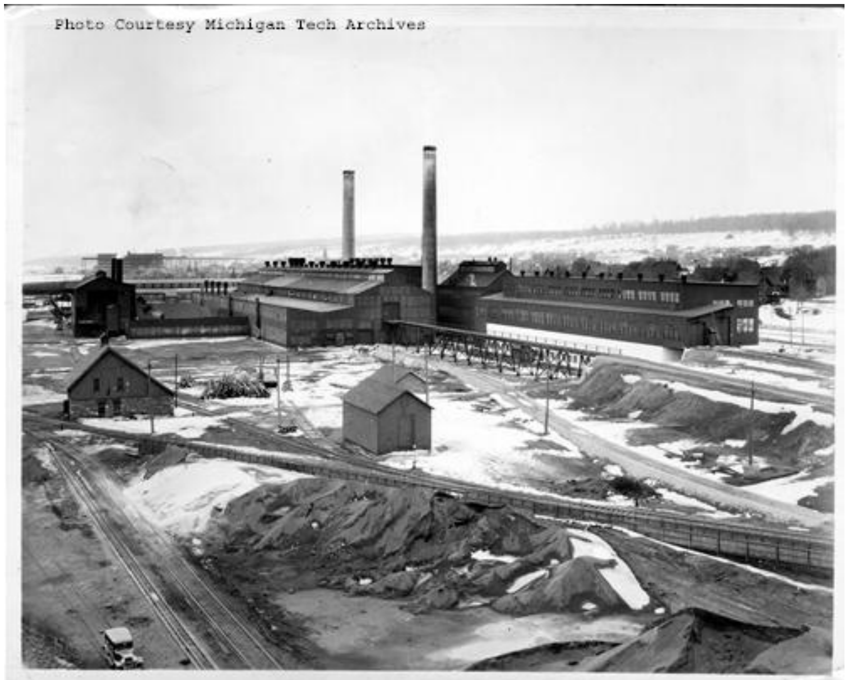


Figure 4. Photograph of C&H smelter and concentrate storage building in Hubbell, MI about 1950.

<u>Remediation History</u>

When copper processing and mining facilities shut down in 1970, pollution concerns surfaced a few years later when residents noticed the presence of fish tumors. For the next 15 years, Michigan DNR and MTU researchers investigated these tumors in an attempt to locate the cause. Evidence pointed to the mining environment, but no causative agents were definitively identified. Meanwhile, in the 1980s, the US EPA and the International Joint Commission each designated Torch Lake and surrounding sites as significantly contaminated and listed them on the National Priorities List (Superfund) and as an Area of Concern (AOC) under the Great Lakes Water Quality Agreement.

Most remedial actions of the Torch Lake Superfund program focused on one waste stream, the stamp sands around the lake above the lake water level (Chapter 3). The fish tumors that were one of the original major causes for concern have disappeared, presumably as a result of cessation of release of carcinogenic compounds into the lake (Chapter 6). Remediation efforts did not focus on removing sources of PCBs or mercury (Hg), and fish in Torch Lake still have elevated concentrations of these pollutants that result in fish consumption advisories/guidelines for multiple fish species (Chapter 7). No concerted effort was made to remediate the soils at the sites of industrial activity, and hence localized areas of soils highly contaminated with metals, PCBs, and asbestos still exist. No effort was ever made to examine the extent of soil and lake sediment contamination by plumes emitted from the boilers and smelters; the extent and degree of contamination from these sources remain unknown. The lake water is safe for contact recreation, and supports a healthy ecosystem with several notable exceptions including a highly depauperate sediment community (benthos) (Chapter 8), restricted shoreline wetlands and macrophyte beds, and possibly limited fish spawning within the lake due to sediment toxicity to eggs.

Lessons from Ongoing Remediation and Citizen Involvement

Our research also included historical analysis of federal and state involvement in the environmental history of Torch Lake (including the remediation details under Superfund) as well as an evaluation of citizen interest in pollution issues and involvement in ongoing remediation. Several lessons emerge from this research.

The historical context is always important. Actions on the national level were important to both the polluting of the lake and to its remediation. Close scrutiny of these actions (Chapter 3) helps to clarify why remediation remains incomplete after 45 years. Torch Lake was specifically exempted from restrictions on dumping of materials into the lake in the 1899 Rivers and Harbors Act; because of the importance of copper production to the war effort, pollution restrictions were again waived from 1940 through 1965. These waivers allowed roughly 50% of the lake volume to be filled with stamp sands (see Chapters 2 and 8 for documentation). Even more than at other sites throughout the U.S., pollution was unchecked by national laws and anti-dumping policies in navigable water bodies. Local concern and local studies coincident with the environmental awareness and associated national legislation in the 1970s were instrumental in the listing of Torch Lake as part of the Superfund and Area of Concern programs in the mid-1980s (Chapters 3, 4).

The historical research presented in Chapter 3 identifies four problems that have impeded the complete remediation of Torch Lake by either Superfund or the AOC program: lack of funding, the narrowing of focus on a complex contamination problem, polarization of local and official viewpoints, and finally the failure of agencies to re-examine early conclusions as new knowledge and remediation tools became available.

Lack of funds within the AOC program led to little action under this program after completion of the first Remedial Action Plan (RAP) in 1987. Funding within the Superfund program was adequate for a remedial investigation (1988-1992) that led to a plan of action (Record of Decision, ROD) in 1992. However, it took six years to make funds available for remediation of stamp sands around Torch Lake (Operating Unit I). In the meantime, the sediments in the lake (OU II) were delisted without remediation. This meant that the lake itself and its sediments received little attention. Later, despite an influx of funds into the AOC program through the Legacy Act (2002) and Great Lakes Restoration Initiative (2010), the lack of an action plan (i.e., the lack of a remedial investigation within the AOC program) has rendered acquisition of these funds for Torch Lake unsuccessful to date.

A second impediment has been the narrow focus of all government agencies involved at Torch Lake, but notably of the Superfund and AOC programs, on a subset of the problems present in the lake. This is further complicated by the lack of any entity capable of integrating all efforts. During the Remedial Investigation of the Superfund program (1988-1992), a sampling design not informed by knowledge of historical industrial activities led to failure to identify many of the hazards present in the area, especially those at upland sites surrounding the numerous industrial facilities and residential communities. As a result, focus shifted from the entire industrial area and the contaminants associated with industrial activities to *only* hazards from airborne dust from the large stamp sand deposits on the lakeshore. This meant little or no attention was paid to the PCB-contamination of soil and lake water, high metal and asbestos contamination of soils around industrial facilities, deposition of toxic substances from smelter and boiler smoke stack plumes in residential soils, and the mercury release from mine discharges and tailings. The AOC's major focus on problems within the lake led to restricted efforts to determine the out-of-lake sources of materials (mercury, PCBs, copper) causing those problems as well as exclusion of other problems on land (e.g., soil contamination). Within both programs, the predominant focus on fish tumors as a potential human health threat was accompanied by a failure to recognize the threat from mercury and PCBs despite documentation of the presence of these contaminants starting in the 1980s. Not until the update of the Remedial Action Plan (RAP) in 2007 did MDEQ formally conclude that the BUI associated with restriction on fish consumption should remain in place because of PCB contamination. It decided that mercury contamination was a regional problem, not specific to Torch Lake. The Michigan Department of Health and Human Services (MDHHS) did recognize the multiplicity of potential concerns, but it had no legal authority or funding to collect data to determine if the risks were significant. The Michigan Department of Environmental Quality Water Division (MDEQ) and U.S. Environmental Protection Agency (EPA) focused on the water quality violations associated with high copper and mercury concentrations in the tributaries, but did not work in conjunction with Superfund or AOC programs to ensure that remediation efforts would solve these problems. While the law governing Superfund does mandate some inter-agency coordination (Applicable or Relevant and Appropriate Requirements), it has been ineffective at this site.

A second issue arose from the focus of each remediation program on narrow, and different, subsets of the total program. The differences between the two programs eventually created confusion among citizens as to the types of problems created by mine processing waste, and further complicated citizen understanding as to what might be appropriate remedial solutions. This confusion and the complexity of problem definition and remediation has likely led to a diminishment of citizen involvement. The EPA Superfund program focused on human health and ecological risk, whereas the AOC focus is on lake beneficial use impairments. Both programs require remediation to reduce or eliminate risks or use impairments before a site can be delisted. While there can be overlap between these two foci (e.g., the health effects behind the restrictions on fish consumption), they can also lead to different definitions of the problems at a site. At Torch Lake the Superfund program identified blowing stamp sands as the primary human health threat, and degradation of the benthic community as the primary ecological health problem. The AOC program, however, focused on restrictions on fish consumption (originally due to the presence of tumors in fish) and the degradation of the benthic community as the two major beneficial use impairments (BUIs). By creating differences in the definition of the contaminant problem at Torch Lake, progress toward remediation was limited. Superfund moneys were spent exclusively on capping and revegetating the sands. The AOC program witnessed little progress in resolution of its defined problems due to lack of funding. From the view of local residents, it appeared that, with the more visible and active work on covering stamp sands and the eventual delisting of the Superfund site, all problems were resolved. This confusion persists today in the local population. The difference in problem definition has enabled much of the Superfund site to be delisted despite the persistence of two BUIs that the local residents are just now beginning to realize.

Third, from the outset, a polarization of viewpoints has existed with one party claiming that no serious problems exist and therefore advocating for immediate delisting of the site, and a second party advocating for more thorough investigation and remediation. These polarized parties have included government agencies (some of whose viewpoints have switched over time) and local groups of citizens. When Michigan Department of Natural Resources (MDNR) completed the first Torch Lake RAP in 1987, the tug of war began between MDNR who favored elimination of the AOC site and the EPA and IJC who advocated more study and eventual remediation. Eventually, EPA's progress in stamp sand remediation led to the delisting of Torch Lake from the National Priority List and the appearance that EPA work at the site was completed. However, upon transfer of operation and maintenance of remedial actions to the State of Michigan, the MDEQ recognized the existence of several critical remaining problems. As a result, since the early 2000's MDEQ has been an advocate for continued research and remediation at Torch Lake—a reversal of the early state position. Multiple emergency removals were conducted by EPA's Superfund Division after the delisting of portions of the Superfund site; these again raised questions in the public mind as to the safety of the site and the efficacy of the prior remediation. The changing positions of state and federal agencies over several decades and the illogical sequence of emergency clean-up after remediation was completed has confused the general public about the actual state of affairs, leading to the impression that different government units are polarized in their conclusions. From the government's perspective, the often vitriolic public criticism of remediation efforts or plans combined with other public calls for more thorough clean-up have left the impression that the local public is divided and lacks a clear vision for the lake's future.

Finally, a few conclusions reached early in the site investigation that may have been justified based on available knowledge at the time were never re-evaluated as new knowledge and tools became available. For instance, the enormity of the problem engendered a pessimistic attitude on the part of government officials from the outset. It resulted in no effort to remediate the lake sediments that would resolve the problem of degradation of the benthic community. The enormity of mining waste in the Keweenaw Peninsula and the complexity of the pollution located at the mineral processing sites along Torch Lake made it difficult to characterize clearly the health and environmental hazards facing the region. Early signs of pessimism are found in AOC and Superfund documents. The 1987 RAP spoke of the impossibility of remediating the massive amounts of stamp sands (200 million metric tons) covering the entire lake bottom. The 1994 ROD for Superfund Operating Unit II (the lake sediments) picked up on this theme and used it as the reason for not evaluating alternatives for remediation. Self-recovery of the lake through natural sedimentation processes was proposed and viewed as the only feasible option, but it was never quantitatively evaluated. This pessimistic outlook created a force for inaction, became embedded within the remediation plan, and allowed the EPA to claim Superfund programmatic progress even in the absence of progress towards recovery of the ecosystem. In addition, because the "remediation" involved no action on the part of EPA to restore the benthic (sediment) community, the agency decided that no monitoring of the sediments for effectiveness (of inaction) is required.

Another early and erroneous conclusion was that fish contaminants were not from local sources. This conclusion led the MDNR to advocate for removing the site from the AOC program in the early 1990s. Despite the development of analytical tools that can identify sources of PCBs, these were not applied in Torch Lake for 15 years after they became available. Tools (stable isotope analyses) are now available for identifying sources of mercury, but they have not yet been applied in Torch Lake. Similarly, devices (passive samplers) widely used for over 20 years to trace the sources of contaminants have not yet been utilized for this purpose in Torch Lake. Mass balance modeling is a tool that has been used for identifying sources of contaminants since the 1980's, but it was never applied by government agencies at Torch Lake. The long duration of the remediation guarantees that knowledge and tools will evolve during that process. At least at Torch Lake, the two remediation programs seem to have repeatedly reiterated decisions made early in the process rather than continuing to apply the best tools available to re-evaluate early decisions.

The multiplicity of governmental agencies and nongovernmental groups working on Torch Lake is potentially bewildering (Chapter 5), and without integration also can be an impediment to progress. Federal agencies include the EPA (Superfund program, AOC program), the Agency for Toxic Substances and Disease Registry (ATSDR) of the U.S. Dept. Health (health assessments required as part of Superfund), the Dept. of the Interior (National Park Service), the U.S. Geological Survey (hydrologic monitoring), and the National Oceanic and Atmospheric Administration (bathymetric mapping). State departments include the MDNR (fish stocking and assessment, contaminant monitoring); Michigan Dept. of Health and Human Services (contaminant monitoring, fish consumption advisories, public health assessments for ATSDR); the State Historical Preservation Office (SHPO); and multiple offices with the MDEQ including the Office of the Great Lakes (AOC program); the Superfund, Compliance and Enforcement, and Program Support sections of the MDEQ Remediation and Redevelopment Division (Superfund operation and maintenance, Part 201 compliance); and the MDEQ Water Division (Clean Water Act requirements). Each office or agency looks at their narrow legal mandates, and there is no requirement for integrated management at the site.

The four points discussed above and the bewildering array of government entities involved have had a significant effect upon citizen engagement in the four-decade search for solutions at Torch Lake. Citizen involvement has varied over time (Chapter 4). Citizens shifted from being substantially involved in monitoring research and early government actions toward general inattention and seeming disinterest. Local efforts, particularly in Lake Linden and Hubbell, drove the research and listing process in the 1970s and early 1980s. The official listing of Torch Lake as a Superfund site and AOC, while encouraging citizen engagement, seemed to dampen actual participation. The initiation of the Superfund process (hazard ranking and remedial investigation, 1985-1992) resulted in a one-way communication system where EPA assumed the role of educating the public on the problems present and the options for remediation, and local residents became less active and inattentive. Release of the Record of Decision (1992-1994) brought more interest and scrutiny to Superfund processes. Community response split into two diverging positions: some community members called for a “No Action” decision that would remove Superfund listing. Others called for a thorough remediation plan and more investigation. The founding of the Public Action Council (PAC) for the AOC process (1997) marked a turning point in local engagement, as it allowed a local citizen’s committee to work with both Superfund staff and the AOC program at Torch Lake. For the next 15 years, the PAC would be the face of the local citizenry to the government agencies. In this time, the PAC was actively engaged in facilitating progress of the

Superfund remediation. The prolonged process of delisting from the Superfund program (2002-present) that happened concurrently with the AOC program's push for further study of the causes of the BUIs led to confusion within the PAC and the local community as to what problems remained and what could be done about them. As this confusion was allayed, partly through the information dissemination by the IA team as well as by MDEQ's Abandoned Mining Waste Program, the PAC once again became active in seeking to clarify what actions could be taken to solve the remaining problems. The interaction of the PAC and the governmental agencies contained elements of mistrust and dislike of government "intrusion" into local affairs, but also an eagerness to solve the contamination problems so that local communities could safely develop and use their resources.

Problems that Remain at Torch Lake

Several problems with ore processing wastes still remain at Torch Lake that have not been resolved by either the Superfund or the AOC programs. They pose risks to both human and environmental health. There remain two Beneficial Use Impairments under the AOC listing that should be addressed. Further, there is evidence of contamination in locations on the shoreline and in sediments along the water's edge that have surfaced and need remediation.

1. Fish Contamination.

Although the fish tumors reported between 1970 and 1986 have disappeared because the causative agent likely disappeared (Chapter 6), issues of fish contamination remain in Torch Lake. The Beneficial Use Impairment related to fish tumors under the AOC program was removed in 2007. However, re-evaluation of evidence of high levels of mercury and PCBs in the fish prompted fish consumption advisories in 1993 (mercury) and 1998 (PCBs) that still persist today (Chapter 7). The BUI related to restrictions on fish consumption remains in effect today. The Superfund program never responded to the evidence evaluated in their early risk assessment for local sources of mercury and PCBs. This report assembles all monitoring records by EPA, MDEQ, and MDNR and discusses the history surrounding the identification of PCBs and mercury contamination. We conclude that contrary to MDNR assessments that argue for a decline in concentrations of PCBs and mercury in Torch Lake since the 1980s, that in fact there is evidence of increased concentrations in Torch Lake fish. This report provides a thorough historical comparison of fish consumption advisories in Torch Lake and its control sites, and demonstrates that consumption advisories for both contaminants in fish have consistently been stricter in Torch Lake than in the control sites. As a result, we argue that there is no basis at present for removal of this BUI. In fact, mass balances for both substances point to continued local inputs of mercury and PCBs to Torch Lake that were caused, indirectly, by mining. Archival research on industrial buildings and processing practices documents the sites where PCBs were used in electrical transformers. The types of PCBs present as well as mass balance calculations clearly point to ongoing inputs of locally-derived PCBs. Similarly, mass balance calculations suggest that mercury inputs from mine drainage, uncovered over a decade ago by the MDEQ, may contribute significantly to the total input to Torch Lake. Identification of these local sources is a prerequisite for clean-up and ultimate removal of the second BUI associated with fish consumption restrictions.

2. Benthic Community.

Similarly, there is little evidence of an improvement in the condition of the benthic community, and hence this AOC BUI still persists in the lake (Chapter 8). A surprising finding of this Integrated Assessment was that there has been no effective monitoring of the benthic community; only four historical benthic surveys were identified over the past 45 years, and no two visited the same sites or used the same protocols. In contrast, the toxicity of the sediments has been thoroughly established. Toxicity to macroinvertebrates, bacteria, fish, and zooplankton has been shown. Toxicity to fish eggs and effects of the sediments on spawning success have not been adequately evaluated. While trends in benthic populations have not been monitored, the combination of mapping of the extensive historical measurements of copper in the lake sediments, recent studies showing high copper concentrations in near-surface sediments, and the extensive toxicity testing of the lake sediments give little reason to expect improvement in the benthic community.

An impediment to action in the AOC program has been the uncertainty regarding the source of metals in the sediments. To what extent are metals eroding from shoreline sites, being brought in by tributaries from the catchment, or diffusing upwards from the massive stamp sand deposits in the lake? This project reviewed the available evidence and concluded that the sediments within the lake are the largest source. Sediment traps placed throughout the lake clearly showed that erosion of shoreline material was not responsible for high copper concentrations in recent sediments. Tributary monitoring, while sporadic, does not indicate that the catchment is the major source. Sediment cores along a transect from the eastern shore to the center of the lake showed profiles that would be created by upward movement of metals in the sediment porewaters. The cores also revealed very slow rates of accumulation of new sediments, and suggested that hundreds of years might be required for copper toxicity in the sediments to be naturally attenuated. Despite this recent evidence, the EPA has dropped its requirement for continued monitoring of sediments and benthic organisms. The sentiment expressed in the 1987 Remedial Action Plan that sediment contamination in this lake is a problem too big to remediate prevented any assessment of remedial alternatives. This report suggests that alternatives worth evaluating do exist.

3. Problems outside AOC scope and never addressed by Superfund.

The Integrated Assessment (Chapter 9) provides a cursory examination of a variety of problems that have received little attention during 35 years of remediation. Not all of these problems lie within the purview of the AOC program, yet were never fully investigated or were ignored by the Superfund program. They include contamination of soils, sediments, and water in and surrounding Torch Lake. These problems include:

- Widespread soil contamination from airborne contaminants released from the numerous industrial smokestacks;
- Deposits of metal-rich sludges such as found in 2007 at the Lake Linden beach;
- Other waste streams (coal ash, slag) and contaminants (arsenic, PAHs) that were never adequately characterized;
- Concentrations of several trace metals in lake water above the state's water quality criteria;
- Physical hazards from derelict buildings, machinery and refuse;
- Contamination in Boston Pond and Calumet Lake – the latter drains into Torch Lake and the former is included in the larger Superfund area;
- An abundance of marine debris on the bottom of Torch Lake including 800 barrels, some of which may contain industrial wastes;
- Sections of the lake at both the north and south ends that were isolated from the rest of the lake by stamp sands such that water quality, habitat quality and aesthetics have been impaired.

Conclusions

The Integrated Assessment indicates that the prolonged time required for remediation at this site has resulted from failure to consider the historical record, programmatic issues within government agencies, and the inability of a local group of stakeholders to coalesce and remain engaged in the remediation process. The Integrated Assessment illustrates how an understanding of historical activities can help to explain (and to predict) what wastes are present and where they are most likely to be located. Remediation of a complex site such as Torch Lake would benefit from an initial investigation of historical industrial activities. Review of the remediation history at this site identified several programmatic obstacles that have hindered progress including lack of funding, too narrow definitions of the problems, and failure to continue to use new tools and knowledge to evaluate what could be done. While the multitude of agencies involved at the site could have resulted in a diversity of viewpoints and options being considered, that did not occur here in part because only one agency at a time had funding for supporting site investigation. A clearer mandate for inter-agency cooperation and integration of effort might have helped both to provide diversity of ideas and to promote use of new knowledge and tools. Public engagement varied considerably over time in response to the clarity of information available, the changing perceptions as to whether the problem was solved, and the degree to which such engagement was promoted by the agencies. Public engagement was instrumental in drawing attention to this site initially, but waned once government programs assumed control. The history of public engagement suggests that involvement of a diverse group of local stakeholders could play an invaluable role in achieving remediation and help to circumvent some of the agencies' limitations.

Figure 5. Photograph of last standing steam stamp at the remains of the Ahmeek stamp mill in Tamarack City. (1990)

Chapter 1. Introduction

1-1. Overview

Current conditions at Torch Lake, Houghton County, Michigan, are the result of about 100 years of copper mining, the subsequent dismantling and repurposing of mining facilities, and the most recent 35 years of remediation. While other regulatory agencies and programs have been involved, the two major programs have been the U.S. federal Superfund program and the Area of Concern (AOC) Program implemented under the Great Lakes Water Quality Agreement (Annex 2). Both programs have involved local stakeholders, albeit in different manners and for different reasons. The Superfund Program views the Torch Lake site as a successful remediation, and has largely delisted the component sites from the program. The AOC program, in contrast, maintains that two significant impairments to human's ability to beneficially use the site (i.e., Beneficial Use Impairments or BUIs) remain. As will be described in detail later, other contradictions among regulatory agencies or programs exist as well. The contradictory conclusions of the regulatory programs that ostensibly serve to protect human welfare are but one facet of the "*wickedness*" (Rittel and Webber, 1973) of the Torch Lake AOC problem.

Another facet of this *wicked* problem has been the weak engagement of the multiple and diverse stakeholder groups in decision making. The history of stakeholder involvement at this site illustrates well the inherent difficulties of representing all stakeholder voices (Gorman, 2001). Although an effort was made initially to include representatives from diverse stakeholder groups in the AOC's Public Action Council (PAC), the group gradually evolved into a smaller, less representative body. In addition, meetings became infrequent and eventually ceased. Several voices from the community, environmental organizations, and tribal interests disappeared from the PAC, as their representatives left and were not replaced. The EPA's public involvement consisted mainly of public meetings to inform the public of work proposed or already accomplished; while comments were recorded and addressed, there was little effort made to engage the public in the decision making. The EPA's press releases and web sites about the delisting of the sites from the Superfund program deliberately gave the general public the impression that the remediation had been successfully completed. Similarly, the absence of funding for this site from the two major programs funding restoration of Great Lakes sites, the Great Lakes Restoration Initiative (GLRI) and the Great Lakes Legacy Act (GLLA), suggested that this site either needs no further remediation, is low on the priority list for further remediation, or has no entity spearheading remediation efforts. As a result, many stakeholders were not aware of the unresolved problems, and had no role in the decision-making process prior to the funding of this Integrated Assessment.

Because of the complexity of the problems involved and the difficulty of resolving them in the previous thirty years, in 2011 Michigan Sea Grant funded three researchers at Michigan Technological University (MTU) to perform an Integrated Assessment of the Torch Lake Area of Concern from 2/1/2012 through 1/31/2014. The objectives of the project were: 1) to gather and to summarize existing information regarding conditions in the AOC; 2) to communicate with stakeholders information about the status of the site as well as stakeholders' ideas for and visions of future conditions in the AOC; and 3) to identify and to begin to evaluate potential remedial actions that could mitigate any remaining undesirable conditions. A particular focus of the project was the two remaining Beneficial Use Impairments (BUIs) of the AOC program: Degradation of the Benthos and Restrictions on Fish Consumption. A unique feature of this project was the application of research into the industrial history to clarify the genesis of, the specific components of, and the spatial and temporal distributions of the problems at the site. The historical research included extensive review of materials from the MTU archives as well as interviews with local residents with memories of the industrial activities and the post-industrial period of reclamation. As part of the project, a series of Fact Sheets were prepared and distributed, multiple presentations were made to local stakeholder groups, and multiple meetings between project personnel and government agency resource managers were held, that eventually led to discussions toward formation of a Torch Lake watershed organization. Arguably, the project has had major impacts on the trajectory of remediation that is now being pursued at the site. This Integrated Assessment report is the final summary of the Sea-Grant-funded project that documents the information assembled about the Torch Lake site. The majority of this report deals with the first objective, but we briefly summarize here the activities taken to meet the second objective. The third objective was dropped because it was too ambitious for the timeframe and funds of this project.

The project progressed from information gathering to information dissemination and idea exchange. Accordingly, the initial meetings were with stakeholders and knowledgeable groups (Table 1-1) to educate the researchers about historical facts. Throughout the project, the researchers maintained regular contact with MDEQ officials to keep informed of developments as well as to share findings. Outreach and information dissemination activities fell into three major categories. First, presentations were made annually at regional and international conferences to share project results with the larger scientific and policy communities. Second, presentations were made in multiple venues (local libraries, churches, and schools; small group meetings in multiple locations; excursions around the lake) to local stakeholders. Third, the researchers presented results formally to agency personnel (MDEQ, EPA, MDCH) via webinars, conference calls, and in-person meetings. In addition, fact sheets were disseminated at multiple meetings as well as posted on the web, and a short update on the site was published in the Binational Forum Newsletter. In response to public interest, multiple meetings were held towards the end of the project to examine the feasibility and utility of forming a watershed planning council. Further details on post-project activities is found in the Time Line in Chapter 2 and in the Epilogue.

Table 1-1. Summary of stakeholder interactions during the Torch Lake Integrated Assessment

Date	Meeting/Activity	Location	Attendees	Summary
Information gathering				
10/26/2012	Former PAC members	MTU	PIs, former PAC member	Discussed early years of PAC activity
May 2012 Oct. 2012	SPAC	Houghton Lake Kalamazoo, MI	N.Urban J. Perlinger	
Sept. 11-12, 2012	GL Restoration Conference	Cleveland	SPAC members from multiple states, C. MacLennan	
Dec. 7, 2012	Historic preserva-tion stakeholders	MTU	PIs, KNHP staff	Discussed KNHP activities, sites of interest on Torch Lake
Dec. 12, 2012	Former MDEQ staff	Houghton	PIs, former MDEQ Superfund staff	Discussed recent history, current priorities for MDEQ
Information and Idea Exchange				
1/31/13		Conference call	PAC, MDEQ, MDCH, EPA, IA PI	
May 9, 2013	MDEQ Superfund staff	MTU	PIs, R. Delaney – MDEQ Superfund	Discussed ongoing activities, MDEQ needs
Aug. 16, 2013	Agency update	Webinar	Personnel from EPA, MDEQ and MI Sea Grant, PIs	PIs provided update on PCB modeling

Date	Meeting/Activity	Location	Attendees	Summary
Aug. 28, 2013	Local environmental stakeholders	MTU	PIs and Representatives from FOLK, HKCD, KBIC, KLT, TU	PIs provided update; discussed visions for lake, paths for sustained improvements
Sept. 23, 2013	PAC, MDEQ	MTU	PIs, PAC, MDEQ Division Head	Discussed PCB work
Oct. 29, 2013	MDEQ	MTU	PIs, MDEQ personnel	Discussed PCB sources
Outreach/Information Dissemination				
2013	MDCH Public Meeting	Lake Linden High School	MDCH, MDEQ, IA PIs, public	
6/2013 6/2014 6/2015	IAGLR	Purdue Univ. McMaster Univ. Univ. Vermont	PIs, grad students, EPA personnel	3 presentations 3 presentations 1 presentation
6/2013	Society for Industrial Archaeology	Minneapolis	E. Schwaiger	1 presentation
Summers of 2013 through 2016	Ride the Waves	Torch Lake and shoreline	School and community groups (~200 participants)	Outreach program funded by GM to educate school children on water-related science
Oct. 1, 2013	HS boat outing on TL	R/V Agassiz on Torch Lake	Lake Linden High School Biology class	Demonstrated impacts of mining on lake
10/13/2013	UU Mining forum	Unitarian Universalist church	Public, UU members, IA PIs	1 presentation
4/15/2014 4/22/2014	Library talks	Lake Linden Lib. Houghton Library	Public Public	PI presentation to public of outcome of IA project
Sept. 15, 2014	4th Thursday in History	KNHP, Lake Lindent	C. MacLennan, public	Presentation on mining legacy of Torch Lake

Date	Meeting/Activity	Location	Attendees	Summary
May 26, 2015	Watershed planning	MTU	C MacLennan, HKCD-led watershed plan-ning participants	presentation on IA work
July 22, 2015 July 30, 2015 July 28, 2016	Geo-Heritage Tour	Torch Lake, Gay stamp sands	N. Urban, public C. MacLennan, public C. MacLennan, public	Presentation on history of mining operations
Jan. 19, 2016	Natural History Lecture Series	Carnegie Museum	C. MacLennan, public	Legacy of mining at Torch Lake
Feb. 10, 2016	HKCD public information session	Lake Linden High School	PIs, public, MDEQ	Session to inform public of status of Torch L.

The authors of this report perceived a great desire for information on the part of the local citizenry. Public meetings organized by the authors were generally well attended (15-50 people). Torch Lake became a Superfund site in the years when EPA's approach toward public engagement was largely a one-directional information flow. As documented in Chapter 3, the Public Action Council formed through the AOC program did not encompass all stakeholders nor see their role to be one of informing the public. The Integrated Assessment project provided a means of enhancing information exchange that had not existed previously.

In addition to the information exchange documented in Table 1-1, the PIs also used written fora to disseminate information about Torch Lake to local and regional stakeholders. The PIs provided updates on the status of work at Torch Lake that appeared in newsletters of the Binational Forum (June 2013) and the Keweenaw Bay Indian Community Natural Resources Department (Fall 2013). Fact sheets were created, disseminated at public meetings, and posted on the project web site.

The remainder of the report is organized in a chronological fashion. Chapter 2 describes the industrial period at Torch Lake (1840-1970) that gave rise to many of the problems. Shaping the waste streams and driving the pollution around the lake were the copper processing technologies developed in response to metal market conditions (1880-1920) and the repurposing of the industry in response to decline of the district (1930-1970). This chapter seeks to link the industrial activities with the waste streams produced and summarizes whatever information was found regarding the disposal of those waste streams. Chapter 3 details the “reclamation period” (1970 to present). This chapter provides important insights into why the problems were not resolved in the 45-years following the cessation of the mining activities. Chapter 4 summarizes the roles of all of the government agencies involved at the site. Chapter 5 discusses the extent and nature of citizen engagement at the site. The next three chapters summarize the status of each of the original BUIs of the AOC program. Each chapter reviews the historical actions taken to understand and to resolve the problems; each chapter summarizes the current status of the use impairments. Finally, Chapter 9 provides a brief discussion of some of the other environmental issues that were not included in the AOC problem definition and provides the authors’ recommendations for future priorities. A brief Epilogue was added because of the high rate of activity at the site since the official ending of this project (12/31/2014); the Epilogue highlights important recent developments.

1-2. Approaches to the Problems at Torch Lake

One insight that came from this project was the importance of the “problem definition” to the subsequent trajectory of “reclamation” activities. An incomplete problem definition necessarily leads to incomplete remediation. Neither the dismantling of industrial facilities nor remediation at Torch Lake has been completed in the sense that derelict facilities, physical and chemical hazards, and environmental degradation still persist (MDCH, 2013b, 2014c). These remaining problems were a result of the fact that none of the remediation programs operating at Torch Lake, singly or in combination, represented comprehensive solutions to the “problem”. Each focused on a small portion of all of the types or locations of contamination, a portion of the environmental or use impairments, or a portion of the hazards present around the lake. The Superfund (SF) program focused all remediation actions on capping of the above-water stamp sand piles in order to reduce air entrainment of metal-rich dusts and, secondarily, to reduce metal inputs into the lake. The U.S. Environmental Protection Agency’s (EPA’s) Emergency Removal program has, on multiple occasions removed highly contaminated soil and sediment that posed an imminent threat to human health; they did not, however, systematically look for locations of such contamination with the exception of the 2007 Weston survey (U.S.EPA, 2007b). The Area of Concern (AOC) program at this site focused exclusively on the impaired uses of resources within the lake; contamination on the shoreline is considered if it contributes to impairment of the use of resources within the lake. The limited scope of remediation results, in part, from the specific legal mandates of each program and agency. This Integrated Assessment (IA) seeks to be comprehensive, but it also restricts itself to problems resulting from mining activities within the watershed of Torch Lake (TL). Therefore, this IA will not address problems related to mining but located outside of the TL watershed even if those locations were included within the TL SF site.

Even once the scope of the assessment is defined, there are multiple ways in which problems may be defined and categorized. Problems could be categorized according to type of waste, source of waste, geographic location, relative risk, pathway of exposure, environmental medium, or other attributes of the site and its wastes. Following a ranking of risks in terms of hazard and exposure pathway, the EPA-run Superfund remediation of Torch Lake ultimately categorized the problem within a limited environmental setting that encompassed only some mining sites. After a preliminary investigation, EPA identified three Operable Units that were defined by their geographic setting (lake shore tailing/stamp sand piles, lake bottoms, and stamp sand piles not adjacent to Torch Lake). This classification facilitated remediation of each Operable Unit; all parts of a unit were treated identically, and each unit was delisted separately (or in subsections) once work on that unit was completed. However, the hazards considered by the EPA were not comprehensive; industrial chemicals used on site, plumes of air contaminants, and concentrated wastes generated by specific industrial facilities were not adequately measured and consequently their risk also was inadequately assessed. Omission of those hazards led to a greatly restricted land area being included within the Superfund site.

The AOC Program defined the problem in terms of Beneficial Use Impairments. To be considered in the AOC program, use impairments must occur in the waterway; the watershed is considered only to the extent that contaminants causing BUIs may originate in the watershed. The location at which a use-impairment is experienced may be different than the location of the cause of the use impairment, and the timescale for recovery of a use-impairment may be different than the timescale for treatment of the cause of impairment.

This IA will use a variety of methods to describe and to categorize problems in the TL watershed. We use historical research to understand what wastes were generated by the mining industry, where they were generated, where they were discarded, and the timeline for generation and disposal (Chapter 2). A historical policy analysis of government involvement at TL highlights agency perceptions and responses, emphasizing that problem definition and remediation solutions reflect the mandates and current state of research of government programs (Chapter 3). Chapters 4, 5 and 6 attempt to show the policy decisions in the context of the scientific knowledge at the time as well as the current scientific understanding.

It is also useful to summarize the problems in terms of environmental media. People encounter contamination by mining-related chemicals either from air, soils, lake water, or from fish. This categorization clarifies routes of exposure and facilitates calculation of total exposure and risk of health effects. Regulatory mandates of agencies are often specific to a single environmental medium. Table 1-2 summarizes the wastes discussed in detail in Chapter 2 and indicates the environmental media affected by each waste. This table is similar to Table 2-1 in the Final Ecological Assessment, but there are many omissions from that table. Those oversights are, in part, why so many surprises happened during the remediation years.

1-3. Hazards to people at Torch Lake

Many misperceptions persist about the hazards present at Torch Lake. Some people believe many more hazards exist than those covered in this report, while others will claim that few if any significant hazards to people are present in or around the lake. Many of the issues discussed in this report are not imminent hazards to people. A goal of this report has been to discuss as many issues as possible, including some that have not been widely discussed in the past. This report does not seek to quantify or to rank the risks associated with the problems that are discussed. Risk depends, in part, on the values of the people involved; by laying all of the issues on the table, we hope that concerned citizens may, in the future, rank these issues according to their priorities. Nonetheless, we do want to point here to two of the known health risks that exist around the lake. These include:

- Fish consumption – the Michigan Department of Health and Human Services (formerly, Dept. of Community Health) has issued Fish Consumption Advisories for some of the fish in Torch Lake because contaminants in the fish are at high enough concentrations to pose a risk of adverse health effects.

- Exposure to metals and other toxic substances in the soil around the lake – This study presents maps showing the locations where substances had been measured prior to 2015 at concentrations above the Direct Contact Criteria adopted by the State of Michigan. These sites are largely adjacent to former industrial buildings; more extensive characterization of these sites was performed by MDEQ in 2015-2017. However, extensive soil testing has never been conducted in the town or in residential areas downwind of historical industrial sites, and no data exist to prove or disprove the safety of those soils for residential development.

Table 1-2. Summary of chemical hazards identified in and around Torch Lake.

Environmental medium affected	Hazard	Source of waste
Air	Copper, lead, chromium, arsenic, mercury	Wind entrainment of fine-grained mine tailings – largely mitigated by capping of stamp sands
	Asbestos	Wind-entrainment from industrial sites
	PCBs, mercury, lead, PAHs	Emissions from distant sources, local burning of electrical wastes, stack emissions
Soil	Copper, lead, chromium, arsenic, mercury	Smelting (slag), Milling (stamp sands, tailings), Extraction (spent leachate, sludges), stack emissions
	Asbestos	Industrial refuse
	PCBs	Disposal of insulating and lubricating oils primarily from electrical generation and distribution
	PAHs	Stack emissions, coal dust and ash
Water	Copper, lead, chromium, arsenic, mercury	River inputs, mine tailings in lake, groundwater flow through stamp sand piles
	PCBs	Disposal of waste oils, migration from contaminated soils
	PAHs	Stack emissions, coal tar creosotes used in flotation, coal ash
Fish	PCBs	Bioaccumulation from contaminated lake water and sediments
	Mercury	Bioaccumulation from water; mercury enters lake from abandoned mines, from mobilization of atmospherically deposited mercury in the watershed. Atmospherically deposited mercury originates both from distant sources and from local emissions during mining period.

Chapter 2. Industrialization of Torch Lake – a History

The industrial history of Torch Lake reveals information vital to the resolution of the contamination in the lake and on shore from copper processing. For over one hundred years, between 1860 and 1970, the western shoreline was an industrial district reminiscent of the large manufacturing districts of its era. It was densely populated with stamp mills that ground copper-bearing rock from the mines, the most modern steam and electrical power systems of its time, a continuously operating smelter, and three large, complex facilities that reclaimed copper from stamp sands and scrap material through chemical processing.

The evolution of industrialization on a lake once the domain of an Ojibwe fishing culture brought significant changes to the waters and sediments, the air above, and the soils and vegetation of Torch Lake. Pollution occurred in many forms and these waste products changed over the life of the district, with consequences for both human and environmental health. As the C&H and Quincy Mining Companies adopted improved technologies, processes changed and so did their waste streams and the impact upon the lake environment. After an introduction to the pre-mining era, this chapter discusses the specific industrial activities (milling, smelting, reclamation, power production), how they changed over time, and the specific waste produced at each stage. Knowing this history makes identification of specific hazards and their locations possible.

2-1. Early Human Use and Settlement of Torch Lake Region

Torch Lake, once a remote lake produced by the receding Wisconsin glaciers nearly ten thousand years ago, has a long history of human use. From early archaic Eastern Woodland Culture communities until the initiation of industrial copper mining of the late 1800s, Torch Lake experienced relatively limited human impact. Archaic and then Ojibwe migrations into the Lake Superior basin surely crossed through the Keweenaw Peninsula, some exploiting the native copper deposits located there. Ojibwe settlements at the foot of Keweenaw Bay kept summer camps and gardens located along Portage Lake near today's towns of Houghton and Hancock. Along with the rich blueberry landscape at Rice Lake and the Torch Lake and Portage Lake fisheries, this region was an important resource base during summers.

With arrival of Europeans in the 1600s into the Great Lakes region and the developing fur trade that depended upon Ojibwe trappers, the first significant consequences of human environmental actions were registered by the depletion of beaver populations throughout all the major waterways. However, the advent of European mining practice in the 1840s swept the Keweenaw Peninsula into the North American industrial age with even more significant environmental consequences in its wake. By the 1880s the Lake Superior copper mining district was an industrial zone. The epicenter of mineral processing in the Keweenaw between 1880 and 1960 was Torch Lake, and to a lesser extent, Portage Lake and the shores of Lake Superior. As a result, the human footprint on the region changed dramatically.

Archaic Indian and Ojibwe impacts on the surrounding Torch Lake were limited primarily to the effects of fishing, hunting game, and the fires associated with blueberry gathering. Europeans (French and British) traders encouraged collection of beaver pelts, causing eventual depletion of the population in the region and the attendant effects on surface waters as beaver dams and diversions declined.

This changed in the 1830s and 1840s with the travel of American explorers and geologists through the Keweenaw district and their notice of copper deposits. At a time in US history when copper was becoming an important metal for brass products in a nascent industrial New England district, the Keweenaw came to the attention of the US government who envisioned the acquisition of a strategic American mining district. Early mining settlements appeared in the 1840s with the Cliff Mine near Eagle Harbor as the most notable. Predating the more intensive industrial mining era, operations such as those at Cliff and other smaller facilities in the upper part of the Keweenaw Peninsula experimented with technologies for stamping the rock extracted from mines and then shipped their products off to smelters on the southern Great Lakes for processing. These mills, relying on the damming of inland streams for “mill ponds” deposited coarse-grained tailings (known as stamp sands) in the vicinity of the mills along streams and rivers. Evidence of these deposits that occurred up into the 1870s on inland sites throughout the Keweenaw, remains today.

Before the 1860s, Torch Lake—its waters and shorelines—remained relatively free of mine operations. The first two mills appeared in the 1860s and 70s in Lake Linden—Hecla and Calumet. Soon thereafter, the Torch Lake Canal Co. (owned by C&H) dredged the canal connecting Torch and Portage Lakes. The 1880s brought new mills in Hubbell (Tamarack) and Mason (Quincy #1). By 1910 the western shore was populated with eight mills. Thus began the rapid industrialization of Torch Lake between Lake Linden and Mason. In all, by 1970 there had been a series of eight mills, one smelter, a major power house, three reclamation facilities, two coal handling docks, and a series of support buildings in operation at various times.[1] All used Torch Lake as a waste disposal site.

A short summary of mining, milling, smelting, and reclamation practice is helpful at this point. For more details on the following summary, the reader is referred to Benedict (1955), Lankton (1982), Laberge (1994), and Bornhorst and Rose (1994). Throughout much of the Keweenaw Peninsula, copper was found in its elemental (native) form and occurred as large masses (these were called float, mass or barrel copper and represented only ~2% of mined copper) deposited in veins or fissures in the rock, as small (few millimeters to ~one centimeter) globules filling holes left by gas bubbles in the basalt (amygdaloidal basalt, ~60% of mined copper), or as fine particles among the cementing matrix of the sedimentary conglomerate rock (~40% of mined copper). The basalt and conglomerate rock contained the majority of the copper, and occurred in alternating layers in the rock strata known as the Portage Lake Volcanics. Copper in the basalt and conglomerate ore was termed "stamp copper" because the ore had to be crushed (stamped) to liberate the copper particles. Ore was mined in underground mines, the deepest reaching to 9,000 feet below ground level. The material brought out of the mines to the surface "rock houses" was ground (mechanically after 1873) and separated into "poor rock" (rock with too little copper to warrant further processing) and ore (on average, 2% copper content). Torch Lake was a combined milling, smelting, reclamation, and power generation site for both Quincy and Calumet & Hecla (C&H) Mining Companies. Narrow-gauged railroads transported the ore from the rock houses to milling facilities (stamp mills) along the lake where steam stamps crushed the ore to particles ranging from tenths to several tens of millimeters in size. These particles were entrained in a flow of water (often containing surfactants or flotation agents) over devices including buddles, jigs, and Wilfley tables to separate the tailings (stamp sands) from the heavier, copper-rich particles.

The metal enriched material (20-30% copper) was typically sent to smelters to be refined, while the stamp sands were loaded onto launder lines and dumped on the ground, in streams, in lakes or on the shore and in coastal waters of Lake Superior. The smelters, heated with coal, melted the enriched ore and removed impurities from refined copper. In the earlier and simpler reverberatory smelters, melting and refining were done in the same unit. Later (~1920), the two processes were performed in separate units. The refined copper was ladled or poured into molds that, upon cooling,

[1] Research by MacLennan for MDEQ in 2014-2015 documents forty-nine major mining facilities along the western Torch Lake shoreline between 1860 and 1970. Thirty-six were tied to C&H Mining Co. processing. Thirteen belonged to Quincy Mining Co (MacLennan, C., Baeten, J., Pelto, B., Schneider, D., Schwaiger, E., 2014. Historical Archive Research & Mapping at Torch Lake. Phase 1, 2, and 3 Reports, prepared for Michigan Department of Environmental Quality, Abandoned Mining Waste Program.)

yielded ingots, cakes or wire bars of pure copper. The waste molten rock from the smelter was cooled (either in air or water) to yield slag which was dumped in lakes or on the ground.

After 1910, C&H and Quincy incorporated the dredging of old tailings from the lake and processing them in reclamation facilities. Reclamation consisted of regrinding in ball mills and recovery of copper from the resultant fine powder either through ammonia leaching to produce copper chemicals or through flotation in large tanks with frothing agents including xanthates. The copper-rich material from the flotation tanks was sent to the smelter for refining. During and after World War II, the reclamation facilities were used not only for reprocessing of stamp sands, but also for recycling copper from previously manufactured goods (munitions, wire, other metal goods). The use of large volumes of water was critical to all milling practice; the water was required for steam generation, gravity separation processes, and transporting the ore and tailings. Torch Lake was home to the longest continually running smelter of the four located in the Keweenaw. Finally, the Torch Lake district hosted a large power facility that provided electricity to all of C&H and Quincy facilities on the lake after 1940.

2-2. Stamp Mills and Stamp Sands

The volume of stamp sands produced by mills along Torch Lake—often stated incorrectly to fill 20% of the volume of the lake—began the evolution of significant environmental impact upon its water, sediments, and shoreline soils as well as its aquatic and human communities.[2]

Hecla Mining Co. and Calumet Mining Co. (later combined to become C&H Mining Co.) and Quincy Mining Co. built the first industrial-sized mills at Torch Lake in order to overcome the problems with processing rock posed by their earlier and smaller mills. The attraction was two-fold: an ample water supply for milling mined rock and permission by the US government to deposit waste rock in the lake. Their activities led to the first significant environmental impact from mining at Torch Lake.

Like many of the early copper mines, Calumet Mining Co. had an early mill in Calumet that was constrained by limited water from streams for its processing. The inland mills of early companies operated by creating millponds from dammed streams, often with limited water supplies in dry periods. Quincy Mining Co. (as well as Pewabic and Franklin mining companies) located their early

[2] Some references as to 20% of the stamp sand fill in Torch Lake are misleading, and refer to the volume filled in since 1940. The value of 50% is given by Donohue and Associates after their thorough mapping of the lake for EPA.

mills on Portage Lake near the town of Hancock. Their stamp sand waste prompted the US government to encourage these companies to relocate their mills where they would not encroach upon the navigable Keweenaw Waterway. As a result, Quincy built its first of two mills at the south end of Torch Lake in 1888-1890. A second mill followed nearby in 1898-1900.

By 1910, a total of eight mills were operating along the six-mile shoreline. Each mill deposited all of its tailings into nearby Torch Lake creating large fans of stamp sands spreading out into the lake in imperfect semi-circles that continued to grow until each mill ceased operation. Mills clustered around the towns of Lake Linden (Calumet and Hecla Mills), Tamarack City (Ahmeek, Tamarack, Lake #2, and Osceola Mills), and Mason (Quincy #1 and #2 Mills) used Torch Lake as a waste disposal site for tailings laden with copper and other metals. Because of the limited recovery of copper utilizing the earlier mill technologies, some of the earliest deposits of sands were quite rich in copper minerals.

From north to south, Table 2-1 provides a list of mills, their location and period of operation.

Table 2-1. Mills on Torch Lake, 1860-1968.

Mill	Dates of Operation	Location
Calumet	1860s-1944	Lake Linden
Hecla	1870s-1921	Lake Linden
Ahmeek	1909-1969	Tamarack City
Tamarack	1887-1919	Tamarack City
Lake Mill #2 (originally Tamarack #2)	1898-1930	Tamarack City
Osceola	1899-1921	Tamarack City
Quincy #2	1900-1921	Mason
Quincy #1	1889-1945	Mason

The mills built between 1870 and 1910 reflected the expansion of the copper industry in scale and location throughout the US which resulted from the electrification of industry and cities. This was an important growth and consolidation period for Michigan copper. Yet, it also was a period of intense competition in the copper market with new districts and mines opening in the American West. Once an important component of brass products, copper soon found a market in wire used for an increasing demand for electricity. The smaller mines and mills would not suffice in an economy that required increased production of copper. Torch Lake (as well as Portage Lake and Lake Superior) afforded locations that provided an unlimited supply of water for milling and a convenient location for dumping increasingly large volumes of tailings. This was also the era in which the Michigan copper district, the dominant producer before 1880, bore the effects of the rise of the Montana and Arizona copper producing districts. C&H was the dominant firm in the Lake Superior region, but it gradually lost its role to Montana's Anaconda production. By 1885, Montana equaled Michigan's production, and by 1887 it became the dominant producer – a position it held well into the twentieth century (Hyde, 1998).

Stamp sand production was considerable. The mills developed a system of movable launders to transport the sands into the lake. When one area filled up, an adjacent area further from shore became the new deposit area. Mining companies mapped their stamp sand deposits, showing the year of deposits as they expanded in rough concentric-like half circles into the lake. Because the mined rock was either conglomerate or amygdaloid, the character of the sands was somewhat different. This mattered more at a later point when C&H and then Quincy decided to reprocess the sands to recover the considerable copper still remaining. During the early years of reclamation, conglomerate sands were processed first because of their higher copper content and ease in processing. From the late 1910s until the 1950s, sands were reclaimed, processed, and then returned in a new, finer form to Torch Lake (to be discussed in detail under section on reclamation). C&H's stamp sands were from conglomerate rock; Quincy sands were from amygdaloid. Sands deposited around Tamarack City contained both types.

Figure 2-1. Osceola, Tamarack, Ahmeek Sand Bank. Source: Michigan Tech Archives, C&H Collection, Maps and Blueprints.

Usually called stamp sands rather than the more common term "tailings" used in western copper districts, the earliest deposits were fairly course from the more primitive mill technologies common in the 19th century. Assays of the sands by the companies revealed a varied copper content, depending upon the source. Also present in small amounts in the sands were other heavy metals, including arsenic.

2-3. Smelting Milled Copper and its Byproducts

Early copper smelting in the Keweenaw was rudimentary, done at small custom smelters, that were replaced by shipment of copper ore to eastern smelters in Boston and Baltimore where Atlantic sulfate copper ores were refined. Unhappy with the copper product, Connecticut brass and copper rolling manufacturers established a smelter in Detroit in 1850 (Waterbury and Detroit smelter) where Michigan's native copper concentrates from the stamp mills were shipped in barrels. In 1860 a similar plant was built in Hancock (Portage Lake Mining Company). Each had one reverberatory furnace and cupola to melt the copper and refine it. The opening of the Sault Sainte Marie canal in 1855 and the dredging of sandbars at the mouth of Portage River in 1860 enabled use of deep-water vessels for regular shipping. C&H smelted its copper at the Portage Lake smelter until it built its own in 1886 on Torch Lake near its stamp mills. C&H followed the Hubbell smelter with another smelter in Buffalo, NY, which ran cheaply using waterpower from Niagara Falls. Tamarack and Osceola Mining Companies built a third smelter in 1888 at Dollar Bay. All had similar technologies, consisting of four reverberatory furnaces in each corner of the building (Conant, 1931).

The 1890s brought improvements in copper smelting. First at C&H's Buffalo plant, an electrolytic facility purified the copper obtained from the reverberatory slag and recovered silver in "paying quantities." The cathode product and the richer grades of concentrates from the mills were combined to create a higher grade of copper product with higher electrical conductivity. When C&H closed the Buffalo smelter in 1914, it opened an electrolytic plant at the Hubbell smelter. At the Dollar Bay smelter, new furnaces were designed where the melted copper flowed into refining furnaces by gravity, and then into molds. In 1905 the Dollar Bay smelter began the practice of using sodium carbonate and lime to lower the arsenic content and raise electrical conductivity of copper. In 1914, C&H began the use of pulverized coal as a fuel in the reverberatory furnaces. It built a coal pulverization plant next to the smelter and not far from the C&H coal handling dock at Hubbell. During this period of transition to more efficient smelting, several mining companies built the Michigan Smelter on Portage Lake near Coles' Creek.

Copper smelters in this district processed more than just ore from the many underground mines (native copper). They also retrieved copper from stamp sands deposited into Torch Lake and from scrap materials imported by rail. Stamp sand processing commenced in the late 1910s. Recovery of copper from scrap began in the 1930s and intensified during World War II. Only C&H's Hubbell and Quincy's Ripley smelters refined copper from dredged stamp sands and scrap.

Table 2-2. Copper Smelters on Portage and Torch Lakes.

Smelter	Dates of Operation	Location
Portage Lake Smelter (became Detroit Smelter in 1867)	1860-1887	Hancock
Dollar Bay Smelter	1888-1919	Dollar Bay
C&H Hubbell Smelter	1887-1967	Hubbell
Quincy Smelter	1898-1970	Ripley
Michigan Smelter	1903-1952	Portage Lake

The C&H Hubbell smelter ran continuously for eighty years—the longest running smelter in the copper district. As it expanded and developed new technologies and processed new materials, its byproducts were distributed into the nearby environment, primarily Torch Lake. Each of the byproducts and pollutants deserve a separate discussion detailing its historical production and disposal.

2-3a. Slag

Slag is both part of the production process and a byproduct to be disposed of once refining is complete. The melting furnaces in a smelter produce both molten copper (sinking to the bottom) and a "slag" of impurities that also include some copper that rises to the surface.

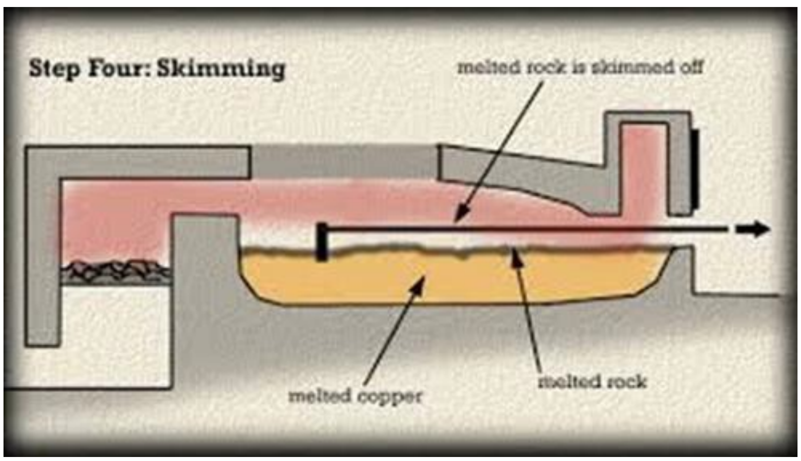


Figure 2-2. Smelter Reverberatory Furnace – Melted Copper and Slag. (Source: Copper Country Explorer. (http://www.coppercountryexplorer.com/2009/11/smelter-tech-the-reverberatory-furnace/)

Smelter operations have typically removed the slag and disposed of it as waste. However, recognizing the high copper content in slag, copper smelters developed a means to collect the more copper-rich slags and send them through the melting process again to recover the metal. C&H was doing this as early as 1929:

> "At the Calumet and Hecla smelter, slag from the "rough" furnaces now is being reground and treated by flotation for copper. A considerable saving will result, but the percentage of copper is not enough to warrant reclaiming metal from the old slag which was dumped into Torch Lake." (Engineering-&-Mining-Journal, 1930)

After that time, some of the skimmed slag was allowed to harden in specially designed rail cars for transporting slag (with sides that opened), and then stored for future processing. Later, in the 1930s, C&H utilized a pumping system to pump "refining slag" to the mineral building for re-smelting.

Prior to this time "waste" slag (which was all of the slag byproduct) was automatically dumped into the lake as it was produced, or after storage near the coal dock under a cover during the coldest winter months when the lake was frozen. C&H gradually developed improved slag disposal systems. When the smelter produced increased volumes of slag in the 1920s with the installation of "jumbo" furnaces and other improvements, it developed a rail car system utilizing a number of specifically designed cars to collect and then dump the slag into the lake.

> "One slag car requires five to six hours to solidify before it can be dumped, which means that C&H needs more slag cars. They must dispose of at least 130 tons of waste slag per day, and each car averages 6.5 tons of slag." (C&H-Mining-Company, 1945)

Figure 2-3. C&H Hubbell Smelter Yard Buildings. Google Map with Building Sites (Prepared by Emma Schwaiger, 17 September 2014)

From oral history interviews and evidence of slag deposits south of the smelter building, it can be assumed that most of the C&H smelter waste slag was dumped into Torch Lake in the vicinity of the smelter building and today's Hubbell beach.

Another improvement in slag waste was "granulating". This is a process by which water is added to hot slag, which then shatters into small glass-like shards. Today granulated slags are used in products such as abrasives. C&H and other companies at the time granulated slag primarily to make disposal easier. The use of pumps in the 1940s separated refinery rich slag from waste slag. The granulated slag waste was then pumped into Torch Lake:

> "We are at present pumping granulated slag from No. 20 furnace at the rate of from 60 to 80 tons per day, most of which is drawn off in the course of a very few hours. We estimate that we may take off as much as 20 tons an hour at some times. This is pumped to the lake with a 6" pump and an 8" pump in series." (C&H-Mining-Company, 1944)

Improvements in retrieving copper from slags continued into the late 1940s. Refined slags that had been used for low-grade copper products improved to the extent that they could be used in high quality commercial shapes. A soda-ash process improved arsenic removal along with the development of an arsenic-leaching process for the removal of this metal from rich soda slags (C&H-News-and-Views, 1949).

> "Never before has copper from a slag charge been refined to the purity required for direct casting into commercial shapes. … The high cost of handling, storing, re-melting and recasting the low grade ingots will be eliminated." (Engineering-&-Mining-Journal, 1949, p10)

Production and disposal of slag was considerable over the 80-year life of the smelter. By the 1950s C&H made slag, its content and handling, and disposal an object of study—all in the name of achieving efficiencies of cost, as well as a source of material for new markets. The company investigated slags for building materials, use in mineral wool industries, and use with asbestos for insulation. In an effort to determine if waste slag could be marketed, C&H's Director of Sales reported in 1950 to a potential buyer that current production of slag waste amounted to 1500 to 1700 tons per month and contained silicon oxide, aluminum oxide, iron oxide, calcium oxide, magnesium oxide, copper and nickel. The current disposal (1950) process was described:

> "The fluid slag is granulated in water, trammeled to remove brick and chunks, which produced a product passing through a ¼ inch mesh screen. That material [is]…loaded into

gondola cars" on a line that carries the product into the lake." (C&H-Mining-Company, 1950)

By the end of the decade, C&H had abandoned the marketing of its slags and returned to dumping them in the lake.

When Universal Oil Products (UOP) – C&H's new owner – closed the smelter in 1968, the quantity of slag piles was measured. Calculation at the time recorded 7,500,000 cu. ft. of granulated slag and 9,600,000 cu. ft. of solid slag. A factor of 20 cu. ft. per ton was used for the granulated slag and 12 cu. ft. per ton for the solid slag. "It must be realized, however, that most of the slag lied under water and the exact measurements are impossible to determine" (C&H-Mining-Company, 1968-76).

2-3b. Other smelter waste

Waste products other than slag from the smelter included coal ash (distinguished by bottom and fly ash), smelter bricks (that were changed regularly), and miscellaneous waste materials from the stamp mills that were brought to the smelter.

Disposal of mill waste: In 1957, C&H reported "all waste materials produced in grinding, jigging, and tabling [from the mills] flow into Torch Lake. Consequently, no additional handling costs are incurred for disposal" (C&H-Mining-Company, 1957).

Coal ash: The smelter produced a considerable quantity of coal ash from burning and pulverizing coal. Initially, stamp mills were supplied with wood for boilers. These were eventually run with coal and also supplemented with electricity from the C&H power plant in Lake Linden. Coal was also used to run the smelter furnaces. The bottom ash residue collected from burning coal was collected by the company and likely deposited in the lake. It contained heavy metals and PAHs (polycyclic aromatic hydrocarbons). Late in its history, C&H investigated the potential of reclaiming the metals from coal ash—particularly copper.

A brief history of coal use and disposal of ash shows that a large portion of the ash was produced at the smelter and the power plant. The first coal pulverization plant was built adjacent to the smelter in the early 1920s, equipped with conveyors that fed the pulverized coal into the smelter furnaces. Pulverization had proven elsewhere to dramatically increase the efficiency of initial melting of copper. In addition, about 25-30% savings accrued from lower fuel consumption (Engineering-&-Mining-Journal, 1924b). In 1947 C&H built a new coal pulverization plant and scrapped the old one. The new plant had a capacity of "11 tons of coal per hour ground to 80 – 85% through a 200 mesh screen" and combined drying and milling of the coal at one time. The older unit, installed in 1924, had pulverized 426,000 tons of coal before it was decommissioned. In 1954 C&H began to investigate profitability of coal ash stored at the smelter. It found that after being put through a gravity concentrator roughly 70% of the copper content is retained. However it proved to be more efficient to use the ash in the fertilizer of C&H's Lake Chemical Co. than to purify it and extract copper (C&H-Mining-Company, 1954). As late as 1967, C&H noted in a document that it was still practicing a direct disposal of coal ash from the Ahmeek mill into Torch Lake (C&H-Mining-Company, 1967). It also illustrates that coal ash deposits came not only from the smelter furnaces, but also from the boiler houses of the mill.

Copper scrap: Scrap copper imported by rail into the C&H smelter yard became another source of mining waste entering into the Torch Lake waters and shoreline soils. As copper deposits from the mines yielded poorer quantities of metal, and the two reclamation plants ran out of high-copper-content stamp sands to reprocess, the company relied more heavily upon scrap products for its smelter. World War II was a boon period for reprocessing scrap. With a subsidized price of copper and encouragement from the Metals Reserve Company to recycle copper materials, the balance tipped toward secondary copper production. This continued into the 1960s, even though the financial return for leaching and smelting copper from scrap declined.

Early scrap material arrived at C&H in the 1930s and processing was relatively simple. High purity copper went directly to the smelter, and clean clad copper was first leached using ammonia to remove brass and copper from steel. By the end of World War II, C&H had established a separate department for secondary copper and developed methods for copper removal from more difficult and less clean scrap.

> "Typical of this class of materials that is now being processed in large tonnage by the Secondary Department is Navy degaussing cable which was used on merchant and naval vessels during the war to protect them from magnetic mines." (C&H-News-and-Views, 1947, p4)

These cables were clad in bronze, aluminum, and rubber that also had scrap value. Some cable was woven under a lead sheathing that was passed through a stripping machine and then collected for sale. Any scrap with lead solder that could not be cut off was melted and passed through a sweating furnace and cast into pigs for sale. C&H also processed telephone communication cable, copper pipe, copper, brass and bronze turnings and shavings from munitions plants; small automobile, refrigerator, and vacuum cleaner motors; generators, transformers, and busbars (Engineering-&-Mining-Journal, 1945).

The volume of material C&H processed is reflected in an editorial from the October 1945 *Engineering and Mining Journal.* Nearly 100 individuals were employed in the Secondary Copper Department, which at its peak had in its yard 30 acres of scrap (half from the armed forces). The leaching tanks could hold 700 tons of telephone-line wire or 1,000 tons of gilding-metal clad steel bullet jacket stock. This volume marked a shift in C&H business priorities as it turned toward exploration of new sources of copper and different products for the market. H.C. Kenney, smelter superintendent, led the research and development of new forms of processing and efforts to deal with the waste products from scrap such as "copper mud," grease, and the typical lead, iron, and brass.

Figure 2-4. Burning of Copper Scrap in C&H Hubbell Smelter Yard (circa 1950s). Courtesy: Keweenaw National Historic Park Archives.

Some copper wire required the burning of insulation, which contained PCBs from the wire before processing. This burning is first documented in the 1940s in *C&H News and Views*. Copper wire was treated as late as 1968, according to C&H reports to the US Bureau of Mines on their secondary copper operations (C&H-Mining-Company, 1968). The practice of burning wire to remove insulation continued into the 1960s in a location between the smelter and Torch Lake, as verified by oral history interviews. PCB residue from the burning was likely deposited into the soils of the smelter yard.

2-4. Reclamation: Stamp Sands and Scrap

Realizing the copper value still located in Lake Linden's stamp sand beds residing in Torch Lake, C&H developed a process for reclaiming the sands in the 1910s. Within ten years the company had built two reclamation facilities at Lake Linden and Tamarack City to regrind and extract copper from the sands produced by the Calumet, Hecla, Ahmeek, Tamarack, Lake #2, and Osceola mills. The tailings piles at Lake Linden alone covered an area of about 156 acres and varied in depth from nothing at the shoreline to 120 feet (Engineering-&-Mining-Journal, 1924a, p277).

Reclamation involved a number of steps, depending to some extent on whether the sands were from conglomerate or amygdaloid rock. In total, the facilities demanded a significant amount of electricity to operate, which was provided by the C&H power plant in Lake Linden (see next section on electrification). Reclamation operations also required large structures on water and on land. On the lake a dredge scooped up the sands. A pontoon-floating pipeline supported its operation with additional supports for electrical wires to run the dredge. A shore plant on the water's edge transmitted the electricity and received the sands pumped from the dredge. A conveyer system then transported the dewatered sands to a regrinding mill that ground the course sands into fine material. Before reclamation, copper production in this district primarily required mechanical methods of extraction. With reclamation came chemical extraction. A leaching plant sent the sand through an ammonia bath. Next, a flotation process that utilized oils further increased the recovery of copper from sands. The smelters then received the copper from the reclamation works and mixed it with other coppers from the mills or from scrap material.

Three reclamation plants operated along western Torch Lake between 1913 and 1967. C&H began construction of its Lake Linden regrinding plant in 1909. In 1913 it added a new electrical substation to help power the reclamation complex, a second regrinding plant, an ammonia leaching plant, and astill house. 1914 marked the official beginning of stamp sand reclamation along Torch Lake. Realizing the great efficiencies in removing copper from stamp sand, C&H then built a flotation plant in 1918. Each of these operations was contained in separate buildings at the north end of C&H property just past the Calumet Mill, whose conglomerate sands were the first to be reclaimed.

Once its Lake Linden operations were demonstrating success, C&H started construction of an updated reclamation facility in 1920 in Tamarack City. Housing all operations in separate buildings beneath one continuous roof, Tamarack Reclamation Plant was completed and operational in 1926. It processed the sands from Ahmeek, Tamarack, Lake #2, and Osceola mills, and by 1929 was processing the slag from the C&H Hubbell smelter.

Dredging sands ended in 1944 and then resumed for a short few years in 1957 to process additional Ahmeek Mill sands from recent depositions. After the 1940s, Ahmeek Mill was the only C&H facility processing mined copper rock. Most of the Tamarack Reclamation Plant focused upon copper scrap in the 1950s and 60s. Lake Chemical Co., organized by C&H in 1945, utilized the Tamarack plant to produce cupric oxide, copper hydrate, and tri-basic copper sulfate for fertilizers and fungicides.

Quincy Mining Company had long desired to build a reclamation plant, which would process the sands from Quincy Mills #1 and #2, but lacked the financing. World War II provided the opportunity with a loan from the US government, engineering help from C&H, and a subsidized copper price. Quincy signed a contract with the federal Metals Reserve Company (MRC) in 1942 to build the plant just south of Quincy Mills 1 and 2 on Torch Lake. Quincy was to produce 10 million pounds of copper per year at a federally guaranteed premium price. Since the two Quincy mills had closed in 1921 (Mill #2) and 1945 (Mill #1), the copper product would come only from the stamp sands. The Quincy Reclamation Plant worked solely with amygdaloid stamp sands that had come from its mines north of Hancock. As a result, it had no leaching operation at its Mason location, relying exclusively on regrinding and flotation to retrieve copper from the sands. Quincy also did not use its reclamation plant to process scrap. What scrap Quincy did acquire and process, was handled directly at its smelter in Ripley.

A fourth reclamation plant was built on Lake Superior in 1937 near the Champion Mill's stamp sands. A minor enterprise for Copper Range, the facility only operated for just over ten years. Powered by cheap hydro-electricity the plant did not function in winter months and only planned to recover those sands above the Lake Superior water line that were not buffeted by strong storms.

Copper recovery from original sands was significant: the regrinding plant, equipped with Hardage mills and Wilfley tables, allowed the recovery of copper at about thirty-five percent of total values in the original sand; leaching produces about forty percent of total values; and flotation about ten percent. Total recovery from the original sands easily amounted to eighty-five percent (Benedict, 1955, p87-88).

Table 2-3. Torch Lake Reclamation Plants.

Plant	Date Started/ Completed	Date Closed	Notes
C&H – Lake Linden	1909/1913 1919: Flotation plant added	1953: all buildings but Leaching Plant which was used for scrap leaching only 1967: Leaching Plant	Treated conglomerate sands from Calumet and Hecla Mills Each operation a separate building Continued leaching facility to process copper scrap
C&H - Tamarack	1920/1925	1968: for overall building use 1965: Lake Chemical ceased	Separate buildings all under one roof Conglomerate sands from Tamarack; amygdaloid sands from Ahmeek
Quincy - Mason	1942/1943	1967	Utilized equipment from C&H; built by C&H; MRC loan of $1.5 million All in one building. Used only flotation, not leaching.

Each step in the reclamation process added to the environmental burden of local soils, sediments, and water. Regrinding began at Lake Linden in 1915, reducing the size of the particle from coarse to fine-grained sands. The availability of central electrical power from the C&H Power Plantmade it possible to run motors for the Wilfley tables for the fine grinding. C&H first achieved 4 to 5 pounds of copper per ton of sand reground (Benedict, 1955, p74). At Lake Linden, C&H built two regrinding plants to help process the stamp sands from Calumet and Hecla mills deposited between 1868 and 1915. Gradually fine grinding equipment [Hardage mills,that replaced Chilean mills] were placed directly in the mills themselves. Lake Linden's two tailings piles of about 150 acres in size were primarily composed of conglomerate rock, with some of the Hecla tailings coming from amygdaloid after 1900. Amygdaloid tailings were considered to be only one quarter the value of conglomerate, and thus shunned by the early reclamation plants. Premium prices of copper during World War I, however, made amygdaloid sand reclamation more profitable. The Tamarack reclamation plant, two miles south of Lake Linden, was erected between 1920 and 1925 primarily to reclaim the conglomerate sands from the Tamarack Mill. Adjacent to Osceola's amygdaloid sands, they were relatively uncontaminated. Eventually Tamarack Reclamation processed the Osceola and later Ahmeek amygdaloid sands.   The Quincy Reclamation Plant opened in 1943 to reclaim two amygdaloid piles of tailings deposited from 1888 to 1945 by Quincy Mills #1 and #2. These amygdaloid tailings required no leaching.

2-4a. Reclamation processes and wastes

A shore plant pump and dredge delivered the sand to the reclamation plants. Because of the depth of Torch Lake, the furthest extent of sand deposition was relatively close to shore. The longest dredge line was three-quarters of a mile—just within the limit of the capability of the dredge pump. C&H had kept a record of tonnage and tailings assays, allowing detailing planning and mapping of dredge operations (Benedict, 1955, p82-86). The pumps at the shore plant sent the sands to classifiers that then sent coarse sand to regrinding and finer sands to leaching and flotation at C&H facilities. The plant at Lake Linden had twenty-four mills, grinding 110 tons per 24 hours (Benedict, 1931, p522-524). The Tamarack Reclamation Plant, built in 1925 had about 2/3 the capacity of the Lake Linden Reclamation Plant. This changed by 1930. All material from the stamp mill as well as the stamp sands in Torch Lake were delivered to regrinding plants. Ahmeek was the only C&H mill in operation after Calumet Mill ceased in 1944. By then it stamped both conglomerate (from Calumet lode) and amygdaloid ores (from Kearsarge and Osceola lodes). It utilized a similar process for both ores, with the primary difference being that conglomerate ore required fine grinding. Following grinding and table processing, the product was separated into sands for ammonia leaching and slimes for flotation. C&H's conglomerate ores required both leaching and flotation.

Leaching of conglomerate ore sands with ammonia converted metallic copper into a soluble oxidized state. Most of the ammonia was recovered and recycled in the plant. Some residue—slimes that are not valuable—was discarded and contained heavy metals other than copper. Both Lake Linden and Tamarack Reclamation Plants worked with conglomerate ore and had leaching plants.   Blueprints for each show a pipeline from the plant to Torch Lake for discarding water and presumably some slime wastes. At the tail end of the ammonia leaching flowchart for C&H plants is located a settling cone from which the cupric oxide is pumped out, filtered in an American filter, and sent to a rail car. Overflow from both the American filter and the settling cone pass through a Sweetland Filter, which is designed to capture other "waste" metals in a cake form (Benedict, 1955, p144). Presumably this "cake" is discarded near the leaching plant, and may account for the "slimes" found at the Lake Linden beach. These were removed through a 2007 EPA Emergency Response action.

C&H entered an agreement with the Metal Reserve Company in 1942 to treat military scrap in C&H's leaching tanks. The company processed 65,000 tons of scrap, yielding 20,800,000 pounds of copper and 40,000 long tons of steel. After the war the leaching plant treated various types of clad-steel scrap, motors, and wire after burning off the insulation (Benedict, 1955, p122).

The flotation plants handled the finer sands from regrinding of the sands in Torch Lake as well as the finer grained sands produced by the stamp mills. In addition, they handled the secondary slimes from the leaching plant (Haskell, 1931, p529). Early methods used coal tar, pyridine, wood creosote and pine oil to promote flotation of copper, which attached to these chemicals and could be removed and processed. After the introduction of xanthates in 1926, recovery of copper improved and xanthates and pine oil became the preferred reagents for the remainder of the life of flotation plants on Torch Lake. After 1920, C&H used flotation methods on its conglomerate ores from both the stamp sands and the concentrates directly from the stamp mill. With the introduction of xanthates, amygdaloid ore from stamp mills and Torch Lake sands deposits could also be sent to the flotation plant. The Champion Mill (Copper Range Mining Co.) on Lake Superior was the first to use flotation methods in 1929 on its amygdaloid ores from the Baltic lode. As a result, by 1930, all the larger mills in the copper district had redesigned their mills to incorporate flotation. Champion, Baltic, Mohawk, and Ahmeek were the major mills operating after that time. The smaller mills (such as Isle Royale) did not make this addition to milling. Waste from the modernized mills and the flotation plants at reclamation facilities in the form of slimes or very fine-grained sands were deposited into Torch Lake and Lake Superior. They likely contained heavy metals that were of no commercial interest. Today they would be pumped into regulated tailings ponds. But during the era of C&H, Quincy, and Copper Range production, Torch Lake and Lake Superior were the available lakes for discarding the fine-grained tailings and wastewater from floatation and leaching.

2-5. Powering Torch Lake Facilities

As stamp mills grew in size and added new functions such as flotation, their power requirements increased. Initially, each stamp mill was powered individually with a boiler house and steam engines. Wood, then coal, fueled the work along Torch Lake. With the advent of reclamation processes in separate plants, and then added to the more modern mills in the 1930s, a centralized power source became imperative. C&H built a central electrical power plant in Lake Linden in 1903. This made the subsequent Lake Linden reclamation plant operable and eventually that in Tamarack. Quincy Mining Company built a steam power plant (utilizing coal) between Mill #1 and #2. It was closed before the Reclamation plant was built and utilized steam from coal, not electricity.

By 1930, the electric power generation plant supplied electricity that reached C&H facilities in Calumet, the Calumet and Tamarack Water Works across the Keweenaw Peninsula on Lake Superior, and as far north as Phoenix Location. When Quincy built its reclamation plant in the 1940s, C&H extended its power lines to Mason. This continuous expansion of centralized electrical power required regular updates at the Lake Linden Power Plant and the placement of several substations along Torch Lake at the three reclamation plants, at the smelter, and at the Ahmeek mill. The smelter and Ahmeek mill also had their own turbines that produced local electrical power as a byproduct (steam) from mill and smelter operations, and at a substantial savings in coal. The central power plant in Lake Linden, however, produced the bulk of the power (76%) for the Torch Lake operations. A small power plant was built in 1931 at the Ahmeek Mill to ensure uninterrupted power, thus augmenting the power generated by the steam from milling waste heat (McIntosh and Burgan, 1931, p542) . In total, Torch Lake hosted a power network that included a central power plant, a secondary power plant (Ahmeek Mill), a power plant at Mason for two mills, at least four sub-stations, a coal pulverization plant, and two large coal handling docks (at Hubbell and Mason).

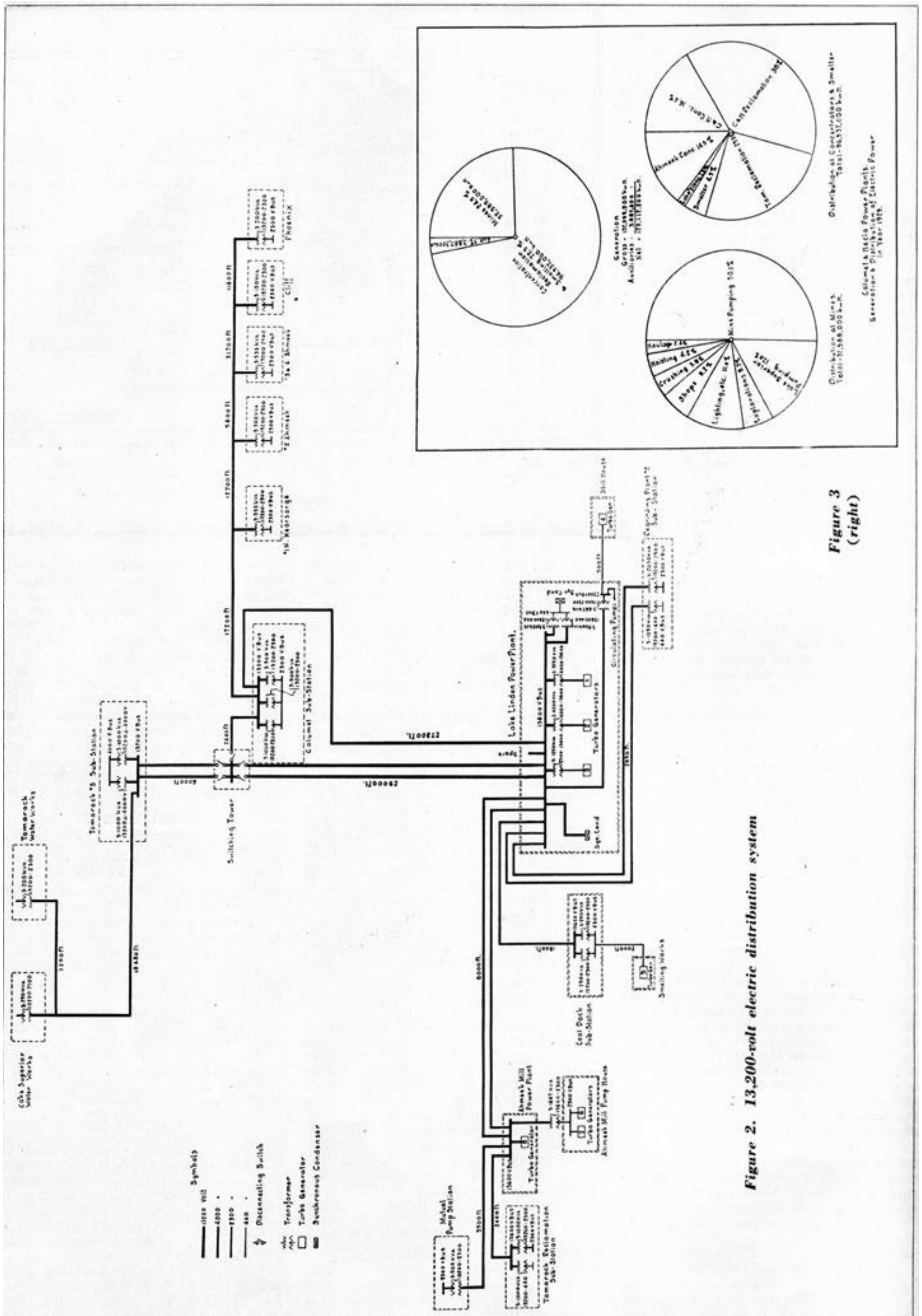
Under a centralized power system, C&H facilities created waste products of significance to the pollution in Torch Lake and nearby soils. With the use of coal to produce heat in the smelter furnaces and the boilers for the power plants and mills, the company imported large quantities of coal to its dock and storage sheds near the Hubbell smelter. A pulverized coal facility at Hubbell supplied this improved product to the smelter and to the Lake Linden power plant. The byproducts of ash, smelter smoke, and coal dust from combustion contained heavy metals and PAHs that made their way into Torch Lake. In addition, after 1930, electrical transformers typically utilized PCBs in their fluids instead of the previously used mineral oil.

2-5a. Coal use

Early mining steam power as well as underground mine structures relied on wood from the nearby forests in the Keweenaw Peninsula. Quickly depleted, wood resources gave way to imported coal in the 1880s. Both C&H and Quincy operated coal docks on Torch Lake. First built in the 1860s (C&H) and 1880s (Quincy), shipping docks served the early mills. With the use of coal the companies rebuilt and enlarged the docks. The coal docks, closely tied to rail lines, handled large deep-water vessels and were equipped with large cranes and open-sided storage sheds to protect coal from the elements. Company trains delivered coal supplies to boilers at mills and power plants.

After 1924, C&H's coal pulverization plant received coal and delivered it to the smelter for furnaces and to C&H power plant in Lake Linden. Quincy Mining Company never built a pulverization plant. Pulverization of coal created a high risk of explosion from dust and required a separate, specially designed facility with proper ventilation and piping necessary to move the coal and

Figure 2-5. Map of C&H Electrical Power Distribution, 1931. (Source: *The Mining Congress Journal, October 1931)*



reduce accumulation of dust. The process of pulverization required reducing lumps of coal to small sizes with rollers, and then removing moisture from the coal. The pulverizer then reduced the coal to a fine powder, which was transported by pipe directly to the smelter furnace. Cost savings included significant reduction in labor for handling coal, as well as efficiencies in burning coal in furnaces.

Extensive use of coal produced a large amount of fly and bottom ash waste that needed disposal. Together they are often referred to as coal ash. Along Torch Lake, bottom ash collected in the base of boilers and smelter furnaces. Fly ash was distributed through the smokestacks. There was clear evidence in the 1960s that the bottom ash at Ahmeek mill was routinely pumped into Torch Lake through a launder. This waste stream had been of interest to C&H researchers because of its copper content, and therefore a likely candidate for further copper recovery. C&H examined possible reclamation of copper from ash at the smelter and at Ahmeek mill in the 1950s and 60s but never implemented any initiatives before the 1968 closure. Coal ash is known to contain heavy metals and PAHs that are considered hazardous waste. Since the 1880s, with coal burning in mill boilers, at the smelter furnaces, and the power plants, ash has entered the waters of Torch Lake along with the stamp sands and other regular waste materials.

2-5b. Wastes and locations

The summary of processes and the development of industrial facilities at Torch Lake begs the question: what specific wastes of significant volume and toxicity ended up in Torch Lake and possibly in the soils around the various buildings? A clear articulation of specific waste and location based upon copper processing history along this industrial shoreline provides definition to the more general studies completed by the EPA Superfund and AOC programs. Specific facilities created known hazards with chemical spills and regular waste streams. Reclamation plants at Lake Linden, Tamarack, and Mason were the sites of likely accidental chemical spills and waste streams of sludges containing heavy metals. They also discharged fine-grained tailings throughout the lake. Power facilities fueled by coal at Lake Linden and Ahmeek Mill distributed PAHs and contained PCBs in their transformers. Substations all along the shoreline also utilized PCB laden transformers. The smelter yard and coal dock produced PCBs, PAHs, and slag contaminating nearby soils and sediments. It is in the historical details of these facilities and their technological changes over one hundred years from which solutions can be crafted that reflect a holistic and complete view of hazards produced by copper processing.

Chapter 3. Torch Lake Pollution and Government Response – A History of Remediation

3-1. Introduction

As a waste disposal site for copper milling and processing it is not surprising that Torch Lake has a history of pollution and a contemporary focus on remediation. This chapter discusses the early development of Torch Lake as a disposal site, including the legal history, which allowed dumping of mine wastes until the 1970s. It continues with a review of the early signs of pollution and subsequent research in the 1970s on water quality and pollutants. Finally, the histories of the listing of Torch Lake as a GLWQ Area of Concern and an EPA Superfund site are detailed. From this account, which begins in the 1860s and ends over one hundred and thirty years later, we can view the long history of governance over Torch Lake.

3-2. Origin of Torch Lake as a Waste Disposal Site

Water bodies such as Torch Lake have historically been considered waste disposal sites; much in the same way that "dumps" and landfills became disposal sites for municipal waste. In the case of Torch Lake, the dumping of waste persisted until the 1970s for mine material and even later for human waste (when sewerage ponds were built on reclaimed stamp sands). This was not the practice, however, for what is known as the Keweenaw Waterway—the nearby navigable passage that cuts through the Keweenaw Peninsula and includes Portage Lake. Torch Lake is connected to Portage Lake through a narrow passage from Torch Bay and has always been considered part of the Waterway and connected to Lake Superior.

In 1891, when the US government assumed authority over the Keweenaw Waterway, taking control from private parties, it explicitly excluded Torch Lake from the provisions of the act.[3] No harbor lines were designated for Torch Lake, and the nominal clause on dumping also did not apply. Consequences for stamp sand disposal were therefore dramatically different between Portage and Torch Lakes. A little history is helpful to illustrate here.

[3] US Code 2001, Title 33, Chapter 9, Subchapter 1, 433. "….the provisions of this act shall not apply to Torch Lake, Houghton County, Michigan."

Figure 3-1. Keweenaw Waterway Map: 1845. (US Engineer Office, Duluth MN, "History of Keweenaw Waterway, Michigan," 1940)

The 1843 Treaty between the US government and the Ojibwe opened land in the Keweenaw to white settlement. In 1845 Houghton County was created and the US government began selling mineral rights and land parcels. Private companies formed to control entry to the Keweenaw Waterway, an important access to settlements in Houghton and Hancock. The south entry to Portage Lake from Keweenaw Bay, through Portage River, was narrow, shallow and circuitous—about 4.5 miles long and 3-

5 ft. deep. Ojibwe voyagers had utilized the waterway to travel west from Keweenaw Bay to Chequamegon Bay, portaging their canoes to Lake Superior over the last bit of land at the northwestern point of Portage Lake to avoid the long trip and perilous trip around the Keweenaw point. The 1855 construction of a canal and locks on the St. Mary's River made industrial shipping possible to locations on Lake Superior. Before the canal, goods moving between Lakes Huron and Superior were off-loaded at Sault Ste. Marie, portaged over land and then reloaded onto a waiting vessel. The new canal prompted several mining companies to privately raise $30,000 in capital and dredge Portage River at the south entry. They charged tolls for transport of vessels through the entry and access to the villages of Houghton and Hancock. This was done without legal authority, and the State of Michigan quickly passed a law allowing the companies to incorporate themselves as the Portage Lake and River Improvement Company. To open up the north entry to Portage Lake, another private company organized in 1864. This one was official and subsidized by the US government with 400,000 acres of land grants. In 1873, the 2-mile north entry canal was completed opening the waterway from south to north, and tolls were collected for passage.

Entry into Torch Lake from Torch Bay on the north side of Portage Lake was narrow and shallow. In 1873 the Torch Lake Canal Company (organized by C&H Mining Co., under a State of Michigan charter) cut a canal 60 feet wide, 16 feet deep, and 2.5 miles long (USArmy-Corps-of-Engineers, 1902, p2621). C&H had recently built its Hecla Mill on Torch Lake in Lake Linden. After further improvement in the canal in 1885, tolls were collected. At this time, not far from its mines, C&H added a smelter in Hubbell and a second mill (Calumet) in Lake Linden (USArmy-Corps-of-Engineers, 1902, p2620-2622; 1940). C&H kept the canal dredged at a depth sufficient to carry the largest ships passing through the Sault canals, ensuring that all machinery, coal, and copper product could easily move from Torch Lake to Lake Superior and beyond.

At the turn of the century, Torch Lake remained an exception to ongoing federal control over the entire Keweenaw Waterway. As the US Army Corps of Engineers located and enforced harbor lines in the Waterway and managed dredging of the entries into Portage Lake, the care of Torch Lake remained in private hands. How did this come about? Through a series of events, portions of the waterway moved from private to public control, beginning with the financial failure of the private (but government subsidized) north entry canal. The US government purchased the physical assets along the north entry as well as those from another private company at the south entry.[4] Once in the hands of the US, the entire Keweenaw Waterway (including Torch Lake) came under the jurisdiction of the Rivers and

[4] US expenditures for purchase of the waterway and establishment of harbor lines in 1891 totaled $365,128. Purchase price was $350,000 (USArmy-Corps-of-Engineers, 1940).

Harbors Act and management by the US Army Corps of Engineers. The details of the subsequent history are interesting.

As a prelude to this development, in 1881 the federal government took control of the State of Michigan improvements to the Sault Ste Marie canal. Shortly thereafter the government was asked to assume control of the Keweenaw Waterway and make it toll-free. Congress ordered a complete investigation, and in 1890 Congress approved the purchase of all existing improvements in the waterway. By then the canals at each end of the Waterway and their entrances had deteriorated and required new work. In 1891 harbor lines were established—an essential step since stamp sands from mills in Portage Lake were filling up the narrow channel between the towns of Houghton and Hancock. Congress funded the deepening of the waterway and enlarging the channel. The 1899 Rivers and Harbors Act restricted dumping of soil and rock to areas inside of the harbor lines. Torch Lake was specifically exempted in this legislation.

Torch Lake, however, remained under the control of the mining companies that continued to dredge it and keep the Torch Lake canal open using private funds (USArmy-Corps-of-Engineers, 1940). Without the restrictions of harbor lines and limits on dumping, Quincy and C&H Mining Companies poured stamp sands into the lake during the lifetimes of their mills. Perceived as a waste depository, the lake became the dumpsite for other materials of no value such as the coal and chemical wastes that became the mainstay of copper processing. By the 1920s with the use of flotation in processing and of coal for power production, sludge and coal ash laden with heavy metals were deposited along with stamp sands.

Again in the 1940s, Torch Lake was officially exempted from any restrictions against dumping by the mining companies. According to EPA notes in the depository record, the exemption covered a period from the 1940s to 1965 due to the industry's critical role in the war effort. However, in 1969 a court order prohibited C&H from dumping into Torch Lake. By that time Universal Oil Co. had purchased C&H properties (April 1968) and a strike had shut down operations. Production never resumed along Torch Lake, and beginning in the early 1970s, both C&H and Quincy mining companies liquidated their facilities. For criteria used to evaluate Torch Lake for the National Priority List, see U.S.EPA (1984). For federal exemptions from regulations on dumping of mine waste into Torch Lake, see U.S.EPA (2003).

3-3. Early Signs of Environmental Change

The earliest signs of environmental change in Torch Lake and its surrounding landscape were the growing volume of stamp sands (tailings) along the western edge of the lakeshore by the late 1800s. Illustrated by the four maps below (Figures 3-2 through 3-5), Torch Lake absorbed approximately one-half of its volume with the coarse sands from the eight mills that lined the waterfront from Lake Linden south to Mason.[5]

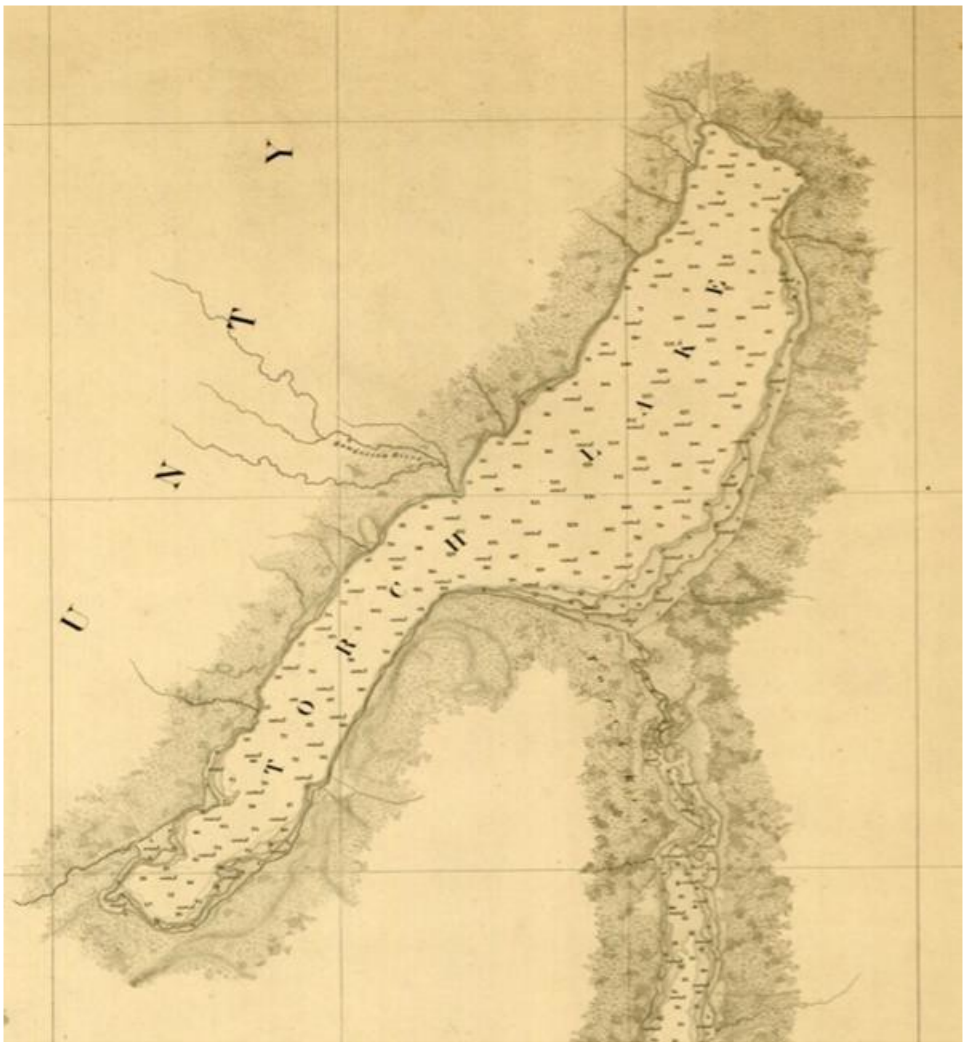


Figure 3-2. Torch Lake Map 1865 ([U.S.Lake-Survey, 1865]), 1924 (Figure 3-3), 1948 (Figure 3-4), 1996 (Figure 3-5).

[5] The amount of stamp sand deposited into Torch Lake has been reported to be as small as 20% of the volume of the lake to as high as 50% according to various EPA and AOC documents. The accurate amount is closer to 50%. This was confirmed by a bathymetric survey completed in 1990 which was then compared to the survey in 1865 before stamp sand waste deposits commenced (U.S.EPA, 1992e).

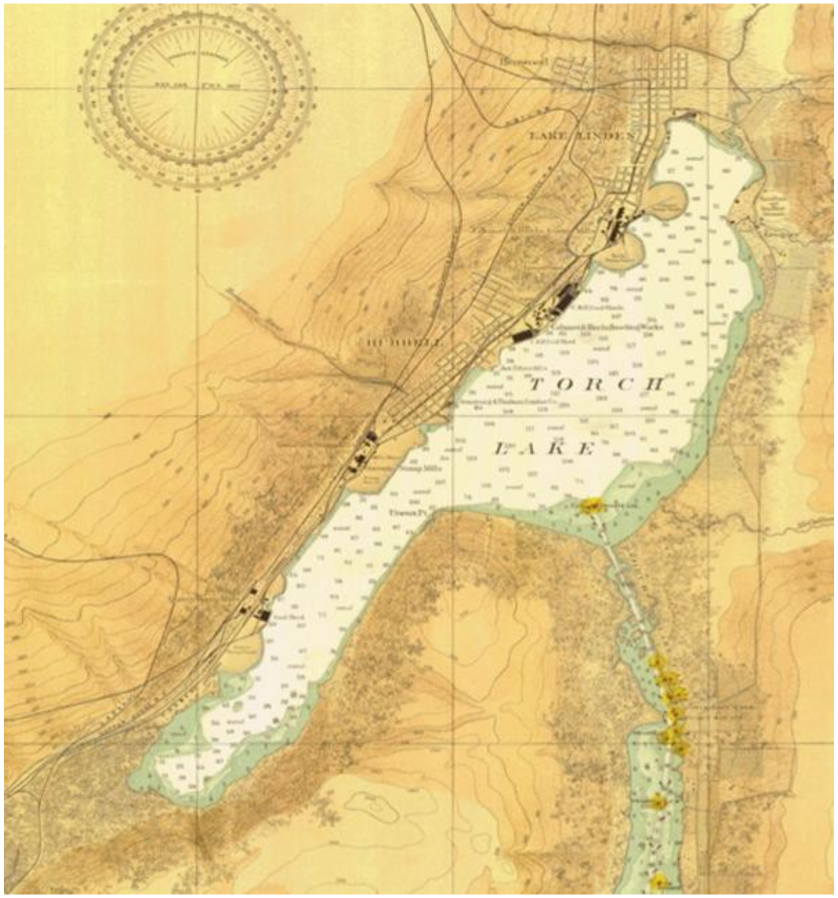


Figure 3-3. Torch Lake Map – 1924 (U.S.War-Dept-Corps-of-Engineers, 1924).

Figure 3-4. Torch Lake Map – 1948 (USArmy-Corps-of-Engineers, 1948)

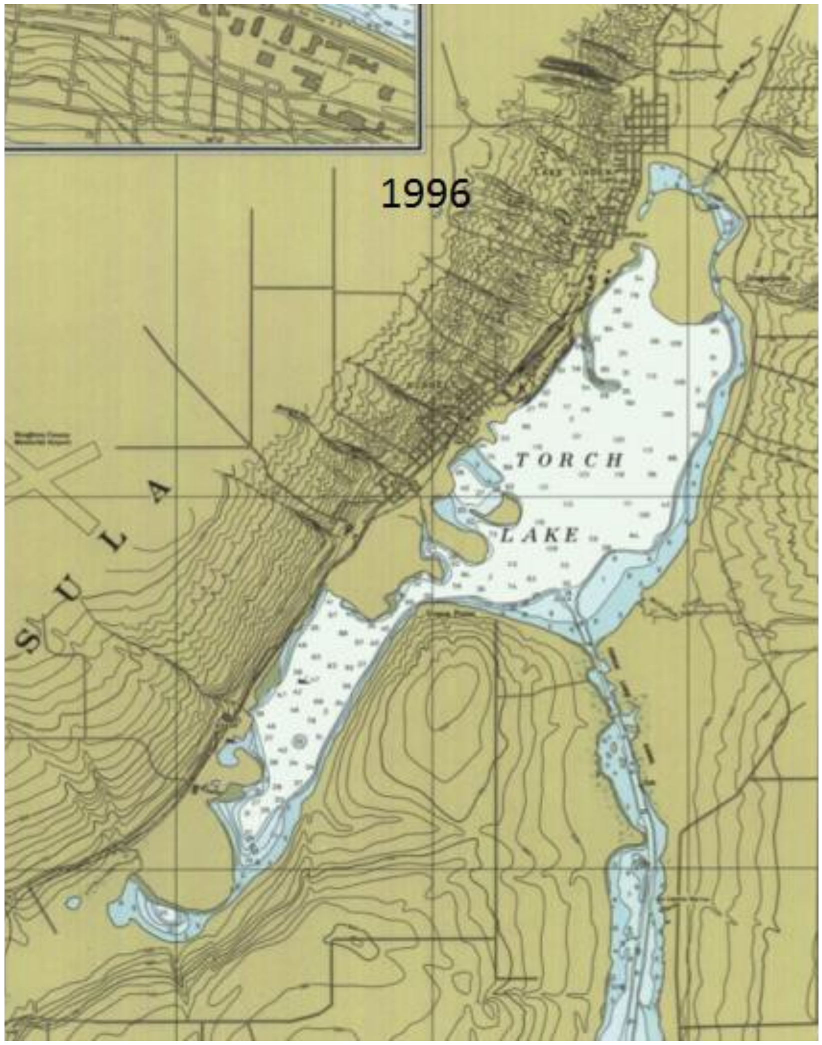


Figure 3-5. Torch Lake Map – 1996 (NOAA, 1996).

Other signs of environmental changes occurred in the form of a treeless landscape, smoke filled skies, and industrial noise. Smokestacks from the C&H smelter, the powerhouse, and several mills utilizing coal for steam and electricity created a hazy atmosphere. Winds from the north and northwest, typical much of the year, pushed the smoke in the direction of the lake. The less typical southern winds allowed it to collect against the hillsides backing Torch Lake in the communities of Lake Linden, Hubbell/Tamarack, and Mason. World War II brought the burning of scrap—especially copper wire—into Hubbell's smelter yard. Announcements of the burn schedule were published in *C&H News and Views.* Figure 2-4 in Chapter 2 shows the intensity of the smoke produced by these burns. Interviews with residents of the communities along the lake produced comments about water that was reddish and opaque at times during the year, and sailors who passed through called Torch Lake the "Red Sea" (DMG, 1955). Aerial photos taken between 1938 and 1963 show a highly turbid, reflective lake.

Beginning in the 1920s, the character and volume of waste began to change. As mills closed, only the Ahmeek Mill continued to operate. Mill waste included fine-ground sands, sludge from flotation, and coal ash. By the 1940s it was the only operating mill on Torch Lake. C&H's Hubbell smelter operated until the 1968 copper mining strike and officially closed in 1970. Smelter operations added both solid and granulated slag to the shore and water south of the smelter. The Tamarack Reclamation Plant had converted in the 1950s to production of various copper chemicals. The Quincy Reclamation Plant continued to operate until the 1960s, pumping the waste sludge from flotation, along with the finely ground sands that had been reprocessed directly into the southern portion of Torch Lake. And, of course, powering all these remaining facilities was the Lake Linden C&H power plant, continuing to operate until 1970.

With the closing and emptying of all Torch Lake facilities after 1970 except for Peninsula Copper Industries (PCI) located near the Hubbell smelter, most waste *production* ceased.[6] However, that did not prevent waste *disposal* of residual chemicals stored in warehouses or equipment. Likely candidates for ready disposal in the depths of Torch Lake would be the PCBs from the transformers of the three power stations in Lake Linden, at the Ahmeek Mill, and at Quincy/Mason; ammonia from leaching plants; xanthates and pine oil from flotation facilities; and the necessary but miscellaneous solvents utilized in all industrial operations. It is likely that various copper chemicals still in the Lake Chemical plant in Tamarack would have been sold. We have documentation from the 1990s of approximately 800 barrels disposed in the water immediately off of the smelter/coal dock location in Hubbell (Kruger and Bartelt, 1992). Discussed in more detail later, these barrels have been long assumed to have contained waste and materials with no resale value that were shoved into the lake. While some testing of barrel contents occurred in 1990-91, more remains to be done.

3-4. Post-Mining: Pollution and Environmental Concerns in the 1970s

The consequences of mineral processing along Torch Lake became more visible and complex beginning in the 1970s and early 1980s. Water quality concerns and fish tumors in Torch Lake heightened concern among residents, and a growing awareness of pollution resulting from copper

[6] PCI, located in the original C&H electrolytic plant near the Hubbell smelter, continued copper recovery (producing copper-based chemicals) from scrap material beginning in 1982. During its initial years it produced fiberglass waste piles on adjacent property from electric circuit boards utilized to recover copper. It also dumped processing water into Torch Lake. EPA eventually regulated both forms of waste through discharge permit and a cleanup order (DMG, 1984. The Daily Mining Gazette, Houghton, MI May 23, 1984.)

processing emerged. The 1970s brought new federal powers for pollution prevention through the Clean Air Act (1970) and Clean Water Act (1972), further engaging local interest in mine pollution. Through popular news sources, citizens received a crash course on the causes and health effects of polluted waterways and dirty air. This began an era of intensive research on Torch Lake. Michigan Technological University scientists conducted several investigations on water quality, copper in sediments, and tumors in lake fish. Residents along the lake had long noted the soot, colored water and sediments, and other environmental "nuisances," but these were not subjects of scientific inquiry until national attention to environmental damage accelerated after 1970.

In 1985 the International Joint Commission (IJC) for the Great Lakes designated Torch Lake as an Area of Concern (AOC)[7] —thirteen years after C&H (then Universal Oil Products, or OUP) and Quincy Mining Companies had decided to shut down their operations permanently. One year later in 1986 the EPA listed mining sites in the Keweenaw copper district on the National Priorities List under the CERCLA (Superfund) program for hazardous waste cleanup. These "listings" have subsequently driven the work to resolve the health and environmental hazards in and around Torch Lake for over thirty years. Each program, Superfund and IJC's AOC program, operates under a different set of rules for designating a hazardous site, and also requires different criteria for removing Torch Lake from their respective "list." It is not easy to delist a site. The scientific inquiry and community politics are largely driven by the particularities of site investigation and requirements for remediation that allow delisting. We will explain this further later.

First it is useful to ask, what led Torch Lake to achieve this dual identity of both a Superfund site and an Area of Concern? In the early 1970s, several studies conducted by Michigan Technological University faculty inquired into the effects of mining wastes, particularly copper, on water quality. Local residents had long been aware of mine disposal in the lake, frequently commenting on what it was doing to the water and fish. Awareness of water quality issues at abandoned mine sites throughout the US increased. This coupled with the local appearance of fish tumors brought the copper-producing region to the attention of EPA and the IJC.

Water quality and mine metal pollution were on the minds of government agencies and

[7] There is some disagreement as to the date of listing as an AOC. The Report to the IJC by the Great Lakes Water Quality Board (1985) indicates that Torch Lake was not on the list in 1983, but was added by the time the 1985 list was published. The Remedial Action Plan (RAP) (MDNR, 1987b) states that it was added to the AOC list in 1985. Multiple EPA documents state explicitly that it was added to the AOC list in 1983 (Donohue, 1988; U.S.EPA, 2001, 2003).

researchers alike. Some of the earliest studies on Torch Lake were completed in 1970, just as the facilities along the lake shoreline shut down. The USGS and MDNR conducted a groundwater study of the Keweenaw Peninsula to determine drinking water quality. The Michigan Water Resources Commission (MDNR) conducted a biological investigation of Torch Lake, concluding that discharge of stamp sands had significant effects on the lake ecosystem. Professor A.D. Kennedy and others at MTU studied the physical and chemical properties of stamp sands. In 1972, 27,000 gallons of cupric ammonium carbonate (known locally as “leach liquor”) spilled from the Lake Linden leaching plant into Torch Lake. Investigations showed that this had happened before. Water quality studies about the same time found high levels of copper, carbonate alkalinity, pH and ammonia nitrogen, probably due to the spill. As a result of the spill, several other studies continued to evaluate Torch Lake into the early 1980s (Donohue, 1988; Doonan et al., 1970; Kennedy, 1970; Kennedy and Chernosky, 1970; MDNR, 1970, 1973; Wright et al., 1973).

The critical trigger that led to Torch Lake’s designation as an Area of Concern was appearance in 1973 of fish tumors in lake fish. After a decade of study, the Michigan Department of Health issued fish consumption advisories in 1983 for Torch Lake sauger and walleye. Soon after, EPA applied the Hazard Ranking System (HRS) to Torch Lake and other local mining sites in 1984, and in 1986 put Torch Lake on the National Priority List (NPL). These actions resulted directly from the appearance of tumors in two species of Torch Lake fish. Large external tumors were first noticed on sauger and walleye. Subsequent pathological research between 1979 and 1982 indicated that both species were commonly affected (Donohue, 1988).

Several MS theses at MTU and the University of Wisconsin between 1973 and 1985 also contributed to the characterization of Torch Lake pollution and water quality issues. They covered topics such as environmental chemistry of copper and heavy metals in Torch Lake, long-term water quality analysis, effects of copper in stamp sands on the benthos in lake sediments, further investigation of walleye and sauger tumors, and hydrology and copper budget of the lake. In chronological order, MS theses during 1969-1987 include Yanko (1969), Brandt (1973), Lopez-Diaz (1973), Tomljanovich (1974), Virnig (1974), Sypniewski (1977), Sabol (1981), Mackay (1985), and Warburton (1987).

Clustered around questions of water quality, benthic health of the lake, and fish tumors, the thesis findings included:

- High copper content affects water quality: In 1972 the copper content of water in Torch Lake was high, but largely in non-toxic form. However, spring runoff (decreased pH and dissolved organic carbon) and increased iron and manganese in the water shift the speciation to toxic forms of copper. These periods of oxygenated water in the spring and fall favor release of metals from the sediments (Lopez-Diaz, 1973). Torch Lake was mesotrophic, had high levels of copper, and was poorly buffered. Fluctuation in pH due to low buffering could cause more harmless copper complexes to shift to more toxic forms (Virnig, 1974). Dissolved copper concentrations in the lake increased with depth and have not decreased since 1972 due to continued surface runoff contributing about 97% of measured flows of dissolved copper to the lake. A large imbalance in the copper budget was inferred to indicate large inputs of copper from the lake sediments (Warburton, 1987).

- Copper from stamp sands in the lake reduces benthic health of the lake: Copper-bearing stamp sands blanketing the bottom of Torch Lake reduced benthic microbial decomposition, possibly resulting in a "poisoned oligotrophic" status (Sabol, 1981).

- Liver and skin tumors are present in walleye and sauger: The sauger with tumors were noted to be in poor physical condition and the specimens averaged 10 or more years in age. Walleye had fewer tumors than the sauger and exhibited no liver tumors. They also averaged 10 or more years in age. The results of liver tumors suggested sex-related factors (Mackay, 1985).

Other university studies figured prominently in MDNR and EPA assessments, as outlined in the 1987 RAP (MDNR, 1987b). Their major findings include:

- Benthic communities were reduced in areas of copper tailings disposal

- Torch Lake sediments were proven toxic according to bioassays.

- Torch Lake had high turbidity during years of mining, but water clarity gradually increased post-mining. Also decreasing is the conductivity of the lake's water. During the active mining years, water released from mine dewatering had increased conductivity of the lake water.

- High concentrations of copper in the water column (from 20 to 80 µg/l) exceed the IJC water quality objective of 5 µg/l[8] as well as state water quality criterion based on hardness. The source of copper in Torch Lake water is from the Trap Rock River (smaller source), as well as from tailings (larger source).

- Copper toxicity is limited by dissolved organic substances that chelate the copper.

[8] This standard was set in the 1978 Great Lakes Water Quality Agreement (IJC, 1978, p56).

By the end of the study period before the 1987 RAP, three major conclusions from various research projects emerged: 1) there was a high volume of copper in Torch Lake sediments and water column; 2) the benthic community in Torch Lake was degraded, some areas more seriously than others; and 3) fish tumors in walleye and sauger (both external and internal) raised concerns about linkages (yet unproven) to copper processing along the lake.

3-5. Torch Lake – A Designated Contaminated Site

Once designated a contaminated site by two sets of criteria (AOC and Superfund), Torch Lake became the object of numerous additional scientific studies to determine the character of mine waste, its pollutants, and toxicity. Intensified research and planning by hired consultants during a ten-year period (1983-1993) expanded the network of research beyond MTU scientists. The two major firms retained were Donohue and Associates by EPA, and Weston, Inc.by MDNR. This work culminated in two major planning documents that would direct further work at Torch Lake to address the contaminants: in 1987, the Remedial Action Plan (RAP) by Michigan Department of Natural Resources (MDNR) for the Torch Lake Area of Concern; and in 1992 and 1994, the Record of Decision (ROD) for three "Operating Units" at the Torch Lake Superfund Site.

The two investigations by MDNR and EPA occurred in parallel time. These simultaneous designations by different government criteria have led to much confusion. While there was considerable overlap in research—both often drawing upon the same studies done by MTU scientists— there were some important differences. First, EPA had funds available to pay for its investigations, whereas MDNR had very limited to no funding from the IJC. (Today the IJC provides funding through each national government to fund the AOC programs in the states.) As a result EPA hired a consultant, and MDNR relied mostly on MTU scientists, their previous work, and some small new studies they could fund. Second, the scope of the two sites differed. EPA's Torch Lake Superfund site included a much larger land and water mass, whereas the AOC pertained only to the water body of Torch Lake itself. Third, the criteria utilized for identifying problems and planning remediation differed: the AOC focused on "beneficial use impairments" and EPA focused primarily upon human health hazards quantified as carcinogenic and noncarcenogenic hazards.

Figure 3-6. Torch Lake Area of Concern. (http://www.epa.gov/glnpo/aoc/torchlake/images/TorchLake_Final_State_Approved.jpg)

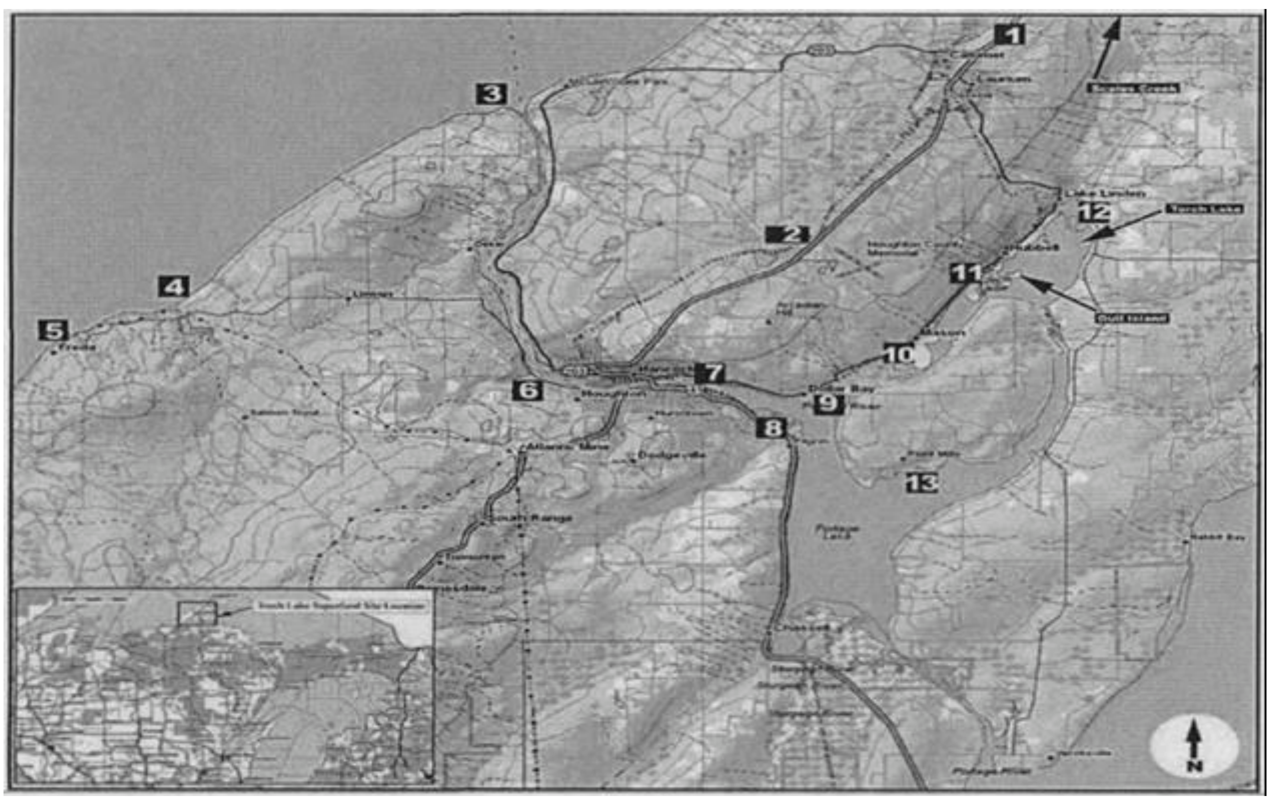


Figure 3-7. EPA Torch Lake Superfund Site. Map showing 13 of 14 Sites on NPL. (From p. 58 of EPA 3rd Five Year Review, 2013. Site No. 14 (Scales Creek) is not shown on this map.

A look at the work accomplished and the investigation results during this ten-year study period illustrates some of these differences. Understanding the events and actions during this time frame is critical to making sense of the problems that the community faces today as it finds new contaminants and new locations that were not considered earlier.

3-6. Michigan DNR and the Remedial Action Plan

The critical variable for listing a contaminated site under the status of an Area of Concern (AOC) is the concept of "beneficial use impairment" or BUI in aquatic environments. Thus, as illustrated in Figure 3-6, the Torch Lake AOC is confined to the lake itself. It does not include the industrial shoreline along the western edge of the lake, which during the mining era (1860s to 1970) generated the contaminants and that were likely causes of the impairments in Torch Lake. An AOC is defined as a geographical area where impairment of beneficial uses has occurred as a result of human activities at the local level (U.S.EPA, 2018).

Under the Great Lakes Water Quality Agreement (GLWQA), Canada and the US have outlined a method to identify AOC sites, determine the major beneficial use impairments to aquatic ecosystems, and prepare a Remedial Action Plan (RAP) that defines the problem and proposes remedies. Attention is to the *uses* of a water supply or water body such as drinking, swimming, fishing, navigation, and ability of waters to support aquatic life and wildlife. If any of these uses are *impaired* they may qualify for the designation of *beneficial use impairment* or a BUI. Once determined, a BUI becomes the driving force behind the listing of an AOC, and after its removal, the delisting of the AOC. Delisting can occur either through specific remediation measures or through natural processes.

For four years (1983-1987) the Michigan Department of Natural Resources investigated Torch Lake—its waters and sediments—and determined that there were three impairments to beneficial uses of Torch Lake waters: fish tumors in the sauger and walleye, a degraded benthic community in the bottom of the lake, and fish consumption advisories. It based its listing of these three BUIs on several findings from the research described earlier. A brief summary of the investigation (also provided in the 1987 RAP) illustrates the focus and limitations of the AOC process for determination of the hazards of a complex polluted mining processing site (MDNR, 1987b). The 1987 RAP detailed several major problems with Torch Lake that related to fish communities, to the bottom dwelling animal (benthic) community, and the sediments (MDNR, 1987b, p24-47).

3-6a. Fish community

At the time of this report, Torch Lake was known to have had a diverse community of more than 20 species of fish for some time. The major sports fish included walleye, sauger, northern pike, and smallmouth bass. After the mine processing ceased in 1970, sauger began to disappear, replaced by the other three species of sports fish. In a 1979 survey, all sauger were over nine years and considered very old.

The early surveys revealed tumors in walleye and sauger, with the liver tumors of most concern since they are frequently associated with organic chemicals. Surveys on fish tumors by MTU researchers continued until 1986. Although the studies were not often comparable with earlier findings, they did reflect a continuance of tumors in walleye and sauger—both liver and dermal. Tumor incidence by 1986 was still present in the older fish of both species. The higher incidence was in sauger, with a lower incidence in walleye. The findings from over fifteen years of research were complicated by various factors such as the mobility of the fish, thought to travel widely through Portage Lake and Lake Superior; by the question of parasitical cause of tumors; and by the use of gross examination of fish in the studies instead of microscopic examination of tumors.

An analysis of the possible contaminants that may cause the fish tumors focused upon creosotes, xanthates, and heavy metals. The flotation methods at Lake Linden, Tamarack, and Quincy reclamation plants utilized creosotes and then after 1929, xanthates to process copper. Ahmeek Mill also installed flotation technology in its updated facility in the early 1930s. These chemicals were part of the waste material (along with sludge and stamp sands) that was discharged into Torch Lake. The MDNR 1987 RAP concluded that creosotes and xanthates were likely to be the causative agents for fish tumors. However, xanthates were not found in the lake and were shown to rapidly degrade under the conditions in the lake (Leddy 1986). Heavy metal and PCB contamination in fish tissue was also considered as a possible cause of the tumors and found to be present. However, because PCBs were found to be near the limit of "detectability" and lower than the consumption advisory criteria, they were not considered a cause of the tumors.

Because of the fish tumors, however, Michigan Department of Health placed fish consumption advisories upon Torch Lake sauger and walleye in 1983. The advisory was viewed as a "precautionary measure until causative agents could be found in the lake" (MDNR, 1987b, p52). Therefore, in the RAP MDNR stated that one of its goals was to suggest remedial actions that would eventually lead to the removal of the fish advisory.

3-6b. Benthic community

The animal community at the bottom of the lake is an important indicator of a healthy lake. Invertebrates, unlike more mobile fish in Torch Lake, remain in one place and can therefore provide indications of toxic conditions. Early research showed a low-density benthic community of primarily worms and midges, indicative of toxic conditions in the sediments or eutrophic conditions in the water; water column conditions ruled out the latter explanation (Massey, 1970; MDNR, 1973; Wright et al., 1973; Yanko, 1969). Because little research had been done on Torch Lake, the RAP noted that Michigan Tech researchers in 1981 and 1984 investigating copper sediment concentrations in Portage Lake found both reduced numbers and taxa of macroinvertebrates where there was a measured high copper content in sediments at the North Entry of Portage Lake.

3-6c. Sediments

MDNR had a more reliable source of data on sediments in Torch Lake from sediment and tailing analysis throughout the Keweenaw Waterway and nearby Lake Superior acquired from dredging projects, and biological and mineralogical studies. They revealed high concentrations of copper in sediments, as well as lead, zinc, arsenic, and tin in Torch Lake. The highest concentrations of these metals in Torch Lake were found near the Hubbell smelter. In a 1973 study, high concentrations of metals were also found near tailings deposits throughout the Keweenaw Waterway at Point Mills, Isle Royale sands (including Pilgrim River entrance and Sunshine Beach), Houghton-Hancock (including Coles Creek entry), and the canal at North Entry (Leddy, 1973). Similarly, high metal concentrations in sediments were reported in Lake Superior at Freda and Redridge near Keweenaw North Entry and Gay near the South Entry.

Overall, the sediments near mills and processing facilities were "heavily polluted" with copper, lead, chromium, lead, zinc, and in some locations, arsenic. As such, they were not considered suitable for dredging and disposal according to EPA guidelines for dredging projects (MDNR, 1987b, p42). In a section on pollutant transport mechanisms (how heavy metals and other pollutants end up in the sediments), the RAP concluded that there were no "significant controllable point source discharges of pollutants to Torch Lake" (MDNR, 1987b, p50). With regard to non-point sources, it concluded that copper tailings were the primary concern and that the pore water in copper tailings deposits infiltrated lake water. In addition, run-off from tailings and wind-born tailings is considered.

3-6d. Water quality

The RAP report defined copper as the major concern with water quality in Torch Lake. The major loading (source) of copper enriched water to Torch Lake is from the Trap Rock River at the north end and the release of copper from the lake sediment. Copper concentrations exceeded Michigan's Water Quality Standard at the time. Torch Lake copper concentrations in the water ranged from 20-60 µg/L (with an average of 40 µg/L). The IJC water quality objective for the Great Lakes at that time was 5 µg/L (IJC, 1978). Similarly, copper concentrations exceeded what would have been allowed in industrial discharges in Michigan at the time (76 µg/L in the discharge, 11 µg/L in the mixing zone). Since drinking water for the residents in the area came from upland wells, copper in drinking water was not listed as a concern.

What did the MDNR advise for Torch Lake remedial action on the basis of the analysis in the 1987 RAP? First, based on the research summarized above, the MDNR focused their recommended actions upon two identified use impairments (BUIs): 1) the fish tumors in sauger and walleye; and 2) the degraded benthic community. The recommendations were as follows:

1) Fish tumors: Investigations confirmed tumors in older walleye and sauger, but found no tumor inducing "causative agent" in the lake. MDNR concluded, based upon likely historical exposure to short lived organic chemicals (xanthates) discarded by mining operations in the lake, that further studies should be done to determine if they could be the cause of the tumors. They recommended that the advisory be removed since the basis for its issuance was to locate the cause and no data provided that information. Several organizations protested this recommendation: the local health department, a local environmental group, some MTU staff (researchers), an EPA review of the report, and the Toxics Substances Control Commission (part of MDNR). These protests were likely the result of the review of an early RAP draft, circulated among interested parties for comment. As a result, in the final RAP draft, MDNR suggested an interim remedial action: over five years, restock sauger or walleye in Torch Lake and analyze every few years for tumors, thus providing a long term monitoring to test the hypothesis that the tumors were caused by past chemical exposure.

2) Benthic community: Study of the macroinvertebrates and sediments revealed a "vast amount of copper-contaminated sediments in and along Torch Lake and its connecting waters" (MDNR, 1987b). By virtue of sediment studies throughout the Keweenaw Waterway and near North and South entries on Lake Superior, MDNR concluded that heavily polluted sediments were part of the waters in the mining district and did not meet EPA standards for disposal of dredging material.

> They argued, therefore, that the vast amount of copper-contaminated sediment precluded any direct action to remove or isolate them. Attempts to remove them would release copper and other heavy metals. Natural attenuation through burial over time by other sediments was the recommended remedy.

It is clear from the record (EPA Repository for Torch Lake) that prior to issuance of the final RAP in October 1987, MDNR had come to the conclusion that Torch Lake should be removed from the IJC's Areas of Concern list, but that questions and protests from other government agencies and community members kept the lake on the AOC list. In a MDNR July 1987 status report the AOC coordinator for Michigan noted that the draft RAP report (written by an EPA contractor) was completed in August of 1986, reviewed by Agency staff, a second draft completed in February 1987 and then forwarded to personnel at EPA Region 5 and MTU research scientists for comments. It noted the MDNR recommendation that 1) the fish consumption advisory be withdrawn on the basis that "no scientific evidence that indicates tumor inducing agents are present in Torch Lake above the normal background levels", and 2) Torch Lake be removed from the IJC's list of Great Lakes' AOCs, because "this lake has little, if any, measurable impact on Lake Superior" (MDNR, 1987a, memo).

After the October 1987 final RAP draft was issued with the revised recommendations detailed in the summary above, it was reviewed by the IJC. It registered several comments that indicated a concern with the RAP conclusions and recommendations: 1) since the RAP did not identify the cause of fish tumors, no remedial action can be recommended; 2) the stated goal of the RAP to eliminate fish tumors is problematic and should include contaminated sediments and impacted aquatic wildlife in the overall RAP goal; 3) there is no schedule for implementing remedial actions; and 4) there is no surveillance and monitoring program. The apparent result of this review was a decision for EPA to move forward with a remedial investigation of Torch Lake in December 1988 under the Superfund program (U.S.EPA, 1988).

3-7. EPA and the Record of Decision: Site Investigation Phase

Parallel to the MDNR investigations of Torch Lake as an Area of Concern, the EPA considered the wider copper mining district as a candidate for the National Priority List (NPL) under the Superfund (CERCLA) program. After a five-year process, Torch Lake was formally listed in 1986. As with the AOC listing, an important trigger for the initial hazardous site investigation was the discovery of fish tumors in the Torch Lake walleye and sauger. Superfund protocol divides its process into two phases for each hazardous waste site. The site investigation phase entails preliminary investigations, placement on the NPL, identification and study of the problem, and plans for remediation. This can take many years. In the case of Torch Lake, it took over a decade. The second phase, once a plan is in place for cleanup, is the process of remediation. In the case of the Torch Lake Superfund site, remediation of stamp sand tailings in OU I (Torch Lake) and OU III (other locations) is complete. Delisting, a third phase, is ongoing. EPA has "delisted" the Torch Lake stamp sands at Lake Linden, Tamarack, and Mason (OU I) as well as the sediments and ground water (OU II). It continues to work on other parts of the larger site.

Several evaluation steps are required before a hazardous waste site can be listed on the NPL. In 1981, an EPA contractor conducted a Preliminary Assessment of a Potential Hazardous Waste Site. A Site Inspection Report and a Hazardous Ranking Score (HRS) followed this in 1984. The HRS estimates hazards based upon ground water route, surface water route, air route, fire and explosion, and direct contact. Torch Lake scoring applied only to ground water, surface water, and direct contact.[9] These investigations led to a "proposed" listing on the NPL in October 1984. Two years later, on June 10, 1986 Torch Lake was officially placed on the NPL. The next step involved a search for potentially responsible parties (PRPs) who would be expected to fund a clean-up of the site once an investigation was complete and remedial actions identified. Between 1986 and 1988, EPA engaged in negotiations with PRPs Universal Oil Products (successor company to C&H Mining Co.) and Quincy Mining Co. Records of these negotiations are not present in the EPA Repository for Torch Lake; however, subsequent EPA reports note that negotiations to secure funding for the next phase of investigation failed in June 1988. In December 1988 the EPA project manager announced that two of three principal parties[10] created a deadlock in negotiations by arguing that additional parties (private residential property owners) needed to be included in any financial agreement to pay for remediation. This deadlock pushed EPA to decide that the project would be paid for out of the Superfund Program.[11]

This began a study period lasting four years, ending with a Record of Decision in 1992 and a second in 1994—over a decade after the preliminary site investigation in 1981. The work during this period is structured by two major investigations ending in two separate, but overlapping studies—the

[9] Torch Lake scores were (out of 100): Groundwater 43.33, Surface Water 33.77, Direct Contact 33.33. HRS scoring today follows a revised system issued in 1990, which now includes exposure to soils. Today, any score over 28.50 makes a site eligible for placement on the NPL. EPA Repository. Document #45722. January 30, 1984. HRS Worksheets.

[10] A third principal party involved in Superfund negotiations was Copper Range Mining Co, whose property lay outside of Torch Lake itself, but were included in the larger Torch Lake Superfund site.

[11] See DMG, 1988. The Daily Mining Gazette, Houghton, MI December 15, 1988. Also, see: Chronology of Site Events and text in (U.S.EPA, 2003). The EPA was able, however, to hold PRPs accountable for some expense and cleanup effort. In 1991, six PRPs removed shoreline and submerged drums under an Administrative Order on Consent issued by EPA.

Remedial Investigation and the Feasibility Study, RI/FS for short. The Remedial Investigation (RI) characterizes the site and determines the nature of the waste, assesses risks to human and environmental health, and evaluates the cost of possible treatment technologies. While the HRS scoring is a quick assessment of the site, the RI involves a complex investigation that includes new research and sampling to establish the nature of the hazard and set the parameters for future work. This is an extremely important phase, as the decisions made for what areas to include, types of wastes to consider, and sampling strategies determine the course of cleanup and ultimately the success or failure of the Superfund effort. The Feasibility Study (FS) provides an evaluation and analysis of treatment options (remediation of the waste) according to EPA specified criteria that include protection of human and environmental health, cost, short- and long-term performance, community acceptance, to name a few.

EPA Region 5 contracted with Donohue and Associates of Sheboygan, Wisconsin, to conduct these studies (RI/FS). Beginning with a Compository Summary in December 1988, Donohue & Assoc. outlined the types of hazardous materials, the affected media (water, soil, etc.), history of regulatory and remedial actions to date, and the physical characteristics of the region and Torch Lake. They included several new hazards near or in the lake that had not been part of MDNR's consideration for the AOC RAP, such as barrels on shore and in the lake, electrical debris, mine water pumpage, and sewage. Donohue & Assoc. completed the RI/FS investigation and report in 1992, nearly four years later.

When Torch Lake was added to the NPL in 1986 it included areas beyond the consideration of the IJC Area of Concern. Because of its size the site was divided into two "Operable Units." Operable Unit (OU) I contained Torch Lake and its surrounding shore, including municipalities of Lake Linden, Hubbell, and Mason on the west and the wetlands on the east of the lake. Operable Unit (OU) II included the North Entry of the Keweenaw Waterway, the northern portion of Portage Lake, and tributary areas. Operable Unit I (Torch Lake) was the first to be investigated. Definitions of these units changed by 1991 as part of the scoping process in the RI/FS phase, and an additional Operating Unit added (OU III) which included stamp sand and smelter slag sites on Portage Lake and at the north entry to Lake Superior; inland stamp sand deposits at Boston and Calumet Lakes; the Quincy Smelter in Ripley, and Scales Creek. For a complex site, the Superfund program frequently divides its study and cleanup into OUs that can be handled separately, and Torch Lake is no exception.

The determination of the OUs and their boundaries that were often buried in the RI/FS study process (scoping), is a critical component. In the case of the area around Torch Lake itself, the study boundaries were drawn in 1988 to include the entire lake and its surrounding eastern and western shorelines (see Figure 3-8). By the time the three OUs were finalized in 1992 and 1994, the shift in boundaries had eliminated the shoreline areas all around the lake and only included the stamp sand deposits. Especially important in this change was the shift away from the industrial zones in Lake Linden, Hubbell, Tamarack City, and Mason where many of the facilities (with pollutants still present in and around the old building sites) were located. Over 40 buildings –including eight mills, a smelter, three reclamation plants, three power facilities, and two coal handling areas—were located along the western shore of Torch Lake. The six-mile western Torch Lake shoreline hosted buildings that utilized hazardous chemicals and produced contaminated wastes that would likely have found their way into nearby soils. Coal-fired plants and a smelter had smokestacks that would likely have spread plumes of fly ash and heavy metals over nearby areas. This upland industrial area was eliminated from the Superfund site. Also eliminated in the final three OUs were the eastern wetlands along the lakeshore. It should be noted that significant areas of industrial stamp sand deposits at Gay (from Wolverine and Mohawk mills), Keweenaw Bay (Mass Mill), and the Freda-Redridge area (Copper Range mills) –all located along the Lake Superior shoreline—were *not* included in the any of the Operating Units.

By the end of the study period these final Operating Unit boundaries were established and published in a Record of Decision. OU I and III were determined in 1992; OU II in 1994. The final boundaries of the Torch Lake Superfund site as defined in the Records of Decision (RODs) differed significantly from the original site outlined in 1988 and a draft of the three OUs created during the study period. The final OUs had *removed* the contaminated industrial area on the western shoreline. Several sites along Lake Superior were never included in the consideration.

In addition, during the study period (1988-1992) a number of hazards were identified by Donohue and Associates (including asbestos and PCBs), that were related to on-shore mine processing facilities. However, as sampling proceeded and the operating units redefined, these materials dropped out of the scope of the investigation.

By the end of the RI/FS study period the final approved boundaries listed in the 1992 Records of Decision for OU I and III had narrowed considerably. Human health concerns were restricted to health hazards created by wind-born, uncovered stamp sands. OU I addressed only tailings, slag piles, and drums at Torch Lake. OU III addressed tailings and slag deposits at North Entry, Michigan Smelter, Quincy Smelter, Calumet Lake, Isle Royale (on Portage Lake), Boston Pond, and Point Mills. In 1994, the Record of Decision for OU II included only water sites based upon environmental degradation caused by metal contamination. It focused exclusively upon the groundwater, surface water, submerged tailings and sediments in Torch Lake, Portage Lake, Portage Channel, Keweenaw Waterway, North Entry to Lake Superior, Boston Pond, and Calumet Lake.

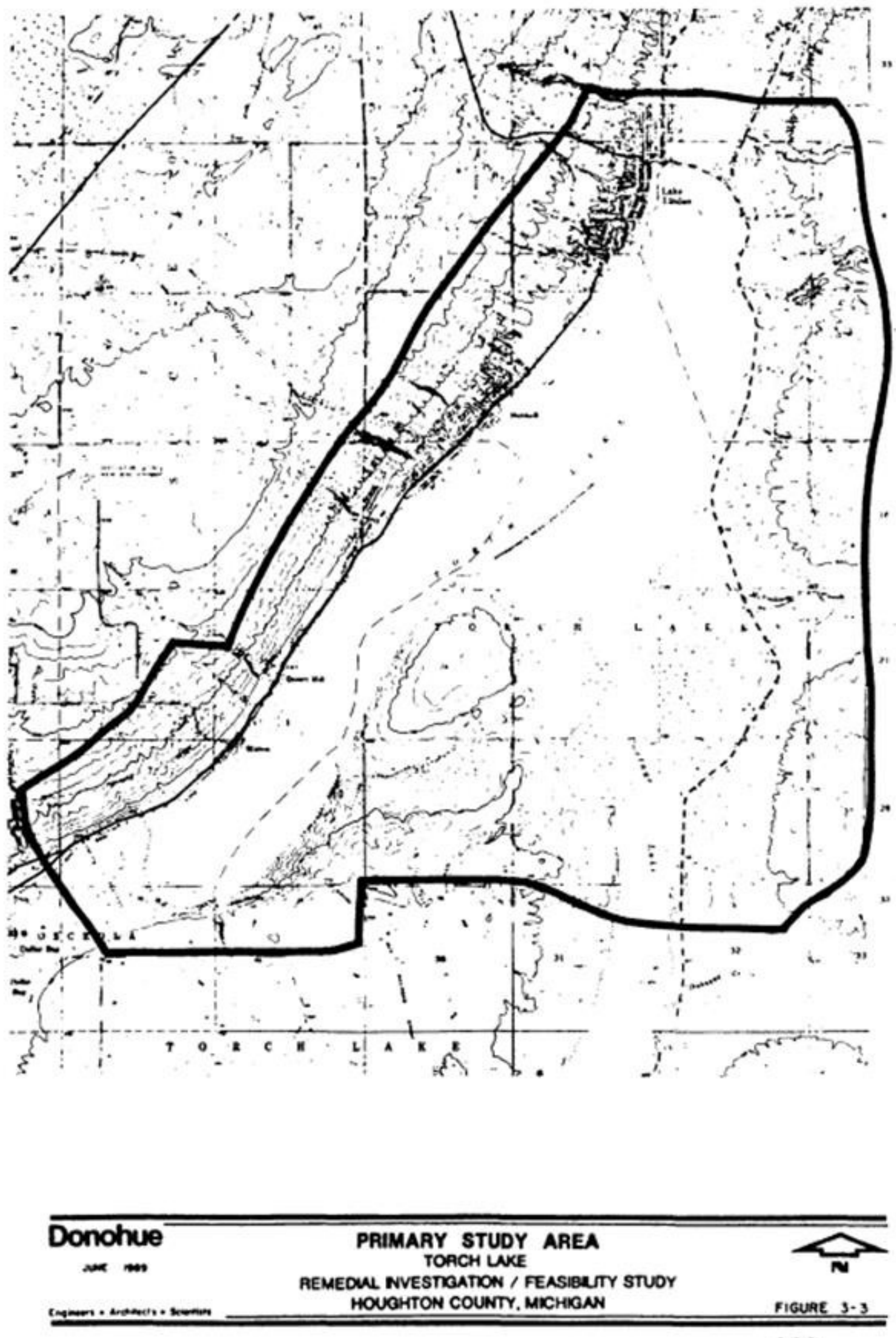


Figure 3-8. Primary Study Area (1989). Source: Donohue & Assoc. Inc. Final RI/FS Work Plan, Vol. 1A (June 1989).

Two things stand out as important in the shifting definitions of the operating units. First, each successive operating unit delineation has more definition of location and specific media. Second, the industrial western shoreline along Torch Lake is eliminated and attention directed solely to any slag or drums located on shore. These changes were the product of sampling for specific contaminants as well as a determination that the primary health hazard was airborne exposure to dust from tailings piles. The narrowing of the geographical area of inquiry and the scope of the hazard occurred during the RI/FS study period.

3-8. Cleaning Up and Delisting Torch Lake

The RODs for each OU set the agenda for the remediation and eventual delisting of Torch Lake parcels from the NPL. Between 1998 and 2008 EPA conducted the primary work at Torch Lake, while the Michigan Department of Environmental Quality (MDEQ), now responsible for the AOC program, remained in the background. EPA obligated over $15 million for work at the site in 1998. MDEQ revised its Remedial Action Plan, organized a citizen's group, and conducted several small studies spending small amounts of funds. However, it had no funds for significant remediation and restoration work to remove BUIs necessary for delisting the Torch Lake AOC. The activities during this phase of work at Torch Lake (1994-2008) can be divided into three periods. A review of each period helps clarify why confusion remains today among local residents and others new to the issues at Torch Lake.

The first period (1988-1999), was devoted primarily to planning for remediation of OU I, and entailed addressing the stamp sand piles at Lake Linden, Tamarack, and Mason that had filled in Torch Lake. EPA also included in its work the identification and removal of barrels of waste along the shoreline. EPA devoted the funds (secured in 1998) and hired contractors to complete the work. During this period the MDEQ organized a Public Action Council (PAC) in 1997 whose purpose was to begin work on remedies necessary to remove the BUIs identified in the 1987 RAP. Representatives from local government, environmental organizations, the business community, and the nearby tribal government (Keweenaw Bay Indian Community) served on the PAC, as did citizens who held "at-large" positions. The PAC also effectively served as a local organization for community involvement, as required under the Superfund program.[12] The EPA had already established two document depositories (in Lake Linden and Houghton) to enable citizens to review documents as part of its

[12] EPA operated under a Community Relations plan finalized in April, 1990 (U.S.EPA, 1990). The plan did not include an advisory group, but focused on public meetings, fact sheets, and provision of accurate information.

Community Relations Plan. But the PAC allowed a regular opportunity for local residents to hear about EPA remediation progress on a regular basis because the local newspaper reported on PAC meetings. The PAC activities and history of citizen involvement at Torch Lake are covered in depth in the next chapter.

The first contaminant removal action occurred during this first period. It addressed the barrels with unknown substances on the shore and in the nearby water. Eight barrels were sampled in 1988-89 from various locations. Under an Administrative Order by Consent issued by EPA, several responsible parties (including UOP and Quincy) sampled and removed barrels. About 80 barrels were removed along with minor quantities of soils. Over 800 drums (claimed to be empty) were found at the lake bottom and not removed (Kruger and Bartelt, 1992).

The second period of work at Torch Lake (1999-2008) encompassed the remediation of stamp sand deposits at Lake Linden (1999), Hubbell/Tamarack (2000), and Mason (2001). At least six inches of soil were added as cover to the tailings that were then vegetated. EPA contracted with the local district of the National Resource Conservation Service (NRCS) for this work, called "construction" in EPA documents. Once completed, inspected, and reviewed, these three sites were delisted from the NPL: Lake Linden in 2002 (partial) and 2007, Hubbell/Tamarack in 2004, and Mason in 2008. Delisting involves placement of deed restrictions on land remediated. In the case of stamp sand remediation, the deed restrictions pertained to removal and digging in capped sands. As a result, once a site is remediated it may take several years for all landowners to register deed restrictions required for delisting. According to Superfund policy, once a parcel of a Superfund site is delisted, it becomes the responsibility of the state government to perform regular inspections to insure continued viability. Referred to as O&M (operations and maintenance), Torch Lake tailings sites have been visited and inspected annually by MDEQ staff in the Superfund unit of the agency.

A significant event during this second period of EPA work at Torch Lake was the delisting of OU II from the NPL in 2002. OU II included the sediments and waters of Torch Lake, as well as other parts of the Keweenaw Waterway. The 1994 Record of Decision (ROD) for OU II recommended "no action" on sediments, with a remedy of long-term monitoring. It took eight years between the recommendation and the delisting. In the ROD, EPA argued that sediment contamination in Torch Lake and the Keweenaw Waterway posed no human health hazard. No action implied that continued, long-term sedimentation of the lake bottom from incoming streams and rivers (called natural attenuation) would eventually cover the contaminated sediments. Specific areas of heavy contamination (e.g. from PCBs) were not considered. In the ROD (1994) it was noted that PCBs and

PAHs were found in one location (the "hotspot" off of the Hubbell coal dock and smelter) in the lake sediments. It was also noted in the ROD that two thirds of the cancer risk from OU2 was associated with fish consumption, and that PCBs made the largest contribution to that cancer risk. However, because there were no benthic organisms found at the hotspot because of sediment toxicity, it was argued that there was no mechanism for entry into the food web of the PCBs found in the lake. Accordingly, the fish contamination with PCBs could not be linked conclusively with site contamination. This reasoning was later shown to be faulty in two respects. First, more extensive sampling for PCBs in 2006-2007 by both the EPA and MDEQ identified two areas of elevated concentrations (Lake Linden Beach area, Hubbell smelter/coal dock area) (MDEQ, 2008c; U.S.EPA, 2007a, 2009). Second, passive samplers deployed in the water column of the lake recorded elevated PCB concentrations (MDEQ, 2006a), and the congener ratios in the SPMDs indicated that the PCBs were of local rather than airborne origin (see Chapter 8). It is widely known that PCBs can partition from sediments into water and from water into the food web (e.g., Armitage et al., 2013; Gobas and MacLean, 2003; Thomann et al., 1992). It is important to note that for Torch Lake, subsequent research published in 2007 concluded that, in fact, natural attenuation from the sediments brought by the Trap Rock River and entering the north end of Torch Lake would take approximately 800 years (Kerfoot et al., 2008). Prior to delisting of OUII, long term monitoring of the sediments began in 1999-2000 with a Baseline Study to establish the conditions of Torch Lake and methods and data to be used as a guide for sampling for the future monitoring. Findings showed highly toxic copper in sediments (for invertebrates) and identified areas of concentrated contamination along the western lake shoreline. In the EPA Third Five-Year Review Report (2013) the agency revealed that the sediments were no longer being monitored: "Since no action was taken for OU II, the sediment does not need to be monitored and a specific O&M plan is not necessary" (U.S.EPA, 2013, p41).

In the meantime, by 2005 the AOC program (managed now by the MDEQ) had identified three BUIs for the Torch Lake AOC: fish tumors, restrictions on wildlife and fish consumption, and degradation of the benthos. The fish tumor BUI was removed shortly thereafter, as the tumors were no longer present and the original fish advisory for tumors had already been removed. This left the AOC site with two remaining BUIs—fish consumption restriction due to mercury and PCBs, and a degraded benthos-- both of which are still in force today. Interestingly, the removal of the fish tumor BUI added to the public perception that Torch Lake was no longer a hazard (see below).

While EPA continued to remediate the Torch Lake stamp sands, the AOC program continued its assessment of Torch Lake fish and sediments with several funded investigations. One of future significance was a small study during 2005 in Torch Lake using semi-permeable membrane devices

(SPMDs) to determine if the PCBs in the lake were widespread or located in specific locations. EPA simultaneously collected sediment samples at the same locations as SPMD sampling locations, testing for PCBs. Both sets of samples showed higher concentrations of PCBs, compared to control sites (MDEQ, 2007a, p26).

To local residents, this period of remediation seemed straightforward. Mining contamination in the form of uncovered stamp sands was contained through a capping and vegetation program, and the three major piles of sands present in Torch Lake were delisted. Citizens and PAC members who witnessed these activities started to believe that problems were solved at Torch Lake. Newspaper reports and public meetings focused primarily on EPA and stamp sands. Issues posed by the AOC program fell into the background. Fish consumption advisories and a degraded benthos received little attention during this era.

A third period of work activity at Torch Lake (2007-2015), however, demonstrated the limited nature of the initial remediation efforts. A series of four EPA Emergency Removal projects between 2008 and 2014 indicated that important hazards in Lake Linden, Hubbell, and Mason had gone unattended. Human exposure to identified sources of asbestos, PCBs, and heavy metals (including arsenic) required immediate action and removal. In addition, the problems of PCB (MDEQ, 2008c; U.S.EPA, 2007a, 2009) and possibly PAH (U.S.EPA, 1991, 2007b) contamination of Torch Lake soils, water, and sediments became evident after many years of inattention to research results. These are discussed in more detail below in the next section (3.9 Missed Opportunities).[13]

Public perceptions did not keep pace with developments of this third period, and the legislative response ran directly counter to the newest developments. While the third period of remediation was still underway, in spring 2014 State Senator Tom Casperson, R-Escanaba introduced Bill 872 into the Michigan Senate, specifying that stamp sands and other copper ore processing byproducts were exempt from the definition of hazardous waste under the Michigan Part 201 regulation. The bill proposed to exempt stamp sands and other copper ore processing byproducts from state environmental law restrictions unless the materials contain hazardous substances that exceed the allowable levels for unrestricted residential use under Michigan Part 201. The definition of exempt

[13] PAH contamination is primarily an issue in soils and not in the lake. However, PAHs in the hotspot were specifically cited. The Weston report listed widespread PAH contamination in soils. Donohue sampled soils in 9 residential lots and found elevated PAHs; the EPA couldn't prove that they originated from mining activities, and acknowledged that the sampling plan was inadequate to characterize risk to residents. Instead of doing more sampling, the issue was allowed to die.

materials in SB 872 is, “finely grained crushed rock resulting from mining, milling, or smelting of copper ore and includes native substances contained within the crushed rock and any ancillary material associated with the crushed rock”.

The bill became law in mid-July, 2014. Prior to bill enactment, the Department of Environmental Quality had to sign off on any development on stamp sands. SB 872 removed that requirement, unless it is known there are unsafe levels of toxics in the stamp sand. Local proponents of the bill said it would promote development on the stamp sands, provide a source of sands to apply to roads during the winter, and make a good ingredient for cement blocks and roof shingles. Other local groups were against the bill, and pointed out that the stamp sands contain unknown amounts of toxic chemicals. They noted that although there are results showing that concentrations of multiple metals (arsenic, lead, cadmium, copper, chromium, silver) and PCBs have been measured at concentrations above the Direct Contact Criteria and the Groundwater-Surface Water Interface Criteria in stamp sands at multiple locations throughout the Keweenaw Peninsula (ATSDR, 1998, 2014; U.S.EPA, 1992e, 2007b), the Department of Community Health has inadequate data to show where stamp sands are safe and unsafe for purposes of uncontrolled development. Opponents were also opposed to allowing special interest groups to dictate the management of the materials, arguing that there is a scientifically-based procedure for defining hazardous substances, and the amendment bypasses that process, making it into a politically-based rather than scientifically-based process (Hauglie, 2014a, b; Koski, 2014).[14]

As the monitors of Torch Lake remediation and witnesses to the new evidence of additional hazards, MDEQ staff began to document the unfinished business of cleaning up the lake environment and removing health hazards. Today, MDEQ local staff have focused new research on PCB and PAH sources as well as heavy metals, along with soil and sediment sampling in areas previously uninvestigated near copper processing facilities on the western lake shoreline. This work forms the foundation for possible redefinition of the problems at Torch Lake and new remedies. (See Epilogue for details on this new work)

As we investigate the history of government action at Torch Lake to resolve the problems brought by over one hundred years of contamination from copper mine processing, the question arises as to how two government programs designed to identify and plan the cleanup of contaminated sites *missed* the opportunity to comprehend the full extent of the problem and seek a remedy.

[14] Kurt Hauglie, “Bill aims to remove control of stamp sands,” *The Daily Mining Gazette*, May 2, 2014. Kurt Hauglie, “Stamp sand bill draws concern,” *The Daily Mining Gazette,* May 6, 2014. Jessica Koski, “SB 872 is not the answer to stamp sands,” Letter to the Editor, *The Daily Mining Gazette,* June 3, 2014.

3-9. Missed Opportunities for Health Protection and Remediation at Torch Lake

It behooves us to understand why PCBs in the shoreline environment and in the larger fish (walleye, pike, smallmouth bass) were not part of the hazard evaluation, and why the shoreline from Lake Linden to Mason that hosted industrial buildings with likely pollution in the nearby soils and shoreline sediments was also deemed not to be hazardous. These concerns framed some of the earliest EPA and AOC investigations. Several indicators pointed to additional contamination in Torch Lake shoreline sediments (e.g., 800 submerged barrels; (Kruger and Bartelt, 1992)) and soils (MDCH, 1995) that the final Record of Decisions for OU I (stamp sands) and OU II (lake water and sediments) did not identify. Subsequent findings by MDNR, MDCH, MDEQ, and EPA point to limitations in the problem definition, geographical setting of boundaries, sampling regimes, and recommendations for remediation and delisting of the Superfund and AOC sites.

3-9a. PCBs and mercury in Torch Lake fish

Beginning in 1988, MDNR began to sample fish and analyze fish tissue from Torch Lake on a regular basis. By 1993, sauger had all but disappeared. This was likely *not* due to toxic effects of contaminants, but probably due to changes in the lake water and sediments. In addition, the walleye sampled in the lake exhibited no external or internal tumors. The fish advisory for fish tumors was removed. However, new evidence of high levels of PCBs and mercury in walleye, trout, pike, and small mouth bass appeared. In 1992, during the remedial investigation (RI/FS work) for OU II (sediments, water, submerged tailings in Torch Lake) highest levels of PCBs and PAHs were found in sediments off the western shore of the lake near the Hubbell smelter site (U.S.EPA, 1992e, 1994, 2001). The PAHs are known to induce tumors in fish. However, the investigators determined that this small sample in one location could not be used to explain the frequency and spatial domain at which fish tumors were observed in the 1970s and 1980s (MDEQ, 2007a).

In 1998, Michigan Department of Community Health (MDCH) reissued fish consumption advisories in Torch Lake for PCBs and mercury in walleye, pike, and small mouth bass. An earlier advisory had listed mercury, but only as part of a statewide advisory (MDCH, 1995). The 1998 advisory added PCBs. This was not based on new fish tissue analysis, but a change in trigger levels (reference dose). Beginning with measurements in 1988, fish tissue samples exhibited elevated levels of mercury and PCBs (e.g., MDEQ, 2001, 2016). Torch Lake samples were compared with control samples from Lake Superior and Portage Lake. PCBs in fish tissue were found at elevated levels compared to those in the controls, and the difference was considered statistically significant. Further research, utilizing SPMDs (semi-permeable membrane devices) revealed that high concentrations in the water did exist along the western shore of Torch Lake near the Hubbell smelter site (MDEQ, 2006a, 2007a) .

In 2007, MDEQ reinforced the concern with PCBs in the Torch Lake environment in their "Biennial Remedial Action Plan Update for the Torch Lake Area of Concern". It described the new evidence of PCB contamination in the fish tissue along the western lake shore and called for further study to identify the source of PCBs. Sediment sampling in this area would be scheduled for 2007 (MDEQ, 2007a, p27).

3-9b. Heavy metal and PCB contamination on shore

Between 2007 and 2014, community reports and an EPA field campaign led to discovery of heavy metal, PCB, and asbestos contamination along the western Torch Lake shoreline. Under the Superfund program, the Emergency Response Program can be tasked to initiate and complete a cleanup of sites that pose an immediate health risk. Four such sites identified after EPA delisted the Torch Lake stamp sands and lake sediments from the Superfund program, attest to the limitations of the remedial investigation during 1988-1992.

- 2007: Lake Linden Beach. Lower lake levels exposed new shoreline and white clayey substance waste and blue colored water. Lake Linden Park samples taken showed elevated levels of PCBs, arsenic, lead, copper, barium, and cadmium. US Region 5 EPA Emergency Response Program removed the sediments.

- 2008: Mason stamp sands. An EPA survey after Lake Linden emergency response reveals arsenic contaminated soils and 10 barrels of residual waste. EPA removed 30 tons of soil and barrels.

- 2011-2014: C&H Power Plant in Lake Linden. The landowner began a site assessment, and in 2010 EPA determined a 14 acre site that included the power house, remains of the Hecla Mill and Still House presented contaminants of concern: asbestos, lead, and PCBs in basement water of the powerhouse. The site was cleared of asbestos and PCB-laden water in its basement by the end of 2014.

- 2014: Tamarack Stamp Mill (officially named Ahmeek Mill by C&H): Asbestos around the Ahmeek Mill in Tamarack was removed. The mill is adjacent to a playground and residential area.

The PCB research and the emergency removal projects identified the threats to human health by pollutants produced by the varied copper processing activities along the lake that are specifically associated with electrical and steam power production, reclamation of stamp sands and copper from scrap material, and the introduction of chemicals into processing beginning in the 1920s. Although the Remedial Investigation was thorough in conception, its intentions were thwarted by a sampling strategy that was inadequate for the site, and by misinterpretation of sampling results. Failure to base the sampling strategy on an understanding of the historical activities resulted in failure to find the asbestos, the PCBs or the concentrated arsenic and lead wastes that were discovered beginning in 2007. The prescribed Risk Evaluation correctly identified PCBs in fish as one of the main sources of risk, but this risk was ignored because of lack of understanding of PCB bioaccumulation. Based on the inappropriate sampling plan, the risk analysis led to the narrow focus on airborne dust as the major threat to human health. The perception that the contaminated lake sediments were too massive to remediate (a view articulated in the 1987 RAP) led to cursory consideration of alternatives to "natural attenuation" (U.S.EPA, 1994).

Remediation therefore becomes simple or impossible. Stamp sands exposed to air can be covered to prevent erosion and wind-driven dispersal. Hazards from eating contaminated fish can be controlled through public notifications (fish consumption advisories) with the hope that eventually the PCB and mercury sources will disappear. And sediments that are perceived to be degraded with a ubiquitous pollutant can be left in place to await coverage from slow-arriving sediments over hundreds of years. The result was limited or no action.

Yet another change in site definition occurred late in the remediation process after multiple OU I, II and III parcels had been delisted. The remediated OU I and III sites are now considered to include only the soil cap and the top six inches of stamp sands. The implication is that any problems (e.g., buried drums, buried layers of metal-rich sludges or coal ash, buried deposits of arsenic-rich slag, leaching of arsenic into surface waters) that are found as a result of erosion, excavation within, or weathering of the stamp sand piles cannot be attributed to failure of the Superfund remedy, although an emergency response and removal of hazardous material would still be possible.

Chapter 4. Who is Doing What at Torch Lake?

From 1845 to the 1960s, the Keweenaw Peninsula was home to industrial copper mining. A good part of mining history is the creation of waste, some of it harmful to human and environmental health. Torch Lake and the surrounding uplands and shoreline provided the home for the most extensive portion of copper processing in the entire Lake Superior copper district. Although several mills and a smelter produced mineral waste along the shores of Portage Lake and Lake Superior, the most intensive contamination occurred at Torch Lake. In the 1980s, just a decade after mining ceased, it became the first site of focused remediation in the district. Federal, state, and local governments have participated in the study of mining wastes, planning remediation strategies, and implementing remediation. It has been a complex array of activities that have often bewildered local residents.

The ongoing attention to the water, fish, soils and sediments in and around Torch Lake is the responsibility of several government programs. Beginning in the early 1980s the EPA and the Michigan DNR set their sights on the problem of fish tumors and possible causal contaminants. Shortly thereafter, the U.S. International Joint Commission (IJC) named Torch Lake an Area of Concern in 1985. After ranking high enough on a hazard evaluation scoring, it also became a Superfund site on the National Priority List (NPL) in 1986. These events drew the focus of several agencies in a concerted effort to address the complex nature of mine contamination.

For the past thirty years, local residents have asked: Who is involved in cleaning up this area? What are they doing? How is it going? This chapter and the accompanying fact sheet for public distribution provide an overview of the cleanup work and government involvement at Torch Lake. No less than eight public agencies and organizations exercise some oversight of the work at the lake. At least two of these agencies delegate responsibility for their work to multiple additional programs. Often during the summer months, public meetings are held by different government bodies. Summer is also the time when sampling and remediation work occurs. With multiple government actors, it is no wonder that local residents have difficulty keeping agencies, programs, and their visiting officials straight. This fragmented system of hazard identification, contaminant study, remediation, operations and maintenance, and delisting has created confusion and sometimes frustration among citizens. Managing mine contamination is a complicated business and a decades-long process, and even the most astute residents who have followed events sometimes scratch their heads. A case in point: when the authors of this Integrated Assessment have presented their findings to local public groups, audience members ask the most basic of questions such as: What is the difference between an AOC and Superfund site? I thought EPA was finished at Torch Lake; why is EPA still here doing work? What is MDEQ doing at Torch Lake when the site has already been delisted? Have health assessments ever been done?

What all residents should understand is this: ***Primary responsibility for cleanup resides with the US Environmental Protection Agency (EPA) and the Michigan Department of Environmental Quality (MDEQ). EPA works closely with MDEQ to carry out the work at Torch Lake.*** Although they address the contaminants in and around Torch Lake, they work in different frameworks. The Superfund program ranks hazards that can pose health and environmental threats through four pathways: soil, air, groundwater, and surface water. If hazards are significant through one or more of these pathways, the site is placed on the National Priority List (NPL). A plan (ROD, or Record of Decision) is implemented to address the hazards that can be on land, in water bodies, or underground drinking water supplies. The object of the program is to study and clean up contaminants and "delist" the site, enabling safer public use. The Area of Concern (AOC) program orients cleanup to water bodies that are part of the Great Lakes. As such, it identifies impairments to a healthy aquatic ecosystem, including human health, that are called BUI's (beneficial use impairments). Once an AOC site is listed, the objective is to remove or "delist" the BUIs. An essential difference between the two programs at Torch Lake is in their boundaries. One, Superfund, can address both land and water sites. Thus, its attention has been on stamp sands, Torch Lake, Portage Lake, and upland industrial sites. The AOC program, however, is limited to water quality in Torch Lake itself, and therefore has a much more narrow scope than afforded by the Superfund program. To a resident living along the shores of Torch Lake or to an individual that recreates in areas affected by mining waste, these differences mean little. But if one wants to ensure that contaminants are removed or addressed to improve health and the environment, understanding how each program works is critical. Delisting of a Superfund or an AOC site demands an informed citizenry that can help the process proceed efficiently.

What leads to citizen confusion at Torch Lake are three things: 1) How the line of responsibility between EPA and MDEQ is drawn; 2) How different programs within EPA and MDEQ represent the responsibilities of each government agency under the law; and 3) What government offices outside of EPA/MDEQ are involved and why. The following description and chart addresses this confusion and attempts to clarify the major actors and their activities at Torch Lake.

Both Superfund and the AOC programs are the responsibility of EPA's Region 5 office in Chicago. The Superfund Program office in Washington DC delegates all responsibility for managing hazardous waste sites within Region 5 to that office. EPA Headquarters provides guidance and requires sound science for management of Superfund site study and remediation. The International Joint

Commission (IJC) delegates its authority to clean up AOC sites in the US to the EPA, who then delegates responsibility for Michigan AOC sites to Region 5. The MDEQ works closely with EPA Region 5 to implement work at AOC sites. EPA also delegates responsibility to MDEQ for Operations and Maintenance (monitoring delisted Superfund sites) after they are delisted. In addition, EPA's Region 5 delegates many of its Superfund and AOC responsibilities to the State of Michigan, primarily the Dept. of Environmental Quality (MDEQ). When a resident attends public meetings, often it is staff from MDEQ who presents information, sometimes accompanied by EPA staff from Region 5. When their work utilizes health assessments or contaminant studies, representatives from the Michigan Dept. of Health and Human Services (MDHSS) or from consulting engineering firms are present to answer questions.

What is important for today's Torch Lake resident to understand from all of the above is this: ***the MDEQ is the most active agency in the local community today. It has been delegated primary responsibility from the EPA and IJC to address mine contamination. Individuals from different offices in MDEQ are working simultaneously on a number of issues still present in and around Torch Lake.***

Between the 1970s and today, no fewer than nine agencies and organizations have operated around Torch Lake and have held public meetings. In addition, representatives from several contractors hired by these agencies have worked on research and remediation actions as well, and have presented their results in the community. Table 4-1 at the end of this chapter illustrates the numbers of agency offices and local programs active at Torch Lake and notes their connections and responsibilities.

The discussion below highlights the two major cleanup programs – Superfund and AOC – and describes which programs are responsible for which activities. Let's hope it answers the question: Who does what at Torch Lake?

4-1. Superfund

The initial and most prominent EPA program involved at Torch Lake since the early 1980s is the national Superfund program. Established by Congress in 1980, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) required the federal government to identify and list the worst hazardous waste sites in the nation and establish strategies to clean them up. All Superfund work is delegated to the Regional Offices whose staff members work with communities, contractors, and state government programs to implement the effort. Michigan is served by Region 5, located in Chicago. Superfund site cleanup can take decades, as witnessed by Torch Lake residents.

Superfund projects progress through nine stages from listing to reuse of the site. (See: https://www.epa.gov/superfund/superfund-cleanup-process for a summary list of the stages). The Torch

Lake Superfund Site is near the end of this process---currently engaged in delisting locations of the Superfund site beyond Torch Lake. All of the Superfund operable units around Torch Lake, including the stamp sands at Lake Linden, Tamarack, and Mason, have been delisted as of 2008. These were part of what Superfund named Operating Unit I (OU I). Operating Unit II (OU II) included sediments in Torch and Portage Lakes that were delisted without any action for remediation in 2002. Other parts of the Superfund site, under OU3, are close to delisting, awaiting implementation of deed restrictions. Boston Pond, Calumet Lake, and North Entry are the remaining targets for delisting once this requirement is met.

EPA appoints a Remedial Project Manager (RPM) for each of its Superfund sites in Region 5. This individual oversees the work through all stages of site evaluation, remediation, and delisting, and works closely with the MDEQ Superfund office. Because Superfund sites take many years, even decades, to clean up, there may be a sequence of Project Managers over the lifetime of the site. Torch Lake has had at least six Project Managers since 1989. The Project Manager, along with the EPA Region 5 Community Relations Director, holds public meetings to brief communities on progress and seek comments. During the first years of Superfund work (remedial investigation), contractors hired by the Regional Office also hold public meetings. Region 5 hired Donohue and Associates between 1988 and 1992 to conduct studies and plan remediation alternatives, and they were present at a number of public meetings after 1992 as the EPA Region 5 staff prepared the Record of Decision.

Once remediation work has been completed, the specific properties in the Superfund site move into a "delisting" phase. Generally, the goal is to make sure that property owners implement deed restrictions before a delisting has occurred. This is typically the job of the Michigan DEQ Superfund staff, which under the authority of the EPA works directly with property owners, frequently visiting the community and holding public meetings. In the case of the three remediated sites along Torch Lake – Lake Linden, Tamarack, and Mason—the deed restrictions have been secured and the sites have been delisted. They are no longer considered official hazardous waste sites. MDEQ staff are currently still working with residents at Boston Pond, Calumet Lake, and North Entry on deed restrictions necessary for delisting those sites.

Once a site is delisted, the Superfund program does not disappear. It has specific "post-construction" responsibilities. During the cleanup phase prior to delisting an Operations and Maintenance Plan is written which details a plan for continued site visits to assess the integrity of remediation. Region 5 Superfund office has delegated the responsibility for annual site visits to the MDEQ. Michigan DEQ staff from its Superfund office visit Torch Lake annually to inspect each delisted site in an Operating Unit. At Torch Lake this occurs regularly during summer or fall months in which staff visit the three stamp sand banks at Lake Linden, Tamarack, and Mason to assess the continued integrity of the six-inch vegetation cap, looking for potential erosion or failure. It is the job of MDEQ to repair any remediated area that is failing.

A second Superfund program in Region 5 (Emergency Response) is also active in Torch Lake. The Emergency Response Division is separate from the Remediation Division in each Regional Office, and operates under different rules. Its job is to provide a quick response cleanup effort for contaminated sites that state programs (such as MDEQ) cannot handle in a timely manner. This program is required to complete a cleanup within 6 months and a cost under 2 million dollars. EPA Region 5's Emergency Response team has been active in the Torch Lake area since 2007 with several projects to remove contaminated soils and sediments along the western shoreline. Several of these areas were not part of the Superfund site as defined under the Record of Decision. However, continued investigations by MDEQ resulted in requests for EPA Emergency response at Lake Linden in 2007, 2012, and 2017 to address heavy metal and PCB contamination. In addition, the Emergency Response team worked in 2008 to remove waste barrels and arsenic-contaminated soils near Mason and on several occasions to remove asbestos from multiple sites. Today the team is planning a removal/dredging project for summer 2018 at the Lake Linden beach where high levels of lead and PCBs are present in sediments near the water line.

4-2. Area of Concern (AOC) Program

Torch Lake has been a designated Area of Concern since 1985. While the IJC and EPA Region 5 are responsible for all AOCs in the Great Lakes, the primary work of study, planning, and remediation in the state is the responsibility of Michigan's DEQ staff. The AOC program is the responsibility of the Office of the Great Lakes (OGL), whose head reports directly to the MDEQ Director (a Governor's appointee)[15]. The OGL is separate and distinct from the line offices of water, air, waste, remediation, etc., that before 2018 fell under the MDEQ Deputy Director. At MDEQ, work at Torch Lake is organized under both the OGL (AOC program) and the RRD (Remediation and Redevelopment Division) that completes the annual Superfund post-construction site assessments.

The MDEQ Office of Great Lakes (OGL) gives the AOC Program a distinct status within the agency and links it directly to EPA Regional Office 5. Every AOC in Michigan has an AOC Coordinator, often sharing that individual with one or two other AOC sites. Torch Lake has had one AOC coordinator for many years, who has recently retired and is replaced temporarily by the OGL Deputy Director. Because the AOC program has lacked sufficient funds to conduct regular research and fund remediation

[15] In 2018, OGL is now located in MDNR.

projects, the AOC Coordinator's role has been to serve primarily as an intermediary between the community and the MDEQ, securing resources for specific, small research projects that address contaminants (i.e. PCBs), and preparing five-year updates on the status of the AOC.

One of the major initiatives of the AOC Program in Michigan is the organization and funding of Public Action Councils (PACs). The Torch Lake PAC (TLPAC) calls itself a Public Action Council. In 1998, it was one of the last PACs in the state to be organized, and is composed of a body of citizens representing different interests (residents along Torch Lake, local townships and villages, and environment, health, and sports stakeholders). Because EPA had never established a Community Advisory Group at Torch Lake (as is typical at other Superfund sites), after 1998 TLPAC served the local community by working with *both* the Superfund and AOC programs. At this point in time, EPA had begun to plan and execute its remediation program at the three stamp sand banks in Torch Lake. The TLPAC helped Region 5 staff and their designated project manager, the local office of the USDA Natural Resource Conservation Service (NRCS), spread information about the details of each summer's project to transport soil, cap, and vegetate the stamp sands. The TLPAC also worked with MDEQ on the revision of the 1987 Remedial Action Plan (RAP) for the eventual removal of the BUIs and delisting of the AOC site.

The MDEQ also works in the Torch Lake watershed through the Remediation and Redevelopment Division (RRD), which is distinct from the OGL's AOC program. The RRD has regional offices and field staff placed through Michigan. The regional RRD office in Marquette, along with its field staff located in Calumet, has been active around the Torch Lake shoreline since 2008 after the delisting of the stamp sands at Lake Linden, Tamarack, and Mason, and beginning with the identification of new contamination problems at Lake Linden beach. The Calumet RRD unit (a staff of one person) works closely with EPA Region 5 Emergency Response team. Beginning in 2014, after a series of Emergency Response Projects along the Torch Lake shoreline, the RRD began its own systematic evaluation of industrial sites along the shoreline from Lake Linden to Mason in the Abandoned Mining Waste Program. This area, upslope from Torch Lake, was not included in the Superfund site as defined in the ROD, thus prompting MDEQ to devote staff and funds to investigation of historical processes at industrial sites along the shoreline and to soil and shoreline sediment sampling for contaminants. This project is ongoing.[16] The project focus started with PCB contamination, but has grown to include other contaminants discovered at sampling sites such as asbestos, arsenic, and other heavy metals. MDEQ

[16] Historical research conducted in 2014 (January through July) provided potential locations for a multi-year sampling program: Summer 2014 at Lake Linden; Summers 2015 and 2016 at Hubbell and Tamarack; and Summer 2017 at Mason.

RRD has paid for some remediation to date (such as asbestos piles). However, the RRD will request help from the EPA Emergency Response program for more extensive and expensive cleanups.

4-3. Other Federal and State Agencies and Private Contractors

While EPA Region 5 and MDEQ are the major actors at Torch Lake, there are several federal and state agencies that aid in the work of evaluating and remediating contamination issues. In addition, EPA and MDEQ have relied considerably on private contractors (primarily consulting firms with extensive technical staff) to conduct research and sampling programs at various stages in the Superfund and AOC programs.

Several health agencies cooperate to evaluate physical hazard and community health issues posed by contamination at Torch Lake. At the federal level, the Agency for Toxic Substances and Disease Registry (ATSDR), part of the Centers for Disease Control, has conducted assessments on specific contaminants. It completed the Preliminary Health Assessment in 1988 for EPA. It has also worked with Michigan Dept. of Health and Human Services (MDHHS), Division of Environmental Health, on fish contamination assessments. The Lansing office of MDHHS has been active in recent years with annual visits to the Torch Lake region to discuss fish consumption advisories. Historically, the MDHHS and its predecessor agencies have funded local assessments by the Western Upper Peninsula Health Department (WUPHD) that included water analysis, stamp sand analysis, and other services by the local Environment and Sanitation Division staff. WUPHD is a six-county health agency, governed by a Board of representatives from the County Commission of each county. Much of WUPHD's funding comes from MDHHS to conduct health assessments, water analysis, and environmental health programs in the Western Upper Peninsula. Torch Lake residents are aware of WUPHD's role in beach closings around the lake when contaminants are exposed along the shoreline during summer months. WUPHD also issues permits for wells and septic systems, thus setting the standard for regulation of well and septic installation for homes built on capped stamp sands.

Private engineering firms provide technical services for the large planning and sampling projects that have been necessary at Torch Lake since 1985. Local residents have likely heard presentations from two firms that have provided essential services over these years. Donohue and Associates (Chicago) worked with EPA Region 5 between 1988 and 1992 on the Remedial Investigation and Feasibility Study (RI/FS). A number of their studies and documents are available in the Torch Lake Superfund Public Repositories at the Lake Linden and Portage Lake District libraries. The MDEQ and EPA Emergency Response Division (Region 5) have relied primarily upon the Houghton offices of Weston Solutions, Inc. (a national environmental services firm based in Pennsylvania). More recently, the local engineers from

Weston, with considerable experience around Torch Lake, have affiliated with a regional environmental firm that serves Michigan and Ohio, Mannik Smith Group. Today, residents interested in current work at Torch Lake will encounter projects involving the local representatives from Mannik Smith who appear with their EPA and MDEQ supervisors at presentations. In addition, the EPA contracted with the local (Baraga) National Resource Conservation Service (NRCS, U.S. Dept. Agriculture) office to supervise remediation around Torch Lake and in its watershed. The Houghton Keweenaw Conservation District, the local government unit responsible for local soil and water conservation activities, has performed stream restoration in the Torch Lake watershed to ameliorate mining-related contamination, and it has partnered with the TLPAC in recent years.

The state has other legal responsibilities for and interests in Torch Lake that are not directly linked with the historical contamination. Torch Lake is a valuable fisheries resource overseen by the Department of Natural Resources (MDNR). The MDNR periodically monitors the fish community in the lake, and, together with the Keweenaw Bay Indian Community, stocked fish into the lake for many years. The tribe and MDNR also catch fish about every five years for the state's Fish Contaminant Monitoring Program; results from that program are used by the Health and Human Services Department for setting fish consumption guidelines and by the MDEQ for assessing compliance with some provisions of the Clean Water Act. The Water Division of MDEQ also samples the lake and its tributaries to monitor water quality to meet its obligation to the EPA to implement the Clean Water Act. The state (MDEQ Water Division) is responsible for planning cleanup of water bodies that do not meet state water quality criteria. At present, several tributaries as well as Torch Lake itself exceed state criteria for one or more metals.

Personnel at Michigan Technological University (MTU) have played several roles in the decades since mining operations ended. Faculty and graduate students primarily from the Chemistry and Biology departments conducted multiple research projects in the 1970s and 1980s that helped to identify many of the problems that later became the focus of remediation efforts (Mackay, 1985; Sabol, 1981; Sypniewski, 1977; Tomljanovich, 1974; Virnig, 1974; Warburton, 1987; Yanko, 1969). However, MTU also sponsored an industrial corridor development along Torch Lake in the 1970s and 1980s, and for this reason became involved in clean-up of spills or contamination caused by the sponsored companies. The MDNR also contracted with MTU to perform assessments of contamination in and around the lake prior to the site's inclusion on the NPL and AOC listing (Costanzo and Oakes, 1984; Leddy, 1973; Leddy et al., 1986; Markham, 1986). Formal engagement of the EPA at the site in the late 1980s largely brought to an end the research of MTU faculty and students. However, multiple MTU faculty served on the TLPAC from its inception in 1997 to the present. The MDEQ did contract with MTU faculty to perform a few additional research projects in the 1990s and 2000s. Most recently, three MTU faculty received funding from Michigan Sea Grant to perform this integrated assessment. This team of two environmental engineers and one anthropologist/historian, along with two graduate students, has been active in community meetings on Torch Lake since 2012.

To sum up the essential points about who does what at Torch Lake:

- Historically, the two most important actors at Torch Lake have been the staff of EPA Region 5 and the MDEQ since the mid-1980s.
- Today, the most important actor at Torch Lake is the MDEQ – Office of the Great Lakes (OGL), for the AOC program; and the Remediation and Redevelopment Division (RRD) for the current project to evaluate terrestrial (upslope) contaminants of legacy mining along the shores of Torch Lake.
- The Emergency Response Division, Region 5 EPA, has become an important secondary actor since 2008 when short-term cleanup projects of significant contaminants that affect human health need immediate attention. Torch Lake has witnessed five emergency cleanup projects within the last nine years.
- Other organizations also currently frequent Torch Lake for work on: fish contamination (MDHHS, MDNR, MDEQ); beach closures, septic regulation, drinking water analysis (WUPHD); water quality (MDEQ); and evaluation of contamination at historical mining industrial sites at Lake Linden, Hubbell, Tamarack, and Mason along the lake shoreline (Mannik Smith Group).

Table 4-1. Agencies, Offices, Responsibilities at Torch Lake

Agency	Programs/Offices	Responsible for?	Notes
INTERNATIONAL International Joint Commission (IJC)	Delegated to: • EPA in Region 5 • MDEQ in Michigan	Areas Of Concern (AOC) in Great Lakes	IJC delegates to Region 5, who delegates to MDEQ
FEDERAL Environmental Protection Agency (EPA)	Region 5: • Remediation • Emergency Response	• Superfund Sites on NPL • Short term cleanup of contaminated sites	
Agency for Toxic Substances and Disease Registry (ATSDR)		Toxicology studies	Works with Michigan Health & Human Services (MDHHS)
STATE (Michigan) Department of Environmental Quality (MDEQ)	Office of Great Lakes (OGL)	Responsible for AOC sites in Michigan	IJC delegates authority to EPA/MDEQ
	Remediation and Redevelopment Division (RRD)	Addresses contaminated sites not under Superfund	Maintains regional office in Marquette; local office in Calumet
	Water Division	Evaluates water quality relative to state criteria	

Agency	Programs/Offices	Responsible for?	Notes
STATE (Michigan, cont.)			
Department of Natural Resources (MDNR)	Fisheries Division	Fish stocking	Historically stocked Torch Lake; no current stocking. Conducts studies of fisheries. Local office in Baraga
Department of Health and Human Services (MDHHS)	Div. of Environmental Health Toxicology & Response	Fish advisories for Torch Lake Performs risk assessments	Works closely with WUPHD in Hancock
LOCAL			
Western Upper Peninsula Health Department (WUPHD)	Environmental Health Div.	Responsible for beach closings, well & septic permits; well water testing receives reports from citizens re: contamination	At Torch Lake has closed mining-contaminated beaches; tested wells; limited septic permits on stamp sands
Torch Lake Public Action Council (TLPAC)	Local citizen organization	Established 1998 by MDEQ under AOC Program	Works with MDEQ and EPA; meets monthly
Houghton-Keweenaw Conservation District (HKCD)	Local government agency	Established under state law to work with landowners on conservation issues	Worked on watershed plan for Trap Rock River; held informational meetings 2014-15 on Torch Lake. Planned and supervised clean-up of Scales Creek.

Chapter 5. Citizen Engagement at Torch Lake

The history of local involvement in the discussion of mining waste and its cleanup around Torch Lake and in the Keweenaw can be documented at least back to the early 1970s. Stamp sands, slag and poor rock piles have been a part of the Keweenaw landscape for a hundred years. However, residents have also noted the effects of less dramatic signs of the mining environment such as smelter smoke, blowing stamp sands, industrial noise, and colored lakes, and remarked on the effects upon everyday life in the district. When the mines throughout region closed permanently in 1970 (except for the White Pine Mine in Ontonagon), the US was simultaneously entering an era of environmental awareness. Copper Country citizens noted tumors on fish, red coloring to Torch Lake waters, and registered concerns about the effect of past mining on drinking water. When Torch Lake became the focus of attention in the 1990s, citizens organized themselves and also were recruited by government agencies to help address contamination problems. The path from that decade until today is characterized by a nearly thirty-year history of government action and citizen response that has not always run smoothly for either government agencies or residents. The face of citizen participation around Torch Lake today exists in the form of the Torch Lake Public Action Council (TLPAC). Established by Michigan DEQ in the late 1990s, this volunteer group has met regularly to track EPA and MDEQ developments in the Torch Lake Superfund and AOC programs. Its public meetings have drawn attention of the local press, which then distributes information throughout the community.

The history of citizen involvement in the Torch Lake story is a complex one. This chapter documents the growing awareness of local citizens about the environmental consequences of mining and mineral processing in the district. It tracks the role of residents who engaged with the federal and state agencies responsible for study and remediation of mining waste through the Superfund and the Area of Concern programs. It also documents the differing viewpoints in the region about the hazards of mining waste and the necessity to remediate them, and how community disagreement affected EPA and MDEQ implementation of Superfund and AOC plans.

This local history unfolded with a backdrop of environmental developments at the national level. When the mining companies wound down their operations at Torch Lake in the 1960s and elsewhere in the Keweenaw, the American public was turning its attention toward serious pollution issues and the strengthening of environmental laws. Air and water pollution, in particular, drew national attention. New laws provided the regulatory teeth to effect air and water standards that had been unattainable under the previous federal and state public health programs. For communities coping with industrial contamination, the Clean Water Act (1970), the law creating Superfund (CERCLA, 1980), and the formation of the Environmental Protection Agency (1970) strengthened the effort to clean up chemical and mining wastes

Torch Lake and the surrounding mining zone was typical of other long-lived mining districts such as Butte, Montana (copper mining/smelting) and Bunker Hill, Idaho (silver mining/smelting) with large, complex legacies of mining waste contamination of water and soils. Legacy pollution sites in these historic mining districts had similarities—surface and groundwater pollution resulting from decades of processing facilities that discharged chemicals and tailings into streams, lakes, and groundwater reserves; smelters that emitted heavy metals through their smokestacks into nearby residential neighborhoods; and adoption of chemical processing techniques and electrification facilities dependent upon coal and transformers that left PCBs and PAHs in the nearby soils and sediments. Like Butte and Bunker Hill, Torch Lake became an early Superfund site.[17]

The public attention devoted to contaminated mining and other industrial sites occurred simultaneously with another political development in the US – that of increased citizen participation in governance at the local and federal level, strengthened by new laws and policies. Legislation from this era, such as Superfund (CERCLA 1980 and SARA 1986), required that local residents be informed about environmental decisions important in their communities and provided with mechanisms to participate. Since environmental contamination is a locally experienced event, it is no wonder that national programs such as Superfund were the first to experiment with strategies that include citizens in planning and final remediation decisions. Other place-based programs such as the Great Lakes AOCs (required by amendments to the GLWQA), also adopted many of these strategies. Over the years these programs have evolved and improved. At the EPA, the national Superfund office has staff dedicated to improving citizen programs through training, technical assistance grants, and a series of handbooks that provide guidance for EPA staff at the Regional offices who work with Superfund communities. The AOC program encouraged Great Lakes states to implement citizen advisory groups at each of their sites. Both Superfund and AOC implemented citizen programs at Torch Lake in the 1990s. However, the approach to citizen involvement differed significantly between the two programs.

Taking a page from the early EPA Community Relations Superfund Handbooks, Region 5 defined its mission for citizen participation as a one-way affair, which consisted of public meetings to inform residents of agency and contractor research and progress in addressing remediation. The contractor who conducted the Research Investigation for Torch Lake prepared a Community Relations

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[17] Bunker Hill Mining and Metallurgical Superfund Site was added to the NPL in 1983; the Silver Bow/Butte Superfund Site was originally listed on the NPL in 1983 and expanded in 1987.

Plan in 1992. During the last twenty-five years Region 5 staff deviated very little from this approach. EPA officers visited the region to report on study results, the completed Record of Decision, and delisting plans for various units of the site. These visits seemed more like information sessions in which residents asked questions rather than contributed to the decision-process. The national Superfund office, however, began to revise its guidance documents for regional offices after 1992 and moved its emphasis from a one-way "community relations" strategy into a more interactive "community engagement" approach that stressed "early and meaningful" involvement by residents. Torch Lake did not benefit from these changes.[18]

Unlike the Superfund program, the MDNR (later MDEQ) actively organized citizen groups known as PACs (Public Action Council) for the AOC sites around Michigan. In 1998, Torch Lake was the last PAC in the state to be established. The focus on creation of active citizen groups in contaminated zones in the Great Lakes region originated from the International Joint Commission (IJC) emphasis on citizen involvement after 1987. The amendments to the GLWQA of that year created Areas of Concern and requirements that Remedial Action Plans (RAP) be prepared with the input of local residents. In line with the new requirements, Michigan formed a statewide Public Advisory Council (SPAC) in 1991 with representatives from its 14 AOC sites. Each AOC developed its own local PAC, with the main agenda item being preparation and review of the RAP. Under the AOC program, the PACs have become active citizen groups that meet regularly, receive reports from AOC program officers and scientists, contribute comments, and raise issues that government staff may not be aware of. The PAC represents a more active form of citizen involvement than that afforded by EPA's early community relations program, and it allows for an ongoing dialogue among the various stakeholders while remediation programs are designed and implemented. Throughout Michigan, the evolution of individual PACs has taken different forms. Some communities have complex organizations of citizens involved in watershed management, of which Superfund and AOC programs are a part; other communities have developed long-term activist organizations through their PACs that monitor and intervene in cleanup strategies. The history of citizen involvement at Torch Lake is different from most of the AOC communities in the state.

Torch Lake is one of four AOC sites in Michigan that also have a Superfund status, so it is not an unknown experience. Nevertheless, this can be confusing for residents because the two programs have different criteria for listing and remediation of contaminated sites. Historically, the communities around

[18] EPA produced five citizen handbooks between 1983 and 2016 for communities and regional EPA staff. The first handbook was titled Community Relations Superfund Handbook; the most recent, titled Superfund Community Involvement Handbook. The shift from "relations" to "involvement" marks a significant change in how Superfund staff is expected to work with communities.

Torch Lake and the wider public in the Keweenaw have found it difficult to distinguish between the EPA Superfund Program and the MDEQ's AOC initiatives, and have often not been clear as to which government agencies and offices are responsible for what aspects of the Torch Lake cleanup. This has a significant impact on effective citizen involvement. For nearly twenty years, the Torch Lake Public Action Council (TLPAC) has been the primary local face of citizen involvement for both the AOC and the Superfund program officials. The two-decade history of the TLPAC also reflects the deep divisions within the community that have been evident since the start of Superfund and AOC attention to Torch Lake in the early 1980s. It is useful to investigate the history of citizen involvement and its implementation at Torch Lake. From this, especially in comparison with other Superfund and AOC sites, we can make sense of why this community is still struggling with significant contamination after nearly twenty-five years of work.

The history of community response to contamination at Torch Lake should be understood within the context of an evolving set of federal and state policies that began in the 1980s as "community relations" programs that emphasized transparency of federal actions and later encouraged citizen involvement through local committees. From the 1990s and into the 2010s, the emphasis shifted toward inclusion of residents of Superfund communities into earlier stages of the decision process and encouraged local involvement through committees and Technical Assistance Grants (TAGs). However, the Torch Lake community benefited little from improvements in citizen participation policies at EPA. Not until 2000 did the Torch Lake PAC (TLPAC) emerge as an active local citizen group, but under the direction of MDEQ and its Area of Concern program. By this time, remediation had commenced on OU I Lake Linden and Tamarack stamp sands. The TLPAC actively followed Superfund progress and also began to investigate a revised Remedial Action Plan (RAP) for the Area of Concern, which was to be its primary focus.[19] The following discussion begins with a summary of citizen participation policies at the federal and state level to establish the context within which we can analyze the community response to Superfund and AOC policies implemented at Torch Lake. It continues with a history of how residents around Torch Lake engaged with mining waste issues beginning in the 1970s (before Superfund and AOCs) and continuing throughout the subsequent four decades. It ends with a discussion of how this unique history of community response to mine contamination and has affected the effectiveness of citizen participation.

[19] Sources for this twenty-five year story include: newspaper articles in the Daily Mining Gazette, Superfund documents housed at local libraries, meetings with current and past PAC members, and PAC minutes.

5-1. Evolution of Superfund and AOC Practice for Citizen Involvement

US Superfund legislation passed in 1980 (CERCLA) required community involvement. "Congress intended to ensure that the people whose lives were affected by abandoned hazardous wastes and EPA's actions to clean them up would have a say in what happened" (U.S.EPA, 2005). Subsequently, Congress through Superfund reauthorization (1986) and EPA through administrative reforms have improved the citizen involvement process and strengthened the role of the citizen. In the 1980s, the term "community relations" reflected EPA's practice of keeping citizens informed as the agency moved through the several steps toward final remediation. Torch Lake was listed on the Superfund NPL during that early era in 1986. Today, after much experience, EPA requires that regional officials who work with Superfund communities develop a plan for early and "meaningful community involvement". The change in language signals an important change in requirements that EPA regional staff and communities must follow.

The Great Lakes Water Quality Agreement (1972; amended 1983, 1987, and 2012) established rules for listing and remediation of Areas of Concern, of which Torch Lake was listed in 1985. It began in earnest in 1975 when, under pressure from citizen groups, the International Joint Commission (IJC) sponsored a public participation workshop for the Great Lakes region. From this date citizens began to participate in advisory boards, reference boards, a binational network, and the Remedial Action Plans (RAP) at Areas of Concern. The 1987 GLWQA Amendments outlined the policies for establishing AOCs and required stakeholder participation at the local level in the RAPs and the use of an ecosystem approach. A departure from the normal top-down, technically-driven approach to pollution control, the RAP process was hailed as innovative but was very slow in getting started in the Great Lakes states. In 1993, ML Becker assessed the limitations of public participation in the IJC commissioned RAPs (Becker, 1993). She found that the IJC had been given oversight but had no authority to intervene and to take an active role in coordinating and monitoring the RAP process in communities with an AOC status. Citizen councils such as the Torch Lake Public Action Council (TLPAC) were organized to implement the RAP process. With no funding or authority from the IJC, some RAPs foundered. Some turned to larger watershed management organizations in search of funding and to increase pressure on public officials to act. Others worked with NGOs such as the Sierra Club or Great Lakes United to pressure the IJC to act. The states took on responsibility under IJC guidance to train local advisory council members and to provide networking opportunities so that local AOC stakeholders could learn from one another. For its 14 AOCs, Michigan established Public Action Councils in each community and in 1991 organized a Statewide Public Action Council with memberships from the local councils. It meets quarterly at different sites throughout the state, and provides training and information sharing.

At Torch Lake, citizen engagement in the Superfund and AOC programs reflects the deeper problems with each program. Under the early Superfund program, the regional offices in charge of sites on the NPL were required to finalize a "Community Relations Plan" before the Remediation Investigation began. The 1986 Superfund Amendments and Reauthorization Act (SARA) stipulated that listing on the NPL triggered community relations requirements. This included public notices, meetings, opportunities for public comment on proposed cleanup remedies, and fact sheets that provided information about the site and its cleanup. It also authorized Technical Assistance Grants (TAGs), enabling Superfund communities to utilize experts to help their review of technical information. The Torch Lake Superfund community relations plan was finalized in 1990 (U.S.EPA, 1990).

In 1992, EPA issued a 255-page community relations handbook for Superfund staff and managers.[20] This was the context within which EPA Region 5 staff worked during the crucial years of Torch Lake work. It framed the relationship between EPA Region 5 and the community throughout the remainder of study and remediation around the lake. The concept of "community relations" as iterated in this 1992 document —reflecting an information-oriented approach—is important to understand. At that time public participation in Superfund reflected an approach weighted heavily toward EPA's responsibility to provide information and, at crucial points, solicit comment. The 1992 EPA handbook defines its responsibility to the community:

> "The superfund community relations program promotes two-way communication between members of the public, including potentially responsible parties (PRPs), and the lead government agency in charge of response actions. The community relations activities discussed in this Handbook provide the opportunity for interested persons to comment on, and provide input to, decisions about response actions. These activities promote public participation in the decision-making process by ensuring that the local public is provided with accurate and timely information about response plans and progress, and that their concerns about planned actions are heard by the lead agency." (U.S.EPA, 1992b, p1)

As outlined in the Torch Lake Community Relations Plan, the community was primarily the recipient of information. Fact sheets, depositories of EPA documents, and public meetings to solicit comments made up the bulk of participatory activities. The central goal was to keep the public informed and to allow for comment on crucial documents such as the Remedial Investigation and Feasibility Study (RI/FS) and the Record of Decision (ROD). This approach, typical of public participation in that era, emphasized a one-

[20] The 1992 Handbook was a revision of the first 1988 Handbook. It reflected a more developed concept and suggested actions for "community relations."

way conduit of information to public audiences *after* major activities were completed in the study, characterization, and plan for remediation of the Superfund site. The community was to respond with comments and questions. Working within the framework of already written documents (reflecting preliminary decisions already made) put community members at a disadvantage.

Citizens, however, found they had an alternative to the EPA community relations approach because Torch Lake was also an Area of Concern. Michigan moved to establish Public Advisory Councils for its 14 AOCs in the 1990s, and with help from MDEQ staff, the Torch Lake PAC was established in April 1997—the last of the State PACs to be formed. The PAC continues to meet today twenty years later. Marked by phases of action in its early years, an interim period of inaction, and more recent monthly meetings to address new contaminants, the PAC has become the *de facto* mechanism for citizen engagement in both Superfund and AOC activity at Torch Lake.

The Torch Lake Superfund public meetings and the PAC activities are the more visible features of citizen involvement in the discussions and decision-making revolving around the Superfund and AOC sites. However, local residents were involved in citizen actions prior to the formal naming of Torch Lake as an AOC and it's listing on the NPL. It is worth recounting some of the more notable citizen events around Torch Lake pollution concerns in years prior to official EPA and IJC designations. Some of the patterns typical in community response to Superfund and AOC programs are found in the first years of attention to Torch Lake pollution after cessation of mining. Understanding these early years helps frame the character of citizen response to the later formal processes of listing, studying, and remediation.

5-2. Before Superfund -- Early Concern with Water Quality

Concern with the water and air quality in the Torch Lake region preceded the implementation of formal government programs. Residents living along the western shore of the lake alongside a smelter, several stamp mills, and three reclamation plants frequently remarked on the color of the lake water, the growing encroachment of sands into the lake, noise from stamp mills, and the black soot from coal-fired steam and electric plants. The industrial zone occupied a thirteen-mile strip of land along the lake and well into the lake itself. Homes and businesses were interspersed among the large facilities. The reach of technology penetrated the lake as well. Pontoons and dredges operated in the water for over 40 years to deliver stamp sands to the shore plants for reclamation. A 1955-newspaper article dubbed Torch Lake the "Red Sea" because of its colored water from the red sands of crushed conglomerate rock (DMG, 1955).

During the 1950s and 1960s, as the federal government promoted clean air and water programs through the US Public Health Service, citizens in Houghton County were also becoming aware of “pollution” and its link to human health issues. What seemed in earlier decades to be a nuisance for residents became a health concern. Soot from smokestacks and dust from tailings, raw sewerage from Laurium and Torch Lake communities, and chemical spills into the lake, and waste disposal practices of mining companies who dumped barrels filled with sludges and chemical residues from leach and flotation plants -- all came under scrutiny.

MTU scientists began biological and chemical research in the Keweenaw Waterway (including Torch Lake) in the late 1960s. From then on through the 1970s and early 1980s a team of researchers at the university maintained an active program of investigation into water pollution, fish abnormalities, and copper tailings. Mostly funded by the Michigan DNR, university scientists published papers and conducted MDNR inquiries into the causes of fish tumors, origins of chemical (especially heavy metals) contamination, and overall water quality of Torch Lake. The first major study of Torch Lake water quality in 1974 resulted from a copper leach liquor spill in 1971 and 1972 at the Lake Linden C&H leach plant. Wright, Leddy, Brandt and Virnig, biologists and chemists, noted in their study a history of “abuse and degradation” (Wright et al., 1973).

Sources of water pollution were numerous during the later years of mining and early post-mining era. Raw sewage from Laurium (population 2500) ceased in 1970, but continued to be discharged from about 1500 residents in communities along Torch Lake. In addition, sewage sludge was used for vegetation growth on stamp sands, thus entering the lake. Water quality was also compromised by large quantities of saline water entering the lake from dewatering of mines in the Calumet area. Stamp sands delivered heavy metals (especially high copper levels) into the lake and sediments. Chemicals from several leaching and flotation plants were discharged into lake water. The end of copper production in 1969 stopped mine dewatering and led to the transfer of responsibilities for water and sewage from the mining company to local governments. By 1980, a new water and sewer authority ceased direct sewage disposal into Torch Lake.

Shortly after C&H and Quincy Mining Companies closed their doors, the *Daily Mining Gazette* reported a chemical spill into Torch Lake, coloring the water. At about the same time, local stories about fish tumors on walleye and sauger caught the attention of biologists at MTU and state officials. Fishermen continued to report a high incidence of external and internal fish tumors in the lake throughout the 1970s. Community members frequently attributed the tumor findings to the chemicals in the leaching and flotation to the recently closed plant in Lake Linden.

The first organized citizen response to Torch Lake fish tumors and historic mining waste occurred in the fall of 1983. Several events led three Lake Linden residents to form a committee to pressure first the Village of Lake Linden and then the Michigan DNR to attend to Torch Lake pollution. What began as a concern over Lake Linden well water evolved into a discussion among residents about how mining chemical wastes might be affecting the health of fish in Torch Lake. *Daily Mining Gazette* articles describe mounting criticism of Lake Linden Village use of a well close to the north end of the lake. Events earlier in 1983 likely spurred this group to action. In April the state health department warned citizens in an advisory not to eat Torch Lake fish until the cause of fish tumors was clarified. The Torch Lake Chamber of Commerce organized a cleanup campaign along the shoreline to rid the area of unsightly mine debris in June. In July, scientists from the EPA lab in Corvallis, Oregon, released results of sediment tests in the Keweenaw Waterway showing elevated levels of arsenic, nickel, zinc, chromium, lead, and copper. Torch Lake samples showed copper levels thirty-six times higher than considered safe by EPA standards at the time. In September the local health agency reported that their first investigation of cancer statistics showed no direct linkage to fish tumors. Torch Lake had the attention of Michigan's DNR and the EPA.

Public interest in Torch Lake pollution came to a head at the end of 1983. MTU scientists met with community members to discuss their research on fish tumors and water quality. Residents travelled to Marquette to testify at MDNR public hearings where Michigan toxic sites were being evaluated and ranked for access to $10 million in state funds to clean up toxic sites. Torch Lake was ranked 32 out of 200. By the end of the year, Torch Lake residents in Lake Linden and communities up and down the shore had made the connection between water quality, public health, and mine practices. As a polluted sited, Torch Lake clearly needed funds for study and cleanup of toxic mine waste.[21]

5-3. Superfund and Area of Concern: Figuring out the Problems

For the next three years, the EPA, the International Joint Commission (IJC), and the State of Michigan evaluated Torch Lake as a contaminated site. In 1984 Michigan's Governor Blanchard committed over $80,000 to MTU research scientists to determine the causes of Torch Lake fish tumors. Michigan DNR elevated the ranking of Torch Lake from 32 to 25 on its contaminated sites priority list. And the US EPA began a hazard assessment to evaluate the suitability of Torch Lake and surrounding mining waste sites as a potential candidate for the National Priority List (NPL). In 1985, the IJC designated it as an Area of Concern. In 1986, Torch Lake was placed on the NPL and a new phase of study, planning, and remediation began.

[21] The *Daily Mining Gazette* (*DMG*) covered Torch Lake pollution issues and citizen initiative quite extensively in 1983. Clipping files from this year and after are available at the MTU Archives in the Vertical File Collection.

Contamination and public health at Torch Lake remained in the spotlight and broadened pollution issues beyond the focus on fish tumors. In 1984, the MDNR cited Peninsula Copper Industries (PCI) for mishandling copper-contaminated waste. PCI, a new company located in the Hubbell (C&H) smelter yard, started manufacturing of copper oxide by reclaiming electronic circuit boards, revisiting and updating a practice started by C&H in the 1950s. Early in 1984 Torch Lake Sewage Authority found its Tamarack lagoons contaminated by processing wastewater from PCI. Copper levels were 2,400 times higher than allowed by permit. During the spring runoff that year, the Authority had to discharge 5 million gallons of that water into Torch Lake. A few months later, PCI had an accidental discharge of 30,000 gallons of effluent containing copper sulfide, ammonia and sodium directly into Torch Lake, requiring the vacuuming of a black sludge along the near shore sediments. A few months later, the Michigan State Department of Public Health released a preliminary health assessment of Torch Lake, calling it a "potential public health concern" in June 1989 and citing the dumping of chemicals and barrels into the lake and the abandoned buildings still dotting the shoreline.

While residents remained watchful of developments at Torch Lake, organized citizen action was relatively quiet. This was a period of study, information sessions, and comment by local, state, and regional authorities. Information meetings that announced study results and presented remediation planning documents brought Torch Lake area residents and citizens from Houghton County together. MTU's fish studies were completed by 1986. Scientists ruled out xanthates (from flotation technology used in milling to separate out copper) and parasites as a cause of fish tumors. Creosote, another chemical agent used in flotation which caused liver tumors in laboratory fish, was also ruled out because it was no longer being used and entering the lake. The sediments in Torch Lake provided another focus of government study. The inability of fish to spawn because of the copper-rich sediments was a concern. Michigan DNR, as part of the requirements under the GLWQA, began preparation of a Remedial Action Plan (RAP) for Torch Lake and presented its recommendations to a public meeting at MTU in August 1987. The author of the plan, Elwin Evans, and the head of the Office of the Great Lakes, Thomas Martin, recommended that Torch Lake be removed from the IJC AOC list and the fish consumption advisory be removed. They argued that the cancerous tumors in the lake's sauger and walleye had abated and no longer posed a threat to the environment (DMG, 1986, 1987; Leddy et al., 1986).

The final RAP, issued in October 1987, however, did *not* contain those recommendations. The local health department, a local environmental group, members of MTU staff, the Toxic Substances Control Commission (Michigan), and EPA's Region 5 protested the decision to remove the fish advisory. As a result, the RAP recommended several actions: restocking of sauger and walleye in Torch Lake annually for five years, study of fish populations in 1988 and examination of fish for tumors every few years. In addition, the RAP addressed the copper-contaminated sediments with a recommendation that vegetation of the stamp sands (with the aid of bio solids from sewage facilities) be encouraged to prevent further erosion of copper into the lake. It also argued that the best solution for reducing the copper in lake sediments would be natural attenuation, i.e. allowing the natural sedimentation of material from an inflowing river (Trap Rock) and streams.

During 1987, the IJC announced that it would begin a new program for citizen participation at AOC-contaminated sites. Michigan DNR started a statewide citizen's advisory committee and encouraged the development of local Public Advisory Councils. The Torch Lake AOC had a citizen member on the statewide council, but it did not develop its own local advisory committee until nearly a decade later.

The EPA Superfund Program was also active during this period at Torch Lake. Once EPA placed the site on the NPL in 1986, it began a search for responsible parties (PRPs) to help pay for the remedial investigation, feasibility study, and eventual cleanup. EPA identified two parties, Quincy Mining Co. and Union Oil Products (who had purchased C&H Mining Co. properties). Negotiations with the parties, however, stalled in 1989 and the EPA proceeded with the Remediation Investigation by hiring Donohue and Associates from Chicago. The Torch Lake community first met with Donohue staff in March 1989, when a consultant visited community leaders to prepare the community relations document required by Superfund rules. From this point on, with MDNR and the Torch Lake Area of Concern in the background, EPA assumed the role as the major lead in the cleanup. Donohue worked from 1988 to 1992 on the studies and planning necessary to complete the formal Remedial Investigation and Feasibility Study (RI/FS) required under Superfund.

During this time, EPA held public meetings designed to inform residents of the significant study findings and the design of the remediation plan. Following the standard outlined in EPA's first Community Relations Handbook (1992), EPA distributed fact sheets and held public meetings, beginning in March 1989. The *Daily Mining Gazette* reported on the meetings, frequently noting attendance size and comments by residents. Residents were clearly very interested in EPA's ongoing activities. Eighty people attended the kick-off meeting to introduce the plan for EPA's remedial investigation in August 1989, and 100 attended an August 1990 meeting summarizing results of that summer's study (DMG, 1989, 1990). By May 1992, when EPA readied the feasibility study that outlined remediation alternatives there was a vigorous public debate in the press and in municipal government meetings. By June, several local governments produced a four-page document outlining why a Superfund designated site was harmful to the community and recommending a "No Action" plan be approved. Cities of Houghton and

Hancock, the Village of Calumet, Houghton County, and other public entities such as Houghton County Road Commission and the Portage Lake Water and Sewer Authority argued that the label of Superfund lowered property values and had a negative impact on tourism, and said that the proposed vegetation cap for stamp sands was “unnecessary and grossly excessive” and would “obliterate evidence of this region’s mining history” (DMG, 1992b). MTU, in a press release, concurred with local government opinion, arguing that it had “substantial reservations” about EPA’s plan and noting the report had “serious technical errors, inconsistences, and shortcomings” (DMG, 1992c; Lode, 1992). A July 9. 1992 *Daily Mining Gazette* editorial titled “EPA, Go Home” captured the sentiment from the several city and village government resolutions.

A growing rift in the community appeared during the summer of 1992 as residents weighed the options for cleanup. Several citizens spoke out through letters to the *Gazette* (*DMG*) editor with arguments for proceeding with the remediation program based upon the complexity of contamination issues and no clear indication of what caused the fish tumors as well as the continued presence of elevated heavy metals in the stamp sands and lake sediments. A representative from a local Sierra Club chapter spoke about the need to consider Operating Unit (OU) II (Torch Lake sediments) in concert with remediation of the stamp sands in OU I and OU III. He argued that the interdependent link between contaminated sands and sediments suggested they should be discussed at the same time, rather than separately. Some letter-writers called for a Public Advisory Council on Torch Lake under the AOC program. The most active proponents for an EPA decision of “No Action” resided in Houghton. The City of Houghton had announced its plans to develop the Isle Royale Sands, located on Portage Lake, for residential use, with the intention of adding soil cover and vegetation itself. City officials noted the earlier work by the Village of Lake Linden to add soil and vegetation to create the Village Park on the site that once housed C & H’s Calumet Mill, leaching plant, and flotation plant. In addition, the Houghton City argued, the new sewage and water treatment facility was to be built on the Isle Royale sands.

EPA’s final decision on stamp sand remediation (OU II and OU III) came in October 1993, after consideration of public comments. The original plan to include Isle Royale stamp sands was abandoned, as was the plan to cover slag at the Quincy Smelter in Ripley, as were the sands used by the Road Commission at Gross Point Shores for winter road treatment. Within a year, EPA brought its recommendations for Torch Lake itself (OU II) to the community with a recommendation of “No Action,” based upon the size of the lake, which was too large to feasibly remedy. Officials also believed the lake would clean itself through natural attenuation (sedimentation). At the public hearing on OU II in March 1994, attendees asked about the hotspot with deteriorating barrels off of the Hubbell smelter and whether they would leak contaminants. The EPA project manager noted that risk assessments found no linkage between contaminants and possible health risks and that most of the barrels appeared to be empty or to contain sands or slag (DMG, 1994).

EPA began planning for remediation of Torch Lake sands in OU I in early 1995 with an agreement for the National Resource Conservation Service (USDA) office in Houghton to serve as project manager for the work plan and construction. Shortly thereafter, reports in the local media of lack of funds at EPA indicated cleanup may be delayed. The local NRCS, having already received planning funds proceeded to prepare for future remediation by holding workshops on stamp sands for local property owners and searching for soil borrow sites for the future capping of sands. In the meantime, the Village of Lake Linden had continued (using grants from Michigan DNR) to cover some nearby sands and building sites. It located a public park and campground on the newly vegetated land (Aho, 1995; DMG, 1995c, a, b). Funds continued to be non-existent for Superfund sites due to a "budget war" in Washington D.C. EPA Region 5 therefore continued to pursue PRPs to help with the costs for remediation of the overall Torch Lake site: Copper Range Co., Quincy Development Corp., and Universal Oil Products. The original mining companies near Torch Lake, after closing, had either been absorbed by new owners or sold lands to local owners. In the meantime, the City of Houghton and Village of Lake Linden proceeded with their projects for capping and vegetation of stamp sands within their borders (DMG, 1996e, d).

5-4. Formation of Torch Lake PAC

With EPA work on Torch Lake OU I stalled, in early 1996 new developments in the Michigan AOC program changed the focus of attention in the community and sparked a new debate among local citizens. In January, the state decided to give responsibility to local communities for the set-up, funding, and maintenance of Public Advisory Councils at its 14 AOC sites. The Torch Lake representative on the Michigan State Public Advisory Council (SPAC) began work with the Michigan Department of Environmental Quality (MDEQ) to establish a local PAC for the Torch Lake AOC.[22] A small grant of \$3,000 allowed a local citizen's group to begin a community process resulting in the organization of a PAC and election of its members (DMG, 1996a).

In the summer of 1996, work began to organize a PAC. It took nearly a year to accomplish. The local representative on the Statewide PAC drew upon a small committee of individuals representing the

[22] Michigan's AOC program was originally housed in the Office of the Great Lakes (OGL), originally part of the MDNR. In 1995, under Governor John Engler, the Michigan DEQ was organized and assumed responsibility for the OGL and the AOC program. This reorganization resulted in the reduction of 12 full time positions to 5 and a plan to move remedial action planning (and funding) to local Public Action Councils (DMG, 1997b. The Daily Mining Gazette, Houghton, MI May 22, 1997.)

Houghton County Commission, Chamber of Commerce, Peninsula Copper Industries (PCI), and Western Upper Peninsula Planning & Development Region (WUPPDR) to develop a format for selection of members for the local PAC. The effort drew some local criticism that mirrored the community differences during 1992 when EPA presented its plan for Superfund remediation at Torch Lake. In a *Gazette* article titled "Sparks fly in Torch Lake tiff" a public meeting in which the Houghton City Manager, a Houghton County Commissioner, a business owner, and a Calumet Township Supervisor protested the organization of the PAC. Questions arose as to who would chose the PAC formation committee, who authorized the State PAC representative to begin the process, and why the formation committee meetings were not subject to Michigan's Open Meetings Act. They voiced concern that a PAC would hold up agreements between Houghton and EPA for the remediation and residential development of Isle Royale stamp sands, and that the new citizen group would suffer from "a lack of credibility and trust" (DMG, 1996c).

Support for formation of a PAC, however, was strong. Several years earlier, some citizens had raised the idea of the formation of a PAC. In a 1992 letter to the *Gazette*, one writer implored state leaders to facilitate the formation of a Public Advisory Council: "There will be no resolution to the conflict involved with Torch Lake Superfund site until all interested persons address the problems that exist" (DMG, 1992a). It took an additional four years before the state acted, while most AOC sites in Michigan had already formed PACs. In response to questions as to why a Torch Lake PAC was so late in coming, an MDNR official noted that lack of resources, the amount of work needed to identify contamination issues, and an ongoing Superfund study prevented the state's investment in this citizen organization. She also explained that the state was waiting to see what happened with the Superfund process and how it could integrate with the state AOC effort at Torch Lake.[23] In addition, the *Gazette*, which had previously weighed in for a "No Action" decision by EPA on remediation of the Torch Lake stamp sands, came out in support of the PAC formation. In an editorial titled "PAC attack wasted effort," the local paper argued:

> "It doesn't surprise us that some government officials around here reacted with fear and loathing to the announcement of a Torch Lake Public Advisory Committee. Most believe naming the area in and around Torch Lake a federal Superfund Site and state Area of Concern was unwarranted to begin with….But this plan isn't enough to get Torch Lake off the Superfund List…Throwing tantrums won't remove the label. There's a process that must be followed. The PAC is part of that process…" (DMG, 1996b)

[23] Torch Lake was one of two AOC sites without a PAC in 1996. 12 Michigan AOC sites had established and funded PACs (DMG, 1996c).

In spite of the spirited public debate, the PAC Formation Committee moved forward and scheduled a public information meeting in March 1997 to introduce the role of a PAC and a process for electing PAC members. Speakers from MDEQ, EPA Region 5, the IJC, MTU, and the Menominee River AOC spoke about the benefits of a PAC to the 70 residents who attended. "It's a never-ending process keeping the community involved. It has become the policy of EPA to highly encourage public feedback. The remediation process is much more successful when community concerns are heard," said Derek Kimbrough from EPA Region 5. He and the representative from MDEQ's Office of the Great Lakes (Dianne Klemns) noted that the PAC would provide an organized means for citizen input into decisions affecting both the Superfund remediation process outlined in the 1992 Record of Decision (ROD) to cap Torch Lake stamp sands, and the AOC 1987 Remedial Action Plan (RAP) (DMG, 1997a).

At about the same time, the *Gazette* also published a lengthy article a few days before the meeting that captured the long history of confusion surrounding Torch Lake pollution:

> "The dual status of the Torch Lake Superfund Site and the Torch Lake Area of Concern has historically generated considerable confusion within our Keweenaw community. Over the last 15 years several public meetings conducted by various state and federal agency officials have been offered to fill us in on their research and their plans. They also asked for our questions and comments. But all too frequently the answers we received were expressed in bureaucratic, scientific and legalistic terms…The lack of clarity, in turn, confused local government and business leadership, resulting in strategies that ranged from ignoring the problem, to threatening lawsuits against local municipalities and private individuals, to administratively trying to delist the area without remediation. The net effect has been to prolong the period of inaction and minimize the urgency for remediation among those who were in power to move the process forward. The legacy is the continued erosion of over 19,000 tons of heavy metal contaminated stamp sand per year into our waterways and the continued absence of a unified, strong local voice to speak for the incorporation of local concerns and goals into the remediation process and eventual delisting of the Area of Concern/Superfund Site." (DMG, 1997c)

The PAC election, scheduled for April 1997 moved ahead with solicitation of nominations for a possible twenty-six individuals to represent seven stakeholder groups: local business, government (townships and county), the general public, Torch Lake shoreline residents, environmental and health interests, and sportsmen.[24] Representation would also be tied to the surrounding Torch Lake communities (Area A) and the wider Houghton County communities of Calumet, Hancock, Houghton, Chassell and South Range/Painsedale (Area B). Each stakeholder group would have at least 2 representatives from Area A and 1 from Area B (1997). The PAC Formation Committee advertised and then held a public meeting in Lake Linden on April 24, 1997 in which citizens could vote. Twenty-two individuals were elected to seven stakeholder groups with three seats still to be filled from the Native American Group. Several individuals who originally opposed the formation of the PAC were nominated and elected to serve (AOC-News, 1997).

5-5. Torch Lake PAC – the Active Years[25]

The Torch Lake PAC (TLPAC) began meeting monthly in January 1998. The first discussions were devoted to education of PAC members on the status of the AOC Beneficial Use Impairments (BUIs), the delisting process for BUIs, ongoing Superfund actions, the work of other Michigan PACs, and development of PAC bylaws. During this first year attendance hovered about 17-20 members of the 22 total elected. MDEQ and EPA Region 5 staff attended during the summer months to brief members on the differences between AOC and Superfund programs. Beginning in January and through April, MTU graduate students in Environmental Policy at Michigan Tech, under the guidance of a faculty member in Social Sciences, presented information on the BUIs and facilitated discussions. Students also aided the PAC in setting up a webpage. At the same time, the Technical Committee began work on revision of the 1987 RAP that was issued prior to the 1987 GLWQA requirements that Remedial Action Plans address BUIs in their AOCs in the plan.

TLPAC minutes indicate some confusion among the PAC representatives over responsibilities of EPA and those of MDEQ under the AOC program. Several meetings devoted to discussion about delisting under the EPA Superfund and the AOC Program highlight repeated concerns: that specifics were not forthcoming on how delisting in the two programs worked, whether EPA and MDEQ communicated with each other about Torch Lake, and why funds from EPA were not forthcoming to address stamp sand remediation.

In September 1998, EPA announced that Torch Lake would receive $15.2 million for capping Torch Land Stamp Sands (DMG, 1998; U.S.EPA, 1998b). Thereafter, the PAC focused primarily upon

[24]The early PAC years are covered primarily in the local newspaper (*Daily Mining Gazette*); PAC minutes beginning in 1998; and in (Gorman, 2001).

[25] PAC minutes provide documentation from May 1998 through February 2003. To date, the author does not have access to PAC minutes after February 2003.

stamp sands and Superfund delisting. As a result, the TLPAC turned its attention to stamp sand remediation. The AOC program, which provided no funding to address the BUIs, became a secondary topic at monthly meetings. The Technical Committee, however, continued work on a revision of the 1987 RAP. A PAC member from MTU was drawing upon university staff to aid the revision process.

During the first months of 1999, the PAC continued simultaneous discussion of the upcoming EPA stamp sand work in the summer and the drafting of the RAP for the AOC program. The PAC formed a subcommittee to work with EPA on the Operations and Maintenance Plan (O&M) because landowners along the Torch Lake shoreline were concerned with future maintenance of the soil and vegetation cover. Major owners were the Torch Lake Sewage Authority, Village of Lake Linden, Lake Shore Estates Assoc., Inc. (a landowner and developer with properties along the lake shore and on stamp sands), and smaller landowners. TLPAC minutes reflect the belief that it needed to represent the interests of landowners with regards to future inspections and maintenance of the capped sands (TLPAC, 1999a).

Work began during summer 1999 on capping and vegetation of the 119 acre Lake Linden sands, with plans for completion in October. Burcar Construction Inc., of nearby South Range, was awarded the contract for $1.07 million, as the low bidder (DMG, 1999b). Under an EPA contract, the local office of the USDA Natural Resource Conservation Service (NRCS) managed the remediation. It identified the source of "borrow" soils to be used in capping the sands, collected bids for the work itself, and supervised the work during the summer. The NRCS Project Manager reported regularly to the TLPAC on progress. Meanwhile, the EPA Region 5 office held regular conversations with members of the TLPAC to address landowner concerns about the O&M Plan for Lake Linden. Members of the TLPAC spoke publicly about the development benefits of covering the sands in interviews with the local newspaper.

> "It certainly will be an impetus for development. It raises the tax base. Homes and recreation areas can be built on it. 'The proof is in the pudding. Look at what's happened on the Isle Royal Sands [in Houghton]. Would you have all those expensive homes [if the site hadn't been covered with dirt and vegetated]? They're bringing [up] the tax base.' If the City of Houghton hadn't stepped in, the Isle Royale Sands would have been among a group of 10 Superfund sites all of which will be able to be waterfront subdivisions." (DMG, 1999b)

The working relationship between the TLPAC and the EPA was a reciprocal one, according to the EPA Remedial Project Manager for Torch Lake: "I see the TLPAC is an integral part of this process…We're going to work with you" (DMG, 1999a). The TLPAC executive committee (officers) held regular monthly phone conferences with EPA Region 5 and MDEQ concerning the O&M plan beginning in April 1999.

The draft RAP was completed by a consultant from MTU (working for the Technical Committee and the PAC). TLPAC members began a lengthy review process during the summer of 1999. EPA work in Lake Linden proceeded and plans made for bidding out the work on the Hubbell/Tamarack sands to be done during the summer of 2000. In addition, the Michigan Department of Health, through the local health office, initiated a health hazard study, which was completed by the end of 1999. Dr. Shebuski, the local official, reported on the results in November 2000: "the survey uncovered no evidence of increased rates of disease in the population living close to Torch Lake. Although not a formal epidemiological study, these findings are nonetheless reassuring" (DMG, 2000).

Beginning in 1999 and continuing into the next year, the TLPAC minutes and local press reporting begin to reflect the conflict and disagreement among its members. Two types of disagreements stand out: first, who should represent the PAC to government agencies and the press; and second, how to interpret the results of studies and agency policies that pertain to the PAC and Superfund site. When one TLPAC officer publically declared that the PAC would seek delisting of the AOC site and that no revised RAP was necessary, claiming that the IJC and EPA had failed to comply with their agreements, two members of the PAC objected. During the December 1999 meeting, another PAC member raised a concern about one of the officers speaking for the TLPAC with the press and government agencies with statements that did not necessarily reflect positions of the PAC (TLPAC, 1999b). Disagreements continued at PAC meetings and by 2001 two of the PAC members representing the Environment Stakeholder Group stopped attending meetings and eventually resigned.

The EPA work at Torch Lake proceeded during the summers of 2000 and 2001 with work at Tamarack and Mason Sands. TLPAC revisions on the RAP also continued, and discussions at meetings focused on delisting strategies for the RAP document. Two MTU professors were consulted in fall 2000 to review the document. According to TLPAC minutes, the consultants believed the original AOC designation was based upon inadequate and incomplete data, thus making identification of future remedies difficult (TLPAC, 2000). Based upon these comments, the TLPAC began to search for a consultant to help revise and edit the draft RAP document. Without adequate funds, however, the PAC was unable to complete this work. In 2001, the MDEQ advised the TLPAC that it was working on a procedure for delisting AOC sites, and the PAC decided to wait until then before revising the RAP.

After 2000, the primary work of the TLPAC was devoted to following the EPA remediation of stamp sands and helping officials resolve local concerns with property owners, operation and maintenance plans, and complaints. Except for occasional reports from MDEQ on fish sampling, there was no discussion of the RAP revisions or of strategies for delisting.

5-6. Continuing Issues at Torch Lake

Capping and vegetation of the Mason Sands in 2001 began the process of the final delisting of the Torch Lake sand banks. By 2006 delisting of Torch Lake sites under the Superfund program was complete. Thus began a relatively quiet period for the TLPAC as focus turned to the MDEQ and the Area of Concern delisting.[26] Unlike Superfund, the AOC program had no funds for remediation. Instead, funds became available periodically to continue investigation into contamination in the lake and its fish population. EPA and MDEQ continued to be involved at Torch Lake, but the TLPAC faded from the news, meeting more infrequently and delegating many of its tasks and communications to the TLPAC Technical Committee members.

In 2007, the MDEQ finalized the Remedial Action Plan without TLPAC input, stating clearly that the BUIs were based upon fish consumption advisories and contaminated sediments. It identified PCBs as a concern for sediments and fish. That year the MDEQ removed the fish tumor BUI at Torch Lake AOC, but a fish consumption advisory for mercury and PCBs remained. The MDEQ continued to monitor the fish and sediments as funding became available. Meanwhile, the EPA conducted several emergency response projects along the Torch Lake shoreline at the Lake Linden beach, Mason sands, and Lake Linden powerhouse between 2008 and 2014. MDEQ began investigations in 2014 for upland sources of PCB contamination along the Torch Lake shoreline. None of these post-2006 projects, however, involved the TLPAC in any significant way. When MTU faculty began work on an Integrated Assessment for Torch Lake (funded by NOAA Michigan Sea Grant), the TLPAC Technical Committee met with them and discussed research on PCB contamination into Torch Lake from the upland historic milling and reclamation building sites along the shore. Once MDEQ began soil sampling in Lake Linden and Tamarack/Hubbell in 2014-2016, the TLPAC began to hold regular meetings again in 2015-16.

[26]TLPAC minutes are unavailable after 2003. The author relies primarily upon *Gazette* news articles for information on the PAC and activities at Torch Lake.

5-7. Conclusion

This detailed review of citizen involvement in Torch Lake Superfund and AOC programs suggests several conclusions:

- Residents were engaged and concerned beginning in the 1970s. From the late 1970s until the listing of Torch Lake on the Superfund and AOC site lists, residents who resided in communities along the lake shoreline were engaged in the issues of fish contamination, reported dumping of wastes and barrels with unknown contents into Torch Lake, and possible health effects of mine processing. In sizable numbers they attended early EPA community meetings and MTU briefings to hear scientific results on fish tumors. Residents in Lake Linden organized a citizen's group and participated in state hearings.

- Torch Lake residents and citizens in Houghton County engaged primarily with the EPA and MDNR as the institutions with the answers on the hazards and strategies for remediation—some opposing their involvement, others welcoming it. This division set the stage for future years. In the 1980s, when Michigan listed Torch Lake as an Area of Concern and EPA declared it a Superfund site, citizens closely followed developments and the local press monitored state and federal activity at Torch Lake in great detail. EPA began a community relations program consisting primarily of one-way communication and solicitation of comments. As the Remedial Investigation/Feasibility Study period ended in 1990-92, local residents, while clearly interested in Superfund studies and planning for cleanup, became split on the issue of cleanup—some believing no action was necessary, and others arguing that Torch Lake must be cleaned up.

- EPA kept the Torch Lake Superfund site limited in geographical scope and in contaminant focus partly because of pressure from elected leaders and university officials who argued for no action. When EPA issued its Record of Decision for Torch Lake OU I, the City of Houghton was allowed to remediate and develop the Isle Royale stamp sands and the focus of Superfund remediation was on the Lake Linden, Tamarack, and Mason sands. OU II called for the delisting of Torch Lake sediments, and the Superfund project became a Torch Lake stamp sand project. Other contamination issues, including the AOC listing, receded into the background.

- The TLPAC became the face of citizen involvement in the Superfund and AOC delisting process, but conflict on the PAC limited its effectiveness in addressing the wide range of issues that citizens originally had pressed EPA to address. By 2000, two or three stakeholder groups seemed to have diminished or no representation: health, environment, and tribal. Those who remained on the PAC primarily represented property holders, elected officials from local governments, and business interests. After 2007 the PAC met sporadically and delegated most of its responsibility to the Technical Committee of three individuals.

- The TLPAC was primarily involved with Superfund work and much less engaged with work toward AOC delisting. During the NRCS stamp sand projects within Torch Lake and the lengthy administrative process for delisting, which required implementation of an O&M Plan, the TLPAC monitored activities, helped with citizen issues, and provided an audience for Superfund reports to the community.

- The TLPAC grew less engaged with the revision of the RAP after the first two years, and eventually once the Torch Lake sand banks had been delisted, seemed to lose interest in AOC delisting. Lack of funding and adequate information about contaminant sources causing fish consumption advisories and contamination of the lake bottom sediments were part of the problem. But the conflation of two hazardous waste regulatory programs into one remediation (stamp sand banks) by local residents seemed to create the impression that Torch Lake had been "cleaned up."

These conclusions point to a long history of citizen involvement in mining waste issues around Torch Lake marked by significant divisions within the wider community as to the urgency of remediation and the extent of government action. The early years of a Superfund community relations program characterized by one-way communication and agency-driven action has had a lasting effect on subsequent citizen initiatives under the Torch Lake PAC. Once organized, the PAC focused upon getting things done and moving Torch Lake toward delisting from the Superfund NPL and the AOC program. However, a pattern of PAC initiatives that were either ignored or circumvented by both EPA and MDEQ, and the lack of funding necessary to address requirements for delisting the AOC site, frustrated PAC members and led to a long period of inaction. This legacy continues today as the TLPAC has begun to meet regularly with state officials and to reengage with the ongoing contamination at Torch Lake.

Chapter 6. BUI 1: Fish Tumors

6-1. Summary & Recommendations

The BUI for Tumors or Deformities in Fish was removed in 2007. There were no reports of tumors or deformities in fish from Torch Lake between 1988 and 2013. Local fishermen did report some deformed fish in 2013. Based on existing information, there appears to be no need for further study or remediation on this account.

Recommendation: Signage near the lake informing the public of what to do if deformities are found would be appropriate.

6-2. History of Tumor Occurrence Reports

Tumors and deformities were reported in walleye and sauger from Torch Lake from 1972 through the mid-1980s. An early MDNR survey of biological conditions in the lake (MDNR, 1970) reported that the fish community was diverse (17 species) and made no mention of tumors or deformities. The first published report of tumors and deformities was the thesis of Tomljanovich (1974), who reported that 10% of Torch Lake saugers had "fat" tumors and 5.6% had ossifying fibromas (lesions or tumors containing fibrous tissue with varying degrees of calcification). Following this initial report, numerous studies reported that nearly 100% of sauger and a much lower percentage of walleye (0-12%) had neoplasms (new, abnormal or cancerous tissue growth), particularly of the liver (Black and Evans, 1986; Black et al., 1982; Costanzo and Oakes, 1984; Markham, 1986; Spence, 1986). According to the 1990 MDNR staff report (MDNR, 1990), conditions changed after 1984. Based on the 1988 sampling of only 458 total fish among which no sauger were caught, the MDNR concluded that sauger had disappeared from the lake following a long decline. The 47 walleye caught in 1988 exhibited no liver neoplasms, and the MDNR concluded that cancerous tumors had disappeared. Based on earlier studies, anywhere from 0 to 6 fish with neoplasms would have been expected based on the sample size. The MDNR recommended that the fish consumption advisory based on tumors could be removed.

More recent evidence, much of it summarized in the 2007 RAP Update (MDEQ, 2007a), supports the MDNR's 1990 recommendation. The 2007 MDNR fish survey in Torch and Portage Lakes caught no sauger among the 37,813 total fish collected (Hanchin, 2013). The MDNR reported in 1998 and again in 2006 that no tumors had been reported in Torch Lake fish for the previous five years. The 2001 and 2008 Fish Contaminant Monitoring Reports (MDEQ, 2001, 2008b) made no mention of gross external or internal tumors observed in the walleyes collected in either 2000 or 2007. Walleye tournaments on Torch

Lake were held in 2003, 2004, 2006, 2012, and 2013; no tumors were reported during these events. There appear to have been no necropsies performed since 1985 that have confirmed the absence of liver neoplasms in walleye, but until 2013 there were no reports of visible tumors since the mid-1980s. In 2013, local fishermen reported observing fish with visible deformities near the north end of Torch Lake (S. Baker, MDEQ, personal communication).

Research regarding the cause of the neoplasms in sauger and walleye was inconclusive. No mutagenicity was detected in Torch Lake sediments (Leddy et al., 1986). Chemicals used in the flotation process, specifically xanthates and polycyclic aromatic hydrocarbons (PAHs) from creosotes, were suspected causative agents. By the 1980s, xanthates could not be detected in the lake (Leddy et al., 1986); these chemicals degrade relatively rapidly (weeks to months) in the environment (Chen et al., 2011; Chen et al., 2013). Because no causative agents were found and because the tumors disappeared, it is assumed that they were caused by chemical agents that are no longer present in the lake (MDEQ, 2007a).

6-3. History of Regulatory Responses

In 1983 a fish consumption advisory (as of 2013, this would be called a fish consumption guideline in Michigan) was placed on sauger and walleye in Torch Lake because of the tumors observed on fish and the possibility that cancer-causing agents could be transferred from fish to humans. In 1993, this fish consumption advisory was lifted based on the recommendation of the MDNR (MDNR, 1990). In 2007, the MDEQ requested permission from the EPA to remove the Fish Tumors or Other Deformities BUI; the request was granted less than one month later.

6-4. Summary of Research on Tumors – Causes

We do not include in this report a summary of the research on probable causes for the tumors. No new analyses have been performed since 1990, and the previous literature on this topic was thoroughly summarized in the 1987 Remedial Action Plan (RAP) (MDNR, 1987b) as well as in the RAP update (Baker, 2007). No new information or insights have come forth since those publications.

Chapter 7. BUI 2: Restrictions on fish consumption

7-1. Summary & Recommendations

Concentrations of mercury and PCBs in Torch Lake fish have been above safe consumption levels for over 25 years, and there is no evidence of a decrease in those concentrations. Concentrations of both substances in Torch Lake fish have been and remain above the concentrations in the reference lakes. On the basis of chemical levels and existing guidelines, there is no basis for removing the BUI related to restricted consumption of fish from Torch Lake. There is clear evidence that Torch Lake has and continues to receive mercury inputs as a result of historical mining activities, but further work is required to determine if those inputs cause the elevated concentrations in fish. There is unequivocal evidence that a local source of PCBs has and continues to contaminate the lake and to cause high PCB concentrations in Torch Lake fish.

Priorities for future research include: measurement of inputs of methyl mercury to Torch Lake, determination if methylation occurs within the lake sediments, and isotopic analysis of the Hg in the fish to determine if it has a mining or an atmospheric source. Use of passive samplers would be an effective means for finding the source of PCBs and determining efficacy of cleanup after remediation of that source. The possibility for controlling Hg concentrations in fish through stocking practices also warrants investigation.

7-2. Historical developments: Problem Awareness and Definition

Although it was the perceptions of tainted fish that caused Torch Lake to be put on the National Priorities List and the list of AOCs, that perception has changed over time. Early concerns all dealt with the presence of tumors (Chapter 6), the cause of which was never conclusively determined. The fish consumption advisory instituted in 1983 because of the presence of tumors was removed in 1993 because of the documented decline in occurrence of tumors (MDNR, 1990). In 1993, Michigan issued a state-wide advisory for fish consumption due to elevated mercury; Torch Lake was thought to have mercury concentrations consistent with this generic advisory (MDCH, 1995). A lowering of the fish consumption trigger levels for PCBs resulted in imposition of additional fish consumption advisories for Torch Lake in 1998. The PCB concentrations in Torch Lake fish on which this advisory were based had been known since 1988; it was the lowering of trigger levels, not the sudden appearance of contamination that caused the fish consumption advisory to be instated. Consumption advisories have been in place continuously since 1993 for mercury and since 1998 for PCBs in Torch Lake fish. The State of Michigan's current protocols for establishing Fish Consumption Guidelines (formerly termed Fish Consumption Advisories) were most recently summarized in 2013 (MDCH, 2013a). The current guidelines for Torch Lake may be found in the online Eat Safe Fish Guidelines (http://www.michigan.gov/mdhhs/0,5885,7-339-71548_54783_54784_54785-301465--,00.html). The most recent report from the MDEQ summarizing conditions in Torch Lake was published in 2016 based on sampling performed in 2013 (MDEQ, 2016).

The imposition of the fish consumption advisory for PCBs in Torch Lake fish in 1998 can be viewed as one pendulum swing in an ongoing debate about the nature of the PCB contamination in the lake. In this debate, the state agencies have generally argued (at least since 1993) that local contamination exists (e.g., MDEQ, 2007a) while the EPA has argued that no local problem of any significance exists (e.g.,U.S.EPA, 2008, 2009). Contamination of fish with PCBs was noted as early as the 1988 fish survey (MDNR, 1991). The EPA's own assessment of human health risk from the lake concluded that the risk was dominated by carcinogenic risk from fish consumption with elevated PCBs (Life Systems, 1992). However, one of the key misjudgments at Torch Lake occurred in the interpretation of this risk. The Michigan DNR had characterized the contamination in Torch Lake fish as some of the lowest in the state. Because PCB concentrations in fish from Torch Lake were observed to be no higher than concentrations in fish from the Great Lakes, the contamination was concluded to be not of local origin and low enough to be disregarded (U.S.EPA, 1992c):

> "There presently is no clear link between OU II contamination and the contamination detected in Torch Lake fish. In addition, the PCB concentration in Torch Lake fish tissue (0.025 to 0.151 mg/kg) is at the low end of the average PCB levels found in Great Lakes and inland Michigan lakes fish and is considerably below the FDA advisory level for PCBs in fish of 2 mg/kg."

In the EPA's Baseline Study (1999-2000), PCBs were not even included among the chemicals analyzed (U.S.EPA, 2001).

The state fish contaminant survey in 2000 again revealed PCB concentrations in Torch Lake fish above the concentrations found in control lakes. While the First 5-year Report does record the fish consumption advisories imposed in 1998, it makes no other mention of PCBs. The MDEQ was concerned enough to commission the deployment of passive samplers (SPMDs) in 2005 to test for local PCB contamination; results (discussed below) conclusively showed local contamination. In 2006 and 2007 the two agencies conducted separate surveys of the lake sediments for PCBs, but failed to find highly elevated concentrations. In the 2nd 5-year Report issued in 2008, the EPA acknowledged that a local source of PCBs might exist (U.S.EPA, 2008). One year later, in the report documenting their sediment survey, the EPA recognized all of the findings of the MDEQ but concluded that the sediment concentrations were below target remediation levels at other sites and therefore not of concern (U.S.EPA, 2009). However, the 2007 fish contaminant monitoring revealed persistent PCB contamination that warranted advising further restrictions on fish consumption. The MDEQ's 2007 RAP update concluded that because the sources of PCBs causing the fish contamination had not yet been identified, the BUI should not be delisted.

The conclusion in the 2007 RAP update began to reframe the PCB problem in terms of finding the source of PCB contamination and removing it. In 2013, MTU presented to the EPA and MDEQ preliminary mass balance modeling based on PCB measurements in and around Torch Lake; the tentative conclusion was that ongoing contamination of the lake with PCBs was likely. Soil sampling conducted from 2011-2012 by the Superfund Division of MDEQ revealed numerous locations of PCB contamination on the western shoreline. In 2011-2014, the C&H power plant was investigated, razed, and remediated; PCB contamination in the flooded basement prompted pump-and-treat remediation for the site, but remediation was restricted to the basement of the building (MacGuire,EPA, personal communication). From 2013 to the present, MDEQ has conducted a comprehensive investigation of industrial sites around the lake to locate contaminants of concern including PCBs. Fish contaminant monitoring in 2013 led the MDCH to report that fish consumption advisories for Torch Lake are driven primarily by PCBs, that although there has been a decline in PCB concentrations in Northern pike and walleye (4%/yr but no decline 2007-2013) as well as in small mouth bass (8%/yr), concentrations in Torch Lake fish remain higher than those from Lake Superior (the control) (MDCH, 2014b). The current perspective of the MDEQ is that local sources of PCB contamination exist; the 3rd 5-year Report of the EPA makes no mention of any ongoing concerns with PCBs (U.S.EPA, 2013).

In contrast, there has been a long-standing perception that the mercury in Torch Lake fish is not locally derived, or that the mercury in Torch Lake fish is no higher than in fish from other lakes including the reference sites for Torch Lake (Huron Bay, Portage Lake). In 1990, a state fisheries biologist stated:

> "Only four (4) of the 56 fish samples analyzed for mercury had concentrations that exceeded the 0.5 mg/kg consumption advisory action limit and none exceeded 1.0 mg/kg. Overall, the fish from these lakes (Torch and Portage) are among the least contaminated fish encountered in the Michigan Fish Contaminant Monitoring Program." (MDNR, 1990)

The 1995 Site Review and Update by the Michigan Dept. of Public Health stated:

> "MDPH considers the mercury concentrations in Torch Lake fish to be consistent with the generic advisory on consumption of fish from any inland lake or reservoir in Michigan." (MDCH, 1995)

Similarly, in the 2007 RAP update, the MDEQ concluded that only PCBs were of local origin. Specifically, the RAP Update states:

> "For mercury, the data indicate that the Torch Lake walleye were not statistically significantly different from the controls, …" and "For the mercury fish consumption advisory, based on the state's Guidance being "fish consumption advisories in the AOC are the same as or less restrictive than the associated Great Lake or appropriate control site," the walleye meet this criterion." (MDEQ, 2007a)

7-3. History of Regulatory Responses: Consumption Advisories, BUI Assessment

The original fish consumption advisory for Torch Lake, issued in 1983 by the Michigan Dept. of Public Health, was due to the presence of tumors and deformities in sauger and walleye. As discussed above, those tumors disappeared by 1990, and in 1993 this particular fish consumption advisory was lifted even though the cause of the tumors was never ascertained. In 1993, Michigan issued a state-wide advisory for fish consumption due to elevated mercury; Torch Lake was thought to have mercury concentrations consistent with this generic advisory (MDCH, 1995). A lowering of the fish consumption trigger level for PCBs resulted in imposition of additional fish consumption advisories for Torch Lake in 1998. The new guidelines were based on fish tissue measurements made in 1988. Consumption advisories for Torch Lake fish because of mercury and PCBs have remained in effect since 1998, although the severity of the advisory has changed (Table 7-1).

In the following sections, this report will assess whether there has been any headway towards reaching Michigan's delisting criteria for this BUI (MDEQ, 2008a), and it will re-evaluate the potential sources of PCBs and mercury to Torch Lake.

7-4. Headway towards Delisting

Michigan's guidelines for AOC delisting (MDEQ, 2008a) list three tiers or criteria that may be used to assess whether the Fish Consumption Advisory BUI may be considered restored. Those criteria are:

1. The fish consumption advisories in the AOC are the same as or less restrictive than the associated Great Lake or appropriate control site.

   OR, if the advisory in the AOC is more stringent than the associated Great Lake or control site:

2. A comparison study of fish tissue contaminant levels demonstrates that there is no statistically significant difference in fish tissue concentrations of contaminants causing fish consumption advisories in the AOC compared to a control site.

   OR, if a comparison study is not feasible because of the lack of a suitable control site:

3. Analysis of trend data (if available) for fish with consumption advisories shows similar trends to other appropriate Great Lakes trend sites.

As documented in Table 7-1, Torch Lake cannot be considered restored based on criterion #1; since 1993 it has had a more restrictive fish consumption advisory than has Huron Bay (Lake Superior), and since 1998 it has had a more restrictive fish consumption advisory than has Portage Lake. In 1993, the generic state-wide fish consumption advisory for mercury was applied to Torch Lake, but not to Lake Superior. In 1998, fish consumption advisories due to PCBs were invoked in Torch Lake, but that did not happen until 2008 in Portage Lake. Since 2008, the fish consumption advisories due to both Hg and PCBs have been more restrictive in Torch Lake than in Portage Lake and Lake Superior.

Table 7-1. Summary of Fish Consumption Advisories and Guidelines for Torch Lake and Control Sites.

Year	Fish	Population	Torch Lake	Portage Lake	Huron Bay
1993 – 1997	SM Bass Walleye	All	Generic statewide inland lake advisory for Hg	Generic statewide inland lake advisory for Hg	No advisory
1998[c]	SM Bass N.Pike Walleye	General Women/children General Women/children General Women/Children	>18" 1 meal/wk Hg, PCB >14" 1 meal/wk >18" 1 meal/mo >30" 1 meal/wk Hg, PCB >22" 1 meal/wk >30" 1meal/mo >22" 1 meal/wk Hg, PCB >14" 1 meal/wk >22" 1 meal/mo	Generic statewide inland lake advisory for Hg (<1 meal/mo for women/children for all SM Bass, N. Pike, Walleye)	No advisory
2001[b]	SM Bass N.Pike Walleye	General Women/children General Women/children General Women/Children	All – 1 meal/wk Hg, PCB All – 1 meal/mo State-wide advisory Hg State-wide advisory Hg All – 1 meal/wk Hg, PCB All – 1 meal/mo	Generic statewide inland lake advisory for Hg (<1 meal/mo for women/children for all SM Bass, N. Pike, Walleye)	No advisory
2007[b] 2008[b]	SM Bass N.Pike	General Women/children General Women/children	 >30" 1 meal/wk Hg, PCB <30" 1 meal/wk >30" 1 meal/mo		

Year	Fish	Population	Torch Lake	Portage Lake	Huron Bay
	Walleye	General Women/Children	>22" 1 meal/wk Hg, PCB <22" 1 meal/wk >22" 1 meal/mo	>22" 1meal/wk Hg, PCB >22" 1 meal/mo Hg, PCB	No advisory
2011/2012[a]	SM Bass	General Women/children	>18" 1 meal/wk, Hg, PCB >14" 1 meal/wk, >18" 1 meal/mo		
	N.Pike	General Women/children	>30" 1 meal/wk, Hg, PCB >22" 1 meal/wk >30" 1 meal/mo		
	Walleye	General Women/Children	>22" NONE Hg, PCB >14" 1 meal/wk >22" NONE	>22" 1 meal/wk Hg, PCB >22" 1 meal/mo	>22" 1 meal/wk Hg >22" 1 meal/mo
2014[d]	SM Bass	All people	>0" 2 meal/mo Hg, PCB		
	LM Bass	All people	>0" 2 meal/mo Hg, PCB		
	N.Pike	All people	>0" 1 meal/mo PCB	>0" 2 meal/mo Hg	
	Sucker	All people All people	<16" 12 meal/mo Hg, PCB >16" 4 meal/mo Hg	<24" 2 meal/mo Hg	>0" 2 meals/mo Toxaph. >0" 2 meal/mo Hg
	Walleye	All people	<20" 1 meal/mo PCB >20" 1 meal/mo Hg, PCB	<28" 1 meal/mo >28" 6 meal/yr	

a. (MDCH, 2011)
b. (MDEQ, 2001, 2007b, 2008b)
c. (MDEQ, 2007a)
d. (MDCH, 2014a)

The second delisting criterion requires a comparison of contaminant concentrations in fish tissues in the AOC with a control site. The goal of such a comparison is to determine if the AOC exhibits greater contamination than nearby sites that lack the point-source inputs of contaminants that exist in the AOC. The selection of an appropriate control site is not trivial. The extent of bioaccumulation of organochlorine contaminants and mercury have both been shown to be influenced by lake and watershed characteristics, not just by the magnitude of contaminant inputs to the lake and watershed (e.g., Clayden et al., 2014; Clayden et al., 2013; Dachs et al., 2000; Muir et al., 2004). Ideally, a control lake would have similar lake surface area, lake depth, trophic state, catchment size, area of wetlands in catchment, food web structure, and dissolved organic carbon concentration. According to the 2007 RAP Update (MDEQ, 2007a), the reference or control site for Torch Lake is Lake Superior. The rationale for this selection is not clear; none of the factors listed above as influencing contaminant concentrations in fish are similar between Torch Lake and Lake Superior. Even if both lakes were receiving only atmospheric deposition of mercury and PCBs, the concentrations of these contaminants in the fish would be different as a result of the influence of these factors. Of the three fish species for which consumption advisories exist in Torch Lake, only one (walleye) is routinely caught and monitored for contaminant concentrations in Lake Superior, although northern pike were also caught in 2013. In this document, we will frequently use Portage Lake as a comparison; Portage Lake is much more similar to Torch Lake than is Lake Superior, but the possibility of fish migration between the two lakes does exist.

As indicated above, a rigorous comparison of fish contaminant concentrations between two lakes is difficult because of the multiple factors that affect such concentrations besides the presence of contaminant sources in a lake. Bioaccumulative contaminant concentrations increase with increasing trophic position and size of fish, and they also differ among males and females (e.g., Gewurtz et al., 2011; Jankovska et al., 2014; Madenjian et al., 2009). Because concentrations may change in both the AOC and control site over time, the comparison should involve the same species, size and gender of fish caught in the same year in the control and AOC sites. Only for the 2006/7 sampling were all of these criteria met; fish gender was not recorded in 1988 or 2000 so comparisons based on those years may be misleading. The number of fish in each size class (2 to 6) was always low, so there is little statistical confidence in the means. In general, concentrations of both mercury and PCBs tend to be higher in Torch Lake fish than in fish from the other two lakes, although the difference is not always statistically significant (Table 7-2). The concentration difference is greatest for the largest fish. In contrast to the 2007 RAP Update (MDEQ, 2007a), this comparison would suggest that both PCBs and mercury are higher in Torch Lake fish than in the control site. As suggested above, although this comparison supports the interpretation that Torch

Lake has a local source of both contaminants, it is not sufficient proof because of the myriad factors that could cause the observed differences among the lakes.

Table 7-2. Summary of fish contaminant concentrations (fillets, skin on) in Torch Lake and its control sites (means ± 95% confidence intervals). Data from Michigan Fish Contaminant Monitoring Program.

Contami-nant	Fish	Gender	Size (cm)	Year	Torch L.	Portage L.	Huron Bay/ Keweenaw Bay
Mercury (mg/kg)	Walleye	Male	40-50	2006/7[1]	0.31 ± 0.13	0.24 ± 0.07	0.34 ± 0.17
			50-60		1.05 ± 0.44	0.63 ± 0.55	0.51 ± 0.23
			60-70		1.33 ± 0.13	NA	**0.68 ± 0.04***[2]
			40-50	2013	0.29 ± 0.12	NA	NA
			50-60		0.71 ± 0.18	NA	**0.28 ± 0.07***
	N.Pike	Male	70-80	2013	0.46 ± 0.13	NA	0.40 ± 0.28
		Female	60-90		0.46 ± 0.24	NA	0.33 ± 0.11
			80-90		0.42 ± 0.31	NA	0.34 ± 0.09
PCBs (mg/kg)	Walleye	Male	40-50	2006/7[1]	0.044 ± 0.061	0.016 ± 0.013	0.013 ± 0.005
			50-60		0.197 ± 0.143	0.113 ± 0.175	**0.043 ± 0.026***
			60-70		0.227 ± 0.099	NA	**0.029 ± 0.019***
			40-50	2013	0.008 ± 0.013	NA	NA
			50-60		0.096 ± 0.054	NA	**0.0042 ± 0.0023***
	N.Pike	Male	70-80	2013	0.032 ± 0.020	NA	**0.0010***
		Female	60-90		0.013 ± 0.012	NA	0.0025 ± 0.0021
			80-90		0.016 ± 0.015	NA	0.0052 ± 0.0051

1. Sampling was done in 2006 in Huron Bay and in 2007 in Torch and Portage Lakes. In 2013, Lake Superior samples for N. Pike were taken from both Huron and Keweenaw Bays.
2. * denotes a statistically significant difference at the 95% confidence level based on a Student's t-test.

The third criterion necessitates comparison of trends in fish contaminant concentrations in the AOC with trends in other appropriate Great Lakes trend sites. Analysis of trends in PCB concentrations is made difficult by a major change in analytical protocols. Prior to 2000, the state's Fish Contaminant Monitoring Program determined PCBs as the sum of component mixtures, or Aroclors. Beginning in 2000, the analytical lab identified and quantified individual component congeners and summed the concentrations of all measured congeners to determine the "total PCB" concentration. The congener-specific method yields results that are approximately 50% of the former method. If no allowance is made for this change in methodology, a trend will be observed in the historical record that is an artifact of the change in analytical procedures. In 1996 and 1999, the state analyzed some fish by both methods, thereby allowing a "correction" of the earlier measurements to make them comparable to the later results (Fig. 7-1). In the discussion below, we will always indicate whether results were "corrected" or "uncorrected"; time trends can only be evaluated with "corrected" values.

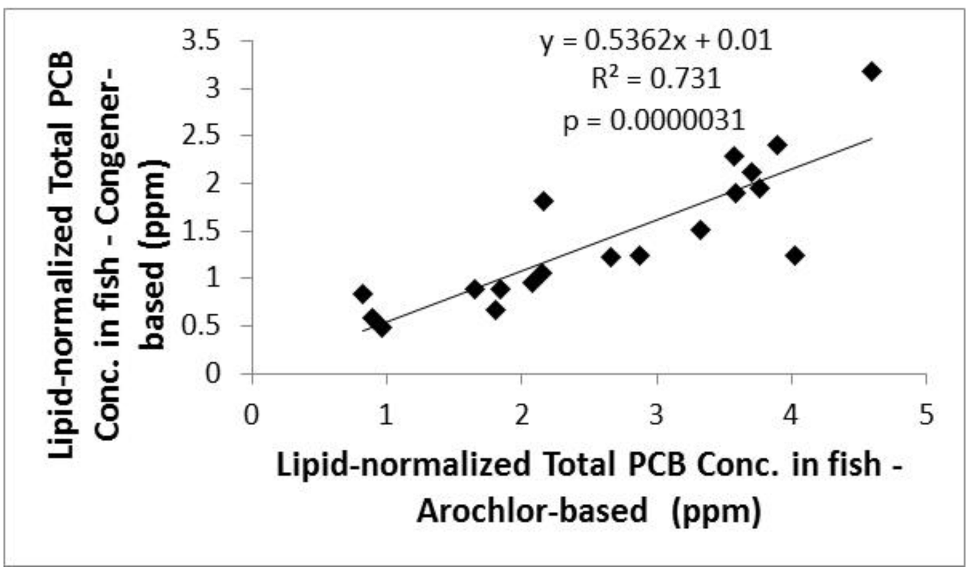


Figure 7-1. Comparison of total PCB concentrations in fish as measured by congener-specific and Aroclor-based methods. Data are for Keweenaw Bay lake trout collected in 1996 and 1999 by the MDEQ Fish Contaminant Monitoring Program. Data are available online at: http://www.michigan.gov/deq/0,4561,7-135-3313_3686_3728-12600--,00.html

There are only two lakes in Michigan's Upper Peninsula in which contaminants are monitored for trends (L. Gogebic, South Manistique L.). In both of these lakes, MDEQ reported that Hg has been declining at rates of 0 to 7.4% yr^{-1} and PCBs have declined at rates of 4-16% yr^{-1} (MDEQ, 2016), but these rates are uncorrected for the change in analytical protocols. In Keweenaw Bay the rates of decline were reported as not significant for Hg and 10.4% yr^{-1} for total PCBs (MDEQ, 2008b). Reanalysis and correction for the change in protocol reveals no statistically significant trends for either Hg or PCBs in Keweenaw Bay (Fig. 7-2).

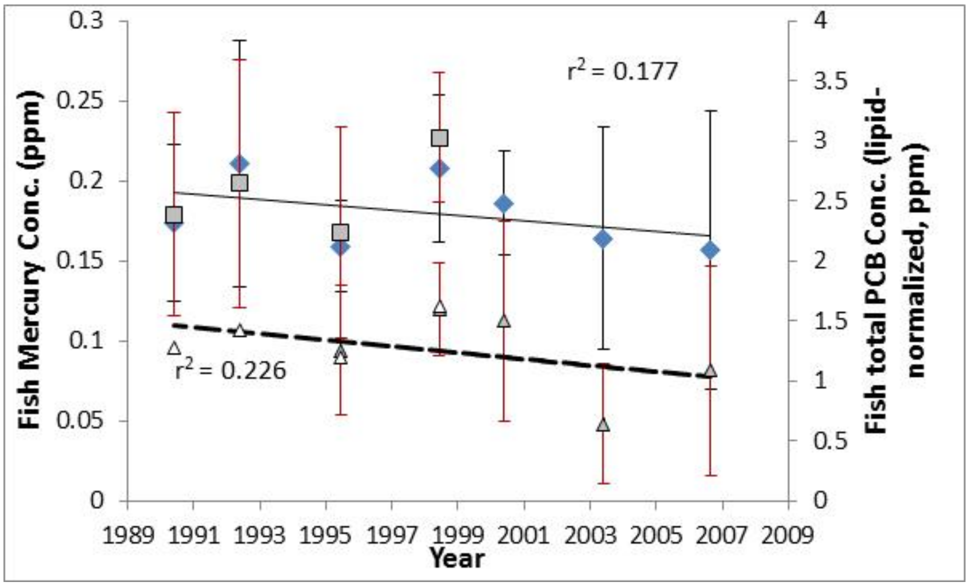


Figure 7-2. Historical trends in PCB and Hg concentrations in whole lake trout from Keweenaw Bay. Data are taken from the MDEQ Fish Contaminant Monitoring Program. Solid diamonds are fish Hg concentrations, and all other symbols represent total PCB concentrations. The squares are total-PCB concentrations calculated from analysis of aroclors, and triangles are based on analysis of individual congeners. Hollow triangles are total-PCB concentrations calculated from aroclor concentrations but adjusted for the difference between congener-based and aroclor-based estimates. The trends are not statistically significant ($p > 0.05$).

Trend analysis of fish contaminants is not trivial because of multiple co-varying factors (fish size, age, gender, lipid content, collection and preparation and analysis techniques). As a first step, we present concentrations measured in all fish for both mercury and PCBs (Fig. 7-3); for PCBs the data have been lipid-normalized and corrected for the change in analytical protocols. The range in concentrations of both contaminants did not change much in either smallmouth bass or northern pike. As discussed below, the apparent increase in concentrations of both contaminants in walleye reflects the different size fish caught in each year; progressively larger walleye were caught each year, possibly as a result of the walleye stocking that began in 1987 (see http://www.michigandnr.com/fishstock/).

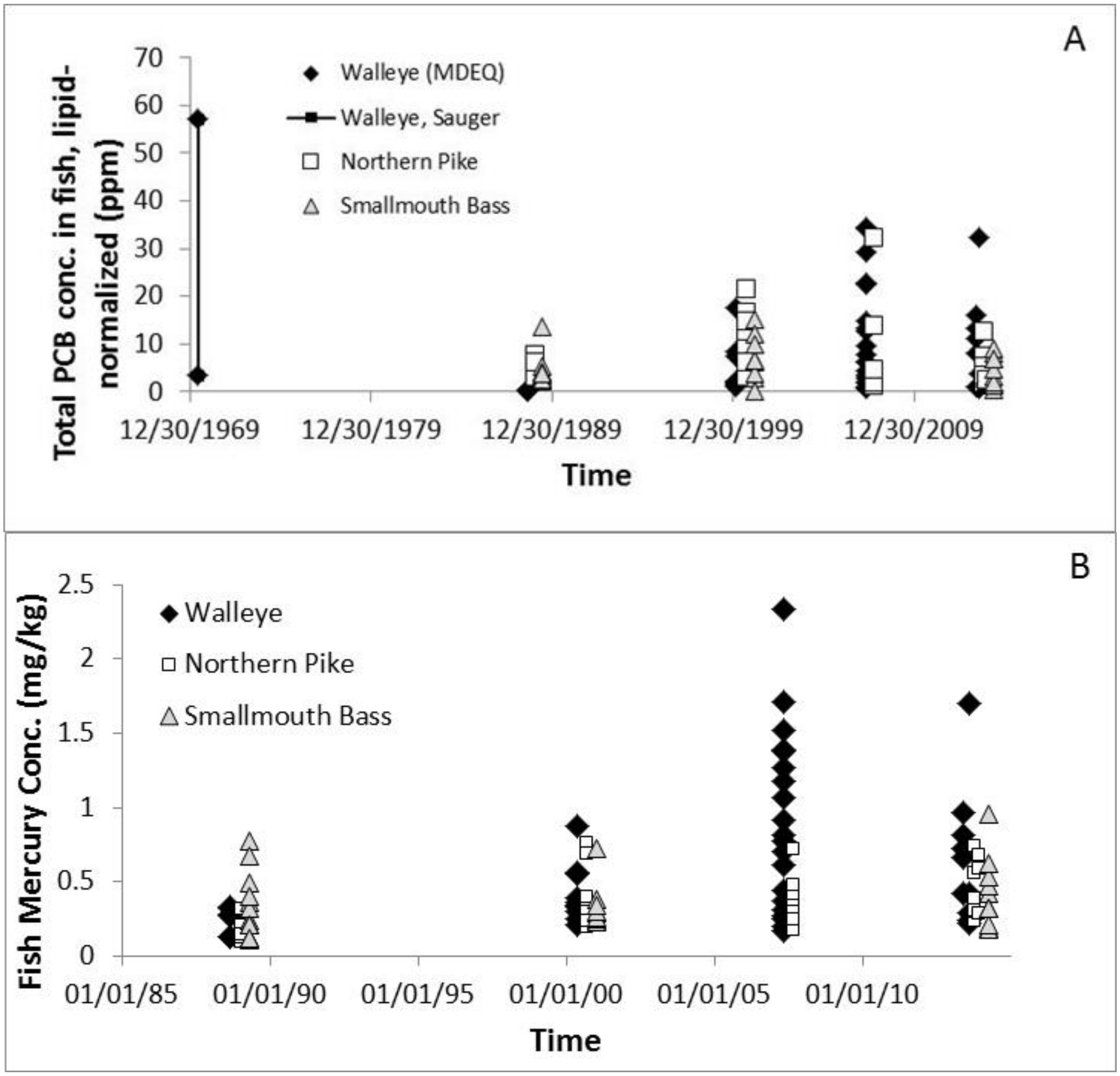


Figure 7-3. Trends in fish concentrations of total PCBs (A) and mercury (B) in Torch Lake. Data are from the MDEQ Fish Contaminant Monitoring Program. PCB concentrations are lipid normalized to eliminate noise from varying lipid content. Pre-2000 PCB concentrations are adjusted for the analytical artifact as shown in Fig. 7-1. Each symbol represents a single fish; size and gender vary among fish. The x-axis (time) scale is different among the two plots.

To reduce the noise in Fig. 7-3, contaminant concentrations have been plotted by year against fish length (Figures 7-4, 7-5). Contaminants that are slowly eliminated from fish and obtained primarily from food consumption tend to increase with age of fish. If growth rates remain relatively constant, fish length may be used as a surrogate for fish age. Both mercury (Fig. 7-4) and PCB (Fig. 7-5) concentrations increase with increasing fish size in walleye, northern pike and smallmouth bass in Torch Lake. Concentrations are successively higher in smallmouth bass, Northern pike, and walleye for both contaminants.

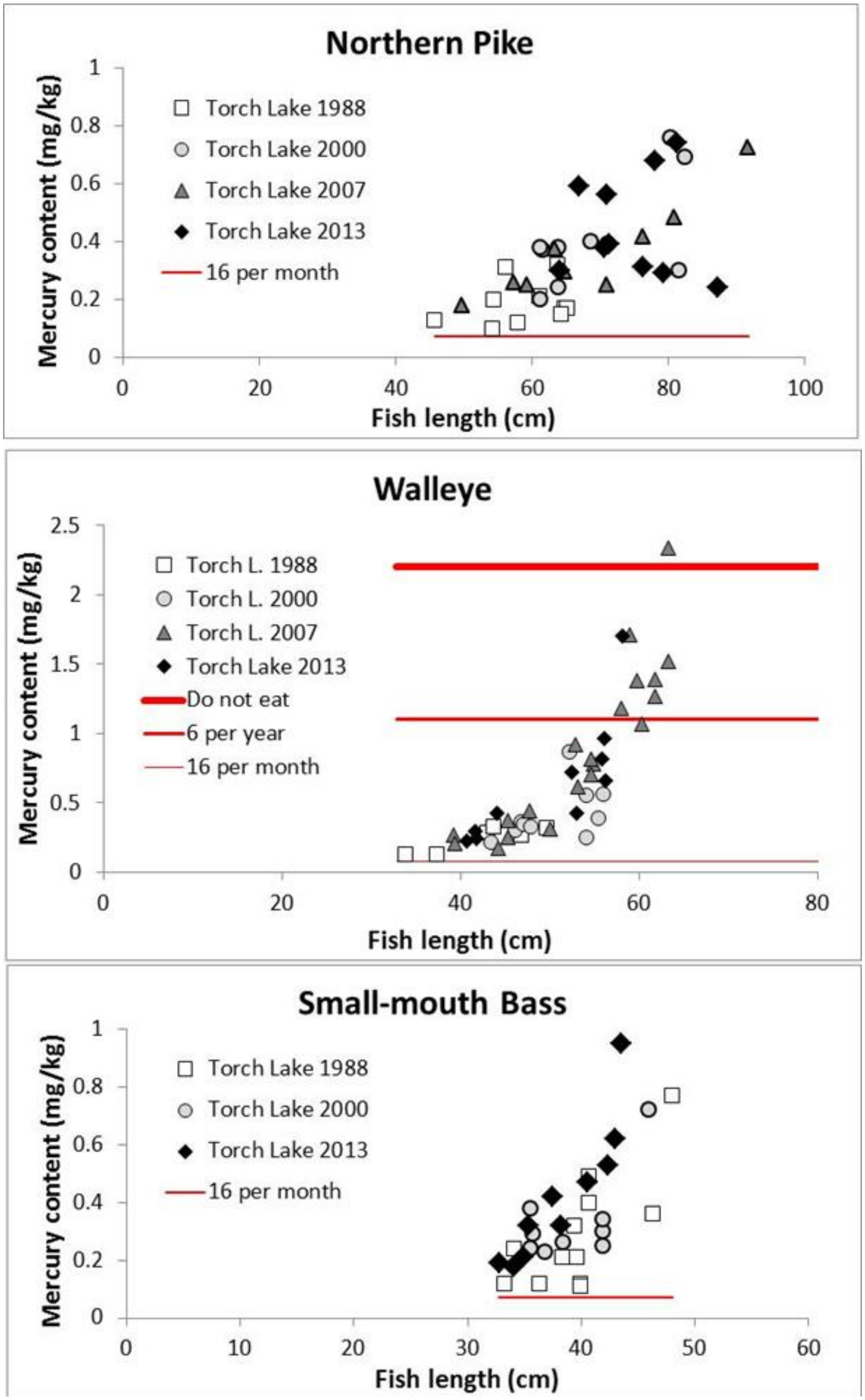
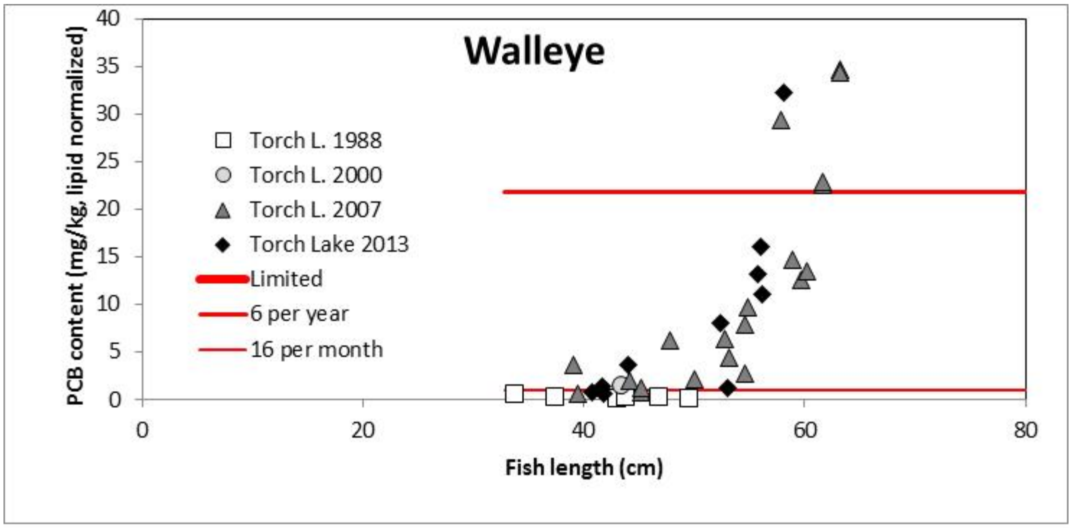
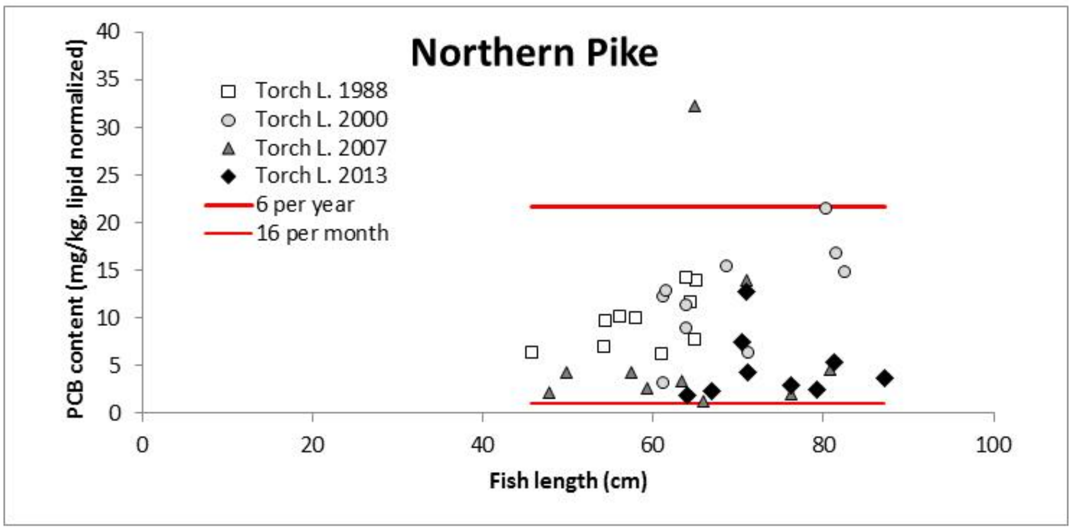


Figure 7-4. Trends with time and fish size in fish mercury content in Torch Lake. Red lines indicate fish consumption trigger levels established by MDCH. All mercury data from the Michigan Fish Contaminant Monitoring Program.





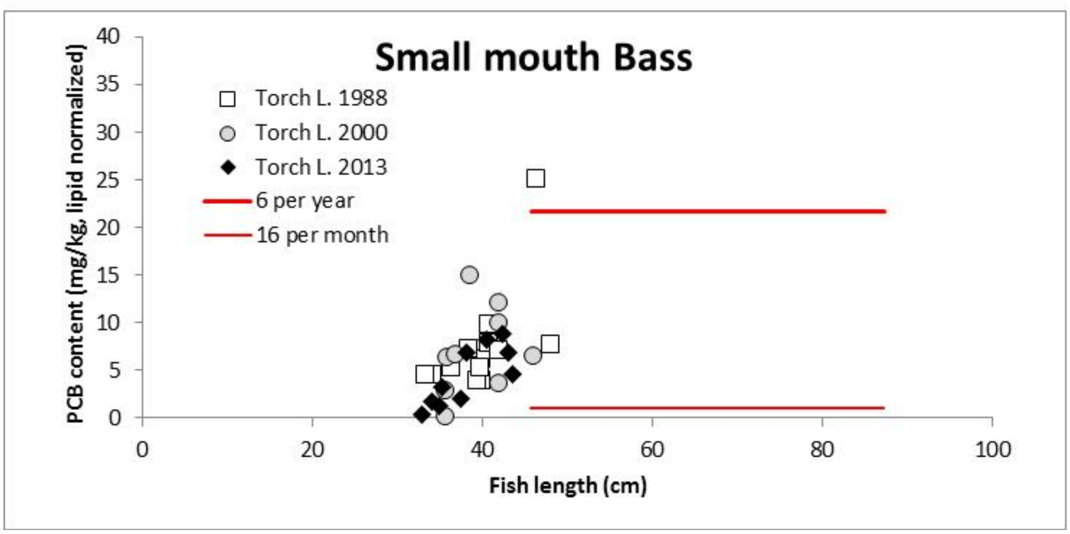


Figure 7-5. Trends with time and fish size in fish PCB content in Torch Lake. Red lines indicate fish consumption trigger levels established by MDCH. All mercury data from the Michigan Fish Contaminant Monitoring Program.

Concentrations in all three fish species are high enough to warrant fish consumption advisories for both contaminants; the red lines in Fig. 7-5 represent the contaminant trigger level divided by the average lipid content for fish of all sizes. The successively larger sizes of walleye caught in each year can be clearly seen in these diagrams. Trends over time are manifested as successively lower concentrations for all fish sizes for successive years. Such temporal trends are visible only for PCBs in northern pike and mercury in smallmouth bass. Temporal trends in single species within a lake are more likely to result from changes in fish populations over time than from changes in contaminant inputs.

This review of the data shows no basis for delisting of the BUI for restricted consumption of fish based on MDEQ delisting criteria. Torch Lake has now and has consistently in the past had more restrictive fish consumption advisories than reference lakes (Table 7-1); hence Criterion 1 is not fulfilled. Concentrations of both Hg and PCBs are higher in comparable fish from Torch Lake than from reference lakes (Table 7-2); hence, Criterion 2 is not met. Lack of data precludes rigorous application of Criterion 3; existing data for Torch Lake show no trends of decreasing contaminant concentrations in walleye. Temporal changes in fish contaminant concentrations are unique to single fish species and particular contaminants rather than applicable to all fish. Such changes may reflect changes in food web dynamics.

7-5. Contaminant Sources: PCBs

7-5a. Local PCB source: evidence from congener ratios

Ratios of summed concentrations of PCB compound groups based on differing number of chlorine atoms bound to the aromatic rings, called isomers, provide conclusive evidence that PCBs in Torch Lake come from a local source. The fish analyses presented above clearly show that PCB concentrations in Torch Lake fish are higher than in fish from either Portage Lake or nearby embayments in Lake Superior, and that there is little evidence that concentrations in the fish are decreasing over time. Because PCBs are a complex mixture of many compounds (called congeners), and because the ratios of summed concentrations of isomer groups differ for different sources of PCBs, these ratios at Torch Lake can be used to provide additional information about the source of PCBs to this lake.

Historically, PCBs were manufactured and sold as specific mixtures, and the ratio of compounds in these mixtures varied depending on the intended use of the compounds. There are a total of 209 possible PCB congeners; the congeners differ from each other in the number (0-10) and location of chlorine atoms on the two six-carbon rings within the molecule (Fig. 7-6). PCBs that have the same number of chlorine atoms are referred to as “isomers” or “homologues”. Isomer groups with fewer chlorines have lower molecular weights, are more volatile and more soluble in water than the congeners with more chlorine atoms. From 1929 through 1950 the dominant use for PCBs was as coolants and lubricants in electrical equipment (transformers, capacitors) and other heavy machinery; mixtures sold for these purposes had relatively more heavy congeners (i.e., more chlorine atoms). Mixtures dominated by the lighter congeners were used for such purposes as de-inking, carbonless copy paper, and adhesives. The PCBs that are transported long distances through the atmosphere are dominated by the lighter, more volatile congeners even if the original source was a mixture of primarily heavy congeners.

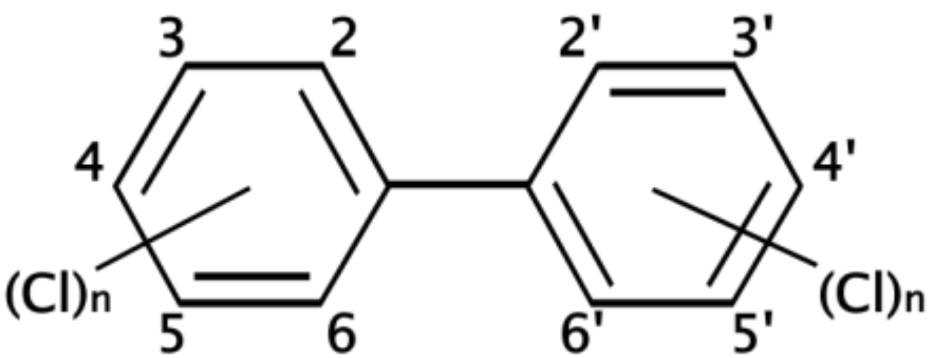


Figure 7-6. Generalized chemical structure of PCB molecule. Two phenyl rings are joined by a single bond. Chlorine atoms may occur at any of the 10 positions labeled 2 to 6 and 2' to 6'.

The PCBs in Torch Lake water contain a higher abundance of heavy congeners than do PCBs in nearby control sites including Dollar Bay, Huron Bay, and the two entrances to the Keweenaw Waterway. Passive samplers (six pairs of duplicate samplers in Torch Lake) were deployed in 2005 to contrast the PCB concentrations and compositions among these sites (MDEQ, 2006b). To illustrate these differences, PCBs are categorized as to the number of chlorine atoms on the molecule (1-10 possible), and the concentrations of these isomers or homolog groups (compounds with the same number of chlorines) are added. The pie charts in Figure 7-7 show the relative abundance of the homologs (10 possible groups of isomers of which only five were observed). In the samplers placed in the control sites, homologs with more than four chlorines represent less than 25% of the total PCBs present. This distribution of homologs is representative of locations receiving PCBs primarily from the air. In the four samplers around the main basin of Torch Lake, the heavy homologs (compounds having more than four chlorines) represent 25-50% of the total PCBs. This collection of homologs strongly suggests that a local source of PCB contamination exists, and that the local source has a high abundance of heavier congeners. The sampler

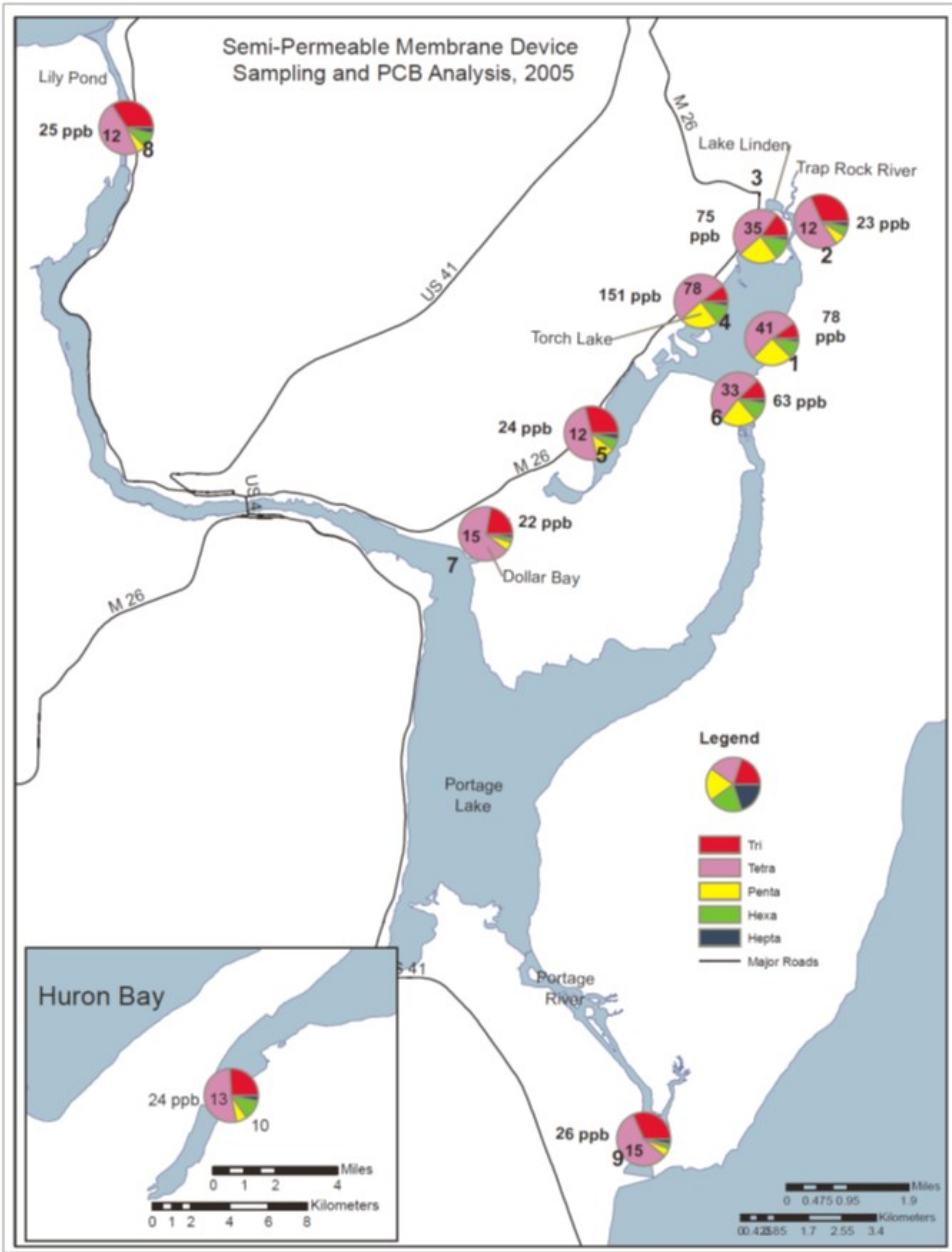


Figure 7-7. Relative abundance of PCB homologs in SPMD devices within Torch Lake and nearby control lakes. The values 1-10 outside the pie charts are site designations. The total PCB concentration (ppb) in the solvent extract from the SPMDs is given alongside each pie chart as well. The concentration of the dominant homolog (tetrachlorinated biphenyls) is given within each pie chart.

near the mouth of the Traprock River has a homolog distribution similar to that at the control sites, and indicates that the Traprock River carries PCBs derived largely from the air. Similarly, the collector placed in the south basin also has a homolog distribution characteristic of the atmospheric source; more sampling would be required to determine if the south basin of the lake is free of local contamination or if just the embayment where the sampler was placed is free of such contamination.

The congener ratios in the fish also indicate a difference in composition of the PCB mixture, but not in the direction expected. Using the 2006/2007 data from the MDEQ Fish Contaminant Monitoring Program, ratios of tetrachlorinated biphenyl compounds to PCBs with six or more chlorines revealed that fish in Torch Lake have more of the lightly chlorinated PCBs relative to heavy homologs than do fish in Portage Lake or Huron Bay (Fig. 7-8). This likely results from the greater absolute concentrations of even the lightly chlorinated PCBs in the water column (and hence in algae and zooplankton) of Torch Lake relative to the control locations; the tetra-chlorinated PCBs are entering the food web at higher rates and hence are bioaccumulated at higher rates within Torch Lake as compared to the control locations.

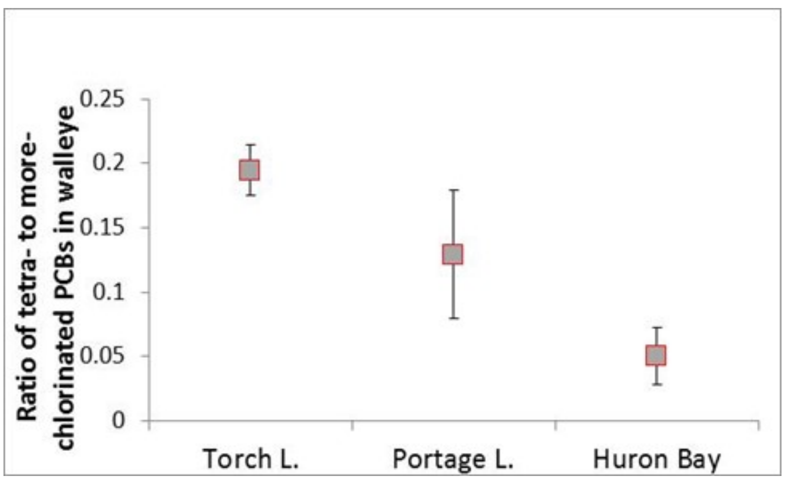


Figure 7-8. Ratios of concentrations of tetrachlorinated biphenyls to (hexa- + hepta- + octa-chlorinated) biphenyls in walleye fillets. Data are taken from the MDEQ Fish Contaminant Monitoring Program results for 2006 and 2007 fish collections. Fish were of comparable size and lipid content in all locations, and ratios were not correlated with fish size. The number of fish ranged from 20 in Torch Lake to 10 in Portage Lake to 16 in Huron Bay.

7-5b. Local PCB source: evidence from concentrations in water and fish

The magnitude of the PCB concentrations in the water column of Torch Lake also attests to the likelihood of a local source. Although PCBs have never been directly measured in the water of Torch Lake, concentrations can be estimated from the Semipermeable Membrane Devices (SPMDs, Huckins et al., 1993) installed in the lake for one month in 2005 (MDEQ, 2006b). These passive samplers consists of an oil within a plastic sheath; compounds like PCBs tend to partition into the oil from the lake water (for illustration see http://wwwaux.cerc.cr.usgs.gov/SPMD/). The mass of PCBs within the SPMD slowly increases over time, and ultimately equilibrium or a constant ratio is reached between the PCBs dissolved in oil in the sampler and PCBs dissolved in the lake water. The 30-day period of deployment was not long enough for such equilibrium to be reached. Consequently, a rate of uptake has to be assumed in order to calculate the PCB concentration in the lake from the mass accumulated in the SPMD. The USGS has made the SPMD Calculator v4.1 freely available (http://www.cerc.usgs.gov/Assets/UploadedFiles/ExternalDocs/SPMD_Water_Conc_Estimator_v4-1.xlsx) for such purposes; the program uses previously measured rates of uptake by SPMDs for specific compounds.

It is the authors' opinion that a valid estimation of **total** PCB concentrations in the lake water cannot be obtained from the SPMD results, but that concentrations of the most abundant congeners can be reliably estimated. Only 13-16 congeners were detected in the SPMDs; typically, 30-40 congeners are detected in environmental samples (e.g., Baker and Eisenreich, 1990; Nizzetto et al., 2012), and hence the basis for extrapolating to all PCB congeners appears weak. However, 12 congeners were detected at all sites. The PCB concentrations calculated from the 10 SPMD devices for seven congeners are summarized in Figure 7-9. It is clear that concentrations of all congeners except 33 were much higher (5- to 10-fold) in Torch Lake than in the control sites. Congener 33 was a minor component (< 1% by weight) of Aroclor 1254 (Capel et al., 1985), the mixture thought to have been used locally around Torch Lake. The 5- to 10-fold higher concentrations of congeners in Torch Lake as compared to nearby lakes receiving only atmospheric inputs supports the conclusion that there is a local source of PCBs in Torch Lake.

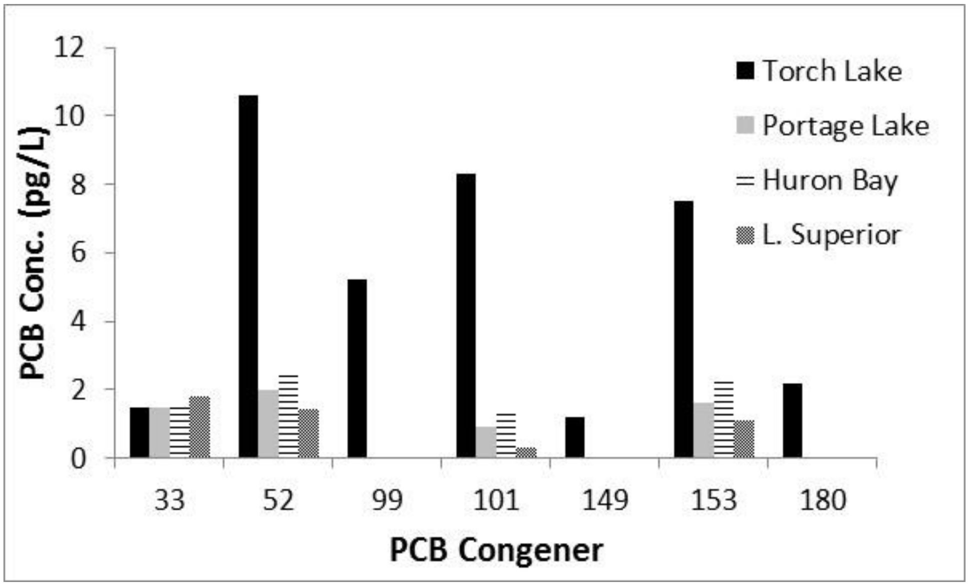
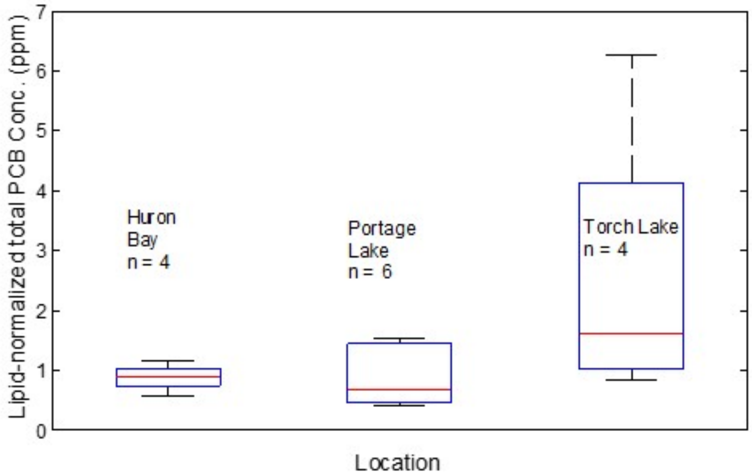


Figure 7-9. Comparison of PCB concentrations in Torch Lake water with those measured in control sites. Shown are concentrations for 7 selected congeners. Concentrations shown for Torch Lake, Portage Lake and Huron Bay were measured with SPMDs. The Lake Superior value is taken from the Great Lakes Aquatic Contaminants Survey (2005).

The PCB concentrations in fish also consistently show that concentrations in fish from Torch Lake are higher than in fish from nearby control lakes. Comparing the values is not straightforward, because concentrations depend on type of fish, gender of fish, size of fish and lipid content. Hence, a statistically valid comparison must compare the same type, gender and size of fish. Of the 42 fish caught in Torch Lake in 2007, only 10 had comparable fish in the control lakes (Fig. 7-10); PCB concentrations in two size classes of walleye were significantly higher in Torch Lake than in either of the control sites. Similarly, only 5 of the 30 fish caught in Torch Lake in 2013 had fish of comparable species, gender, and size; again, the concentration in Torch Lake fish was significantly higher than the concentration in fish from Huron Bay (Fig. 7-11). Contaminant concentrations in fish are influenced by a host of lake-specific features (e.g., depth, surface area, littoral vs. pelagic areas, dissolved organic carbon (DOC) concentrations, trophic state); hence, higher concentrations in Torch lake fish do not prove, but are consistent with, there being a local source of PCBs.



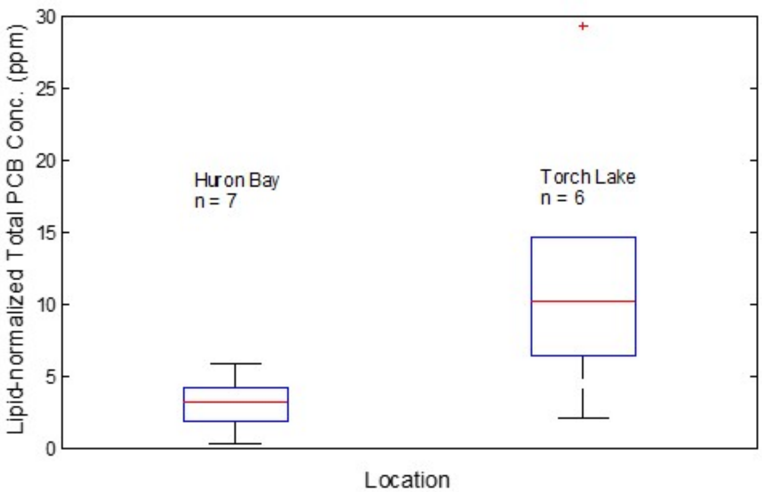


Figure 7-10. Comparison of fish PCB concentrations in Torch Lake and control sites. Upper figure compares male walleyes of length 40-50 cm caught in 2006 and 2007 (means are: Torch Lake 2.57, Portage Lake 0.86, Huron Bay 0.87 ppm). Lower figure compares male walleyes of length 50-60 cm caught in the same years (means are: Torch Lake 12.2, Huron Bay 3.1 ppm). All data are from the Michigan Fish Contaminant Monitoring Program (FCMP).

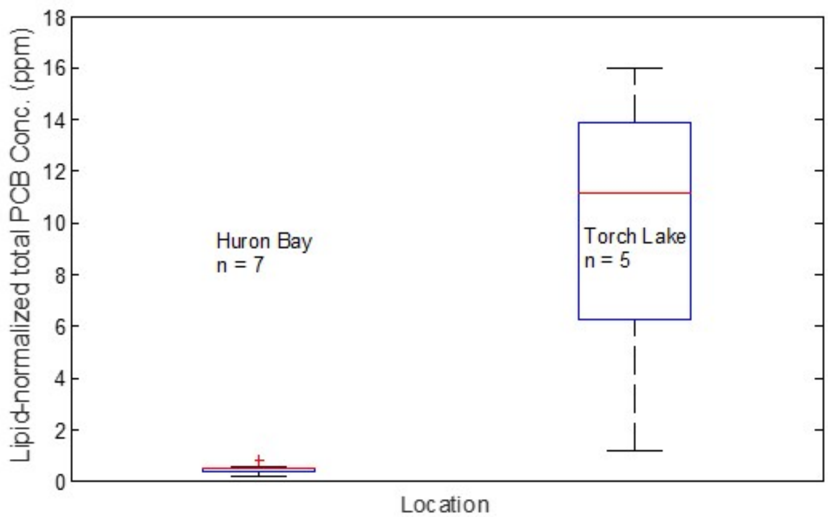


Figure 7-11. Comparison of PCB concentrations in fish caught in 2013. Shown are values for male Walleye between 50 and 60 cm in length. Means are: Torch Lake – 9.9, Huron Bay – 0.48 ppm). Data from Michigan FCMP.

7-5c. Local PCB source: utility of mass balance calculations

Useful insights can be gained from looking at the "cycle" of PCBs within Torch Lake (Fig. 7-12). Such cycles exist in all lakes, because all lakes receive PCBs from the atmosphere. The PCBs that enter a lake via wet (rain, snow) or dry (particle fallout) atmospheric deposition ultimately must either adhere to particles and be buried in the lake sediments, flow out the outflow of the lake, or be re-emitted in gaseous form from the lake's surface. In addition to inputs from the atmosphere, Torch Lake also receives an input from the area of contaminated sediments and in runoff into the lake of PCBs in/on surface soils or in contaminated groundwater; PCBs on the contaminated sediments slowly dissolve and diffuse into the lake water. By comparing the relative magnitudes of the fluxes, one can infer the major source of PCBs to the lake as well as the major mechanism(s) for removal of PCBs from the lake.

The fluxes of PCBs into and out of Torch Lake were calculated based on the estimated concentrations in the water (derived from the SPMDs), measured concentrations in the air and rates of atmospheric deposition (taken from the Integrated Atmospheric Deposition Network, IADN, station at Eagle Harbor), and the concentrations measured by MDEQ and EPA in the sediments. Fluxes are calculated for individual PCB congeners; in this study, seven congeners were used based on the availability of data. The calculated fluxes should be regarded only as rough approximations; fluxes

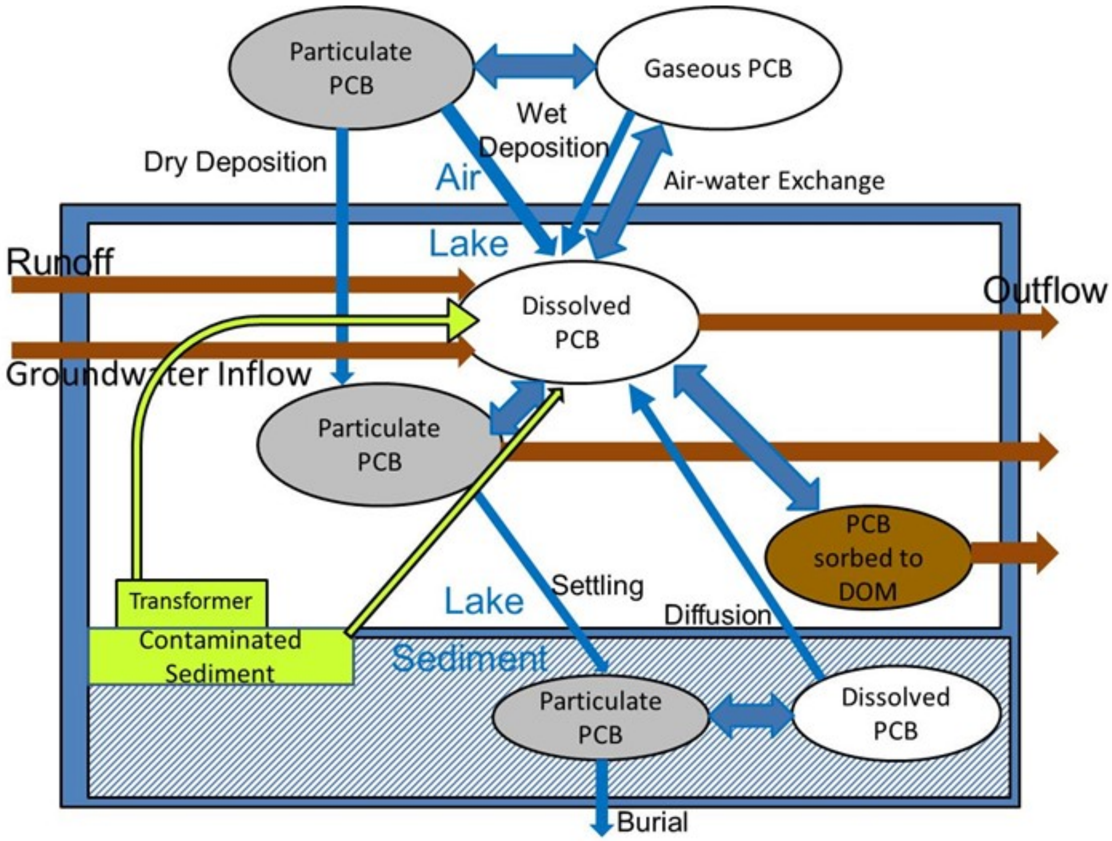


Figure 7-12. Schematic of PCB cycle within Torch Lake. The only features unique to Torch Lake are the presence of contaminated sediments and potentially of concentrated PCB sources such as barrels of waste oil or actual transformers or PCB hotspots in the lake or on its shore.

depend on environmental factors (wind speed, air and lake temperatures, particle concentrations in the water) that change over time, but constant values (annual averages) were used for the flux estimation. The calculations also assume steady state conditions prevail; we do not know whether concentrations in the lake are changing with time. Details of the calculations are provided in Mandelia (2016).

While the estimation is intentionally crude, some useful insights may, nevertheless, be gained (Fig. 7-13). First, comparison of the concentrations of PCBs in the air and the lake indicates a local source of PCBs must exist. All congeners are calculated to be degassing from the lake; such degassing is possible only if there is an input of PCBs to the lake because only such an input could drive concentrations above equilibrium with the air. For Torch Lake, the input from wet and dry deposition is not large enough to explain the amount volatilized from the lake; the remainder comes from the contaminated sediments and possibly other inflows. Second, for all congeners except 33 the sum of the known inputs (atmospheric deposition, contaminated sediments) is not large enough to account for the calculated losses (air-water exchange or volatilization, outflow, sedimentation); this imbalance suggests that PCBs are entering the lake by means other than atmospheric deposition and release from the contaminated sediments.

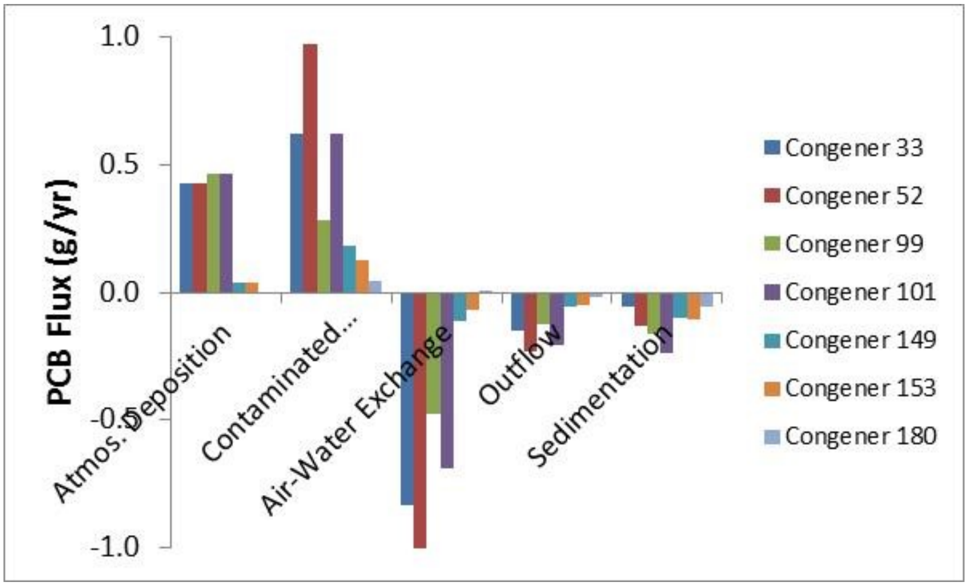


Figure 7-13. Calculated fluxes of PCB congeners into and out of Torch Lake. Positive fluxes are into the lake, negative fluxes are leaving the lake. The second category of fluxes is contaminated sediments.

7-6. Contaminant Sources: Mercury

7-6a. Summary & recommendations

Concentrations of mercury (Hg) in Torch Lake fish have been above safe consumption levels for 25 years, and there is no evidence of any decrease in those concentrations. Mercury concentrations in Torch Lake fish have been and remain above the concentrations in the reference lakes. On the basis of existing guidelines, there is no basis for removing the BUI related to restricted consumption of fish from Torch Lake.

There is clear evidence that Torch Lake has and continues to receive mercury inputs as a result of historical mining activities, but further work is required to determine if those inputs cause the elevated concentrations in fish. Drainage from multiple mines contributes mercury to streams that flow into Torch Lake. The 200 million metric tons of stamp sands in the lake contain, on average, ~200 ng Hg/g or a total of 40 metric tons of Hg. Sediment cores show that methyl mercury was accumulated in the sediments during the period of tailings discharges, but it remains unknown if any of the Hg in the stamp sands is bioavailable or if any is currently being mobilized and methylated (Kerfoot et al., 2016).

Priorities for future research include: measurement of inputs of methyl mercury to Torch Lake, determination if methylation occurs within the lake sediments, and isotopic analysis of the Hg in the fish to determine if it has a mining or an atmospheric source. The possibility for controlling Hg concentrations in fish through stocking practices also warrants investigation.

7-6b. Comparisons with other locations

As for PCBs, potential sources of Hg to Torch Lake include local mining and long-range atmospheric transport from distant sources. It is well established that historical mining in Michigan's Upper Peninsula caused an enrichment of Hg above "background" concentrations in many environmental media. The iron, copper, silver and gold ores found in the U.P. are all highly enriched in Hg (1-1000 μg/g or 20 to 20,000 times concentrations in uncontaminated soil) (Kerfoot et al., 2002). Consequently, mine residues are also enriched in mercury relative to soil or rock not associated with mining. Mine residues include poor rock (9-281 ng Hg/g), stamp sands (i.e., coarsely ground, extracted mine tailings; 3-265 ng/g), mine tailings (i.e., finely ground, extracted ore; 17-95 ng/g), soils (60-200 ng/g), and lake sediments (50-600 ng/g) (Kerfoot et al., 2002). The recent USGS mapping of surface soils of the contiguous U.S. shows elevated mercury concentrations (> 150 ng/g) in surface soil and soil A horizons in Marquette, Baraga and Ontonagon counties; all of these were historically areas of mining activity (Smith et al., 2013). A recent report to the MDNR (Knauer et al., 2011) reported elevated total Hg concentrations in sediments of mining-impacted lakes in the Marquette iron mining region. While it is well known that Hg from gold and mercury mining becomes methylated and bioavailable in stream and lake environments (Brown et al., 2007; Gehrke et al., 2011; Gray et al., 2004; Gray et al., 2000; Hines et al., 2000; Navarro et al., 2009; Rytuba, 2000; Stamenkovic et al., 2004; Wong et al., 1999), no studies have yet examined whether the Hg from iron and copper mining in the U.P. is similarly bioavailable.

Mine residues are not the only mechanism for release of Hg into the environment from mining. Metal smelting releases large quantities of Hg from the ore to the atmosphere, and this mercury is deposited to catchments and lakes downwind of smelters. Kerfoot (2002) estimated that 24 metric tons of Hg were released from copper smelting in the U.P. Furthermore, coal combustion was the major fuel for steam and electricity generation needed to operate the mines and ore-processing facilities. Elevated rates of mercury deposition are now observed for a few hundred kilometers downwind of coal-fired power plants (e.g., Gratz and Keeler, 2011; Sherman et al., 2012); shorter stack heights and lack of emission controls (higher particulate Hg emissions) may have reduced that footprint in earlier decades. It is not yet known how long after cessation of mercury emissions from metal smelters or coal-fired power plants that mercury deposited downwind continues to be mobilized from soils into streams and lakes (Wiklund et al., 2017).

It is known that Hg is being released into stream waters from mines in the Torch Lake catchment. Drainage from the Kingston mine (Copper City) was found to have a Hg concentration of 310 ng/L (i.e., 3.1×10^{-7} g/L) and discharged 0.36 g/d (Degraeve and McCauley, 2003). Slaughterhouse Creek which receives drainage from multiple mines had a Hg concentration of 39 ng/L (3.9×10^{-8} g/L) in summer 2002 and a Hg flux of 0.57 g/d (Degraeve and McCauley, 2003). Osceola mine #4 was estimated to discharge 0.8 g/d of Hg in fall 2001 when flow from the mine was relatively low; the Hg concentration in the outflow was 130 ng/L or 1.3×10^{-7} g/L (MDEQ, 2002). For comparison, the average rate of atmospheric deposition of Hg to Torch Lake is 0.27 g/d. Clearly, the potential exists for mine drainage to contribute significantly to the mercury inputs to Torch Lake.

It also is clear that some portion of the mercury reaching Torch Lake in the Traprock River is derived from mine drainage or exposed tailings. In a 2002 study commissioned by the MDEQ, mercury concentrations in the Traprock River increased from 2.1 ng/L (flux of 0.02 g/d) above the confluence with Scales Creek to 4.6 ng/L (0.41 g/d) below Scales Creek; concentrations remained constant for the remaining 1.5 km of the river (Degraeve and McCauley, 2003). The concentration in the Traprock River (4.6 ng/L) was well above the mean (1.1 ng/L) and the 99th percentile (3.3 ng/L) of concentrations in eighteen Upper Peninsula rivers unaffected by mining (Degraeve and McCauley, 2003).

The magnitude of the actual contribution from mine drainage depends on the extent to which the Hg is attenuated in the streams and rivers prior to reaching Torch Lake. Possible mechanisms for attenuation include volatilization and sorption to particles or organic matter and retention in the stream bed. The drainage from Osceola mine #4 flows into Hammell Creek; concentrations were found to be attenuated from 130 ng/L to 2.6-8.5 ng/L by the time this stream emptied into the Traprock River (Degraeve and McCauley, 2003; MDEQ, 2002). Most of the attenuation occurred in a stretch of the stream that flows through an extensive wetland (MDEQ, 2002). Similarly, the high Hg concentration (39 ng/L) and flux (0.57 ng/d) in Slaughterhouse Creek were attenuated to a concentration of 16 ng/L and a flux of 0.33 ng/d after this creek joined Scales Creek (Degraeve and McCauley, 2003). If the Hg is being retained in the stream bed, it is susceptible to being mobilized during periods of high stream flow (Hurley et al., 1998; Ruzycki et al., 2011; Shanley et al., 2005). If the Hg is being retained in riparian wetlands, the potential for methylation and subsequent transport of the methyl mercury to Torch Lake is enhanced (e.g., Dennis et al., 2005). Clearly, the potential exist for high inputs of mining-derived mercury to streams and rivers draining into Torch Lake, but further measurements are required to define the magnitude of this source more accurately.

7-6c. Sediment mercury

Concentrations of total Hg in Torch Lake sediments are higher than in many other lakes (Table 7-3), but the relative importance of mining inputs, atmospheric deposition, and catchment runoff have never been clarified. In sediment cores from 10- and 20-m water depths, the concentrations of total Hg in the post-mining (i.e., after 1970) sediments range from 240-650 ng/g (Kerfoot et al., 2016). Concentrations in recent sediments from lakes in the upper midwest typically range from ~10 to ~400 ng/g. However, concentrations are a poor basis for comparison because they result from the relative rates of mercury and sediment accumulation. Low rates of sediment accumulation in Torch Lake (0.02 g cm^2 yr^{-1}) (McDonald et al., 2009) could contribute to high concentrations of Hg in the sediments.

Comparison of accumulation rates of Hg in sediments is unaffected by different rates of sediment accumulation among lakes. However, mercury accumulation rates are seldom uniform throughout a lake due to the focusing of fine sediments towards deep areas. This spatial heterogeneity within a lake is typically accounted for by using ^{210}Pb-based focusing corrections. Such focusing corrections work for any substance that binds primarily to fine organic matter within lake sediments. Many studies (Suchanek et al., 2008; Sunderland et al., 2006) have shown Hg to be bound primarily to organic matter in lake sediments.

Mining may have caused slightly elevated concentrations and accumulation rates of Hg in the sediments of Torch Lake. Accumulation rates of Hg in lake sediments are influenced both by rates of atmospheric deposition, in-lake focusing, and mobilization of atmospherically-derived Hg from the catchment. Drevnick et al. (2012) report that recent atmospheric deposition rates as calculated from lake sediments in the Great Lakes region are in the range of 10-13 μg m^{-2} yr^{-1}. Total Hg was measured in sediment cores from Torch Lake (Kerfoot et al., 2016) as were ^{210}Pb-based focusing factors (1.05 - 2.0) and sedimentation rates (280 g m^{-2} yr^{-1}). Focusing-corrected total Hg accumulation rates in the surface sediments of Torch Lake (75-87 μg m^{-2} yr^{-1}) yield an estimated atmospheric deposition rate of 12.9-15 μg m^{-2} yr^{-1} using the method of Drevnick et al. (2012). These rates are slightly higher than the range (10-13 μg m^{-2} yr^{-1}) reported by Drevnick et al. The discrepancy may indicate that up to 15% of Hg in recent Torch Lake sediments is derived from mining.

Table 7-3. Comparison of Hg concentrations in Torch Lake sediments with concentrations in other lake sediments.

Lake	Sample type or source	Total Hg conc. (ng/g)	Total Hg accum. Rate (µg/m^2yr)	Reference
Torch Lake	Post-mining sediments	240-650	60 – 218	This study
Portage Lake	Surface sediments	500		(Kerfoot et al., 1999)
	Background	31-69		(Kerfoot et al., 2002)
6 lakes in Michigan's Upper Peninsula	Surface sediments	200-400		(Kerfoot et al., 1999)
16 small lakes in Michigan's Upper Peninsula	Recent sediments	3-74	2-24	(Kerfoot et al., 2002; Kerfoot et al., 2004)
7 Minnesota lakes	Recent sediments	63-370	16-32	(Engstrom et al., 1994)
Lake Superior	Surface sediments	15-960	8-100	(Kerfoot et al., 2004; Rolfhus et al., 2003; Rossmann, 1999)
	Background (deep sediments)	13-48		(Kerfoot et al., 2002)
Lake Michigan	Sediment cores	2-260	11	(Mason and Sullivan, 1997; Rossmann, 2002)
Little Rock Lake, WI		9	9	(Porcella, 1994)
7 Wisconsin lakes			5-9	(Watras et al., 1994)
Minnesota bog	Recent rates		19	(Benoit et al., 1998)
Greenland lakes	Surface sediments	25-440	5-10	(Bindler et al., 2001)

Concentrations of total mercury in the surface sediments of Torch Lake, while posing some cause for concern, are not likely to be responsible for the very low population of benthic macroinvertebrates throughout the lake. Comparison of published sediment quality criteria (Table 7-4) suggests that no acute biological effects are observed below a threshold concentration of about 150 ng/g (0.15 ppm), while effects are highly probably at concentrations above 1,000 ng/g (1.0 ppm). The absolute values for these thresholds must be used with some caution; while the Consensus-based Probable Effects Concentration (CbPEC) correctly predicted toxic effects in 100% of samples, the Consensus-based Threshold Effects Concentration (CbTEC) was not as accurate, with only 35% of samples with Hg concentrations below the threshold being, in fact, nontoxic (McDonald et al., 2000). Concentrations of Hg in Torch Lake sediments ranged from 30 to 1,200 ng/g (0.03-1.2 ppm) with a median value of 110 ng/g. Approximately 60% of samples had concentrations below the Threshold Effects Concentration (TEC), and 98% were below the PEC. The large regions of the lake with concentrations below the TEC suggest that Hg is not the primary source of toxicity that causes low benthic macroinvertebrate populations throughout the lake.

The distribution of mercury in surface sediments of Torch Lake (Fig. 7-14) suggests that the Calumet & Hecla smelting/refining activities between Hubbell and Lake Linden and the Quincy reprocessing activities at Mason produced waste materials with somewhat elevated mercury concentrations. Interestingly, there is little indication of elevated mercury concentrations in the soils around these sites (Fig. 7-14). Neither the stamp sand piles themselves, nor the fine sediments focused to the deep locations in the lake, appear to have elevated mercury concentrations.

Table 7-4. Sediment Hg Criteria

Criterion	Substance	Value (ppm dry weight or mg/kg or µg/g)	Reference
Canada Interim Sediment Quality Guideline (ISQG)	Total Hg	0.17	Canadian Council of Ministers of the Environment. (CCME) 1999. Canadian sediment quality guidelines for the protection of aquatic life: Mercury. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg
Threshold Effects Level (TEL)	Total Hg	0.174	(Ingersoll et al., 2000)
Michigan Threshold Effects Conc.	Total Hg	0.18	
Lowest Effects Level (LEL)	Total Hg	0.2	(Persaud et al., 1993)
Minimal Effect Threshold (MET)	Total Hg	0.2	Env. Canada 1992
Effect Range – Low (ERL)	Total Hg	0.15	(Ingersoll et al., 2000)
Consensus-based Threshold Effect Concentration (CbTEC)	Total Hg	0.18	(McDonald et al., 2000)
Probable Effects Level (PEL)	Total Hg	0.486	(Ingersoll et al., 2000)
Severe Effect Level (SEL)	Total Hg	2	(Persaud et al., 1993)
Toxic Effect Threshold (TET)	Total Hg	1	CCME 1999
Effect Range – Medium (ERM)	Total Hg	1.3	(Ingersoll et al., 2000)
Consensus-based Probable Effects Concentration (CbPEC)	Total Hg	1.06	(McDonald et al., 2000)
Michigan Probable Effects Conc.	Total Hg	1.06	

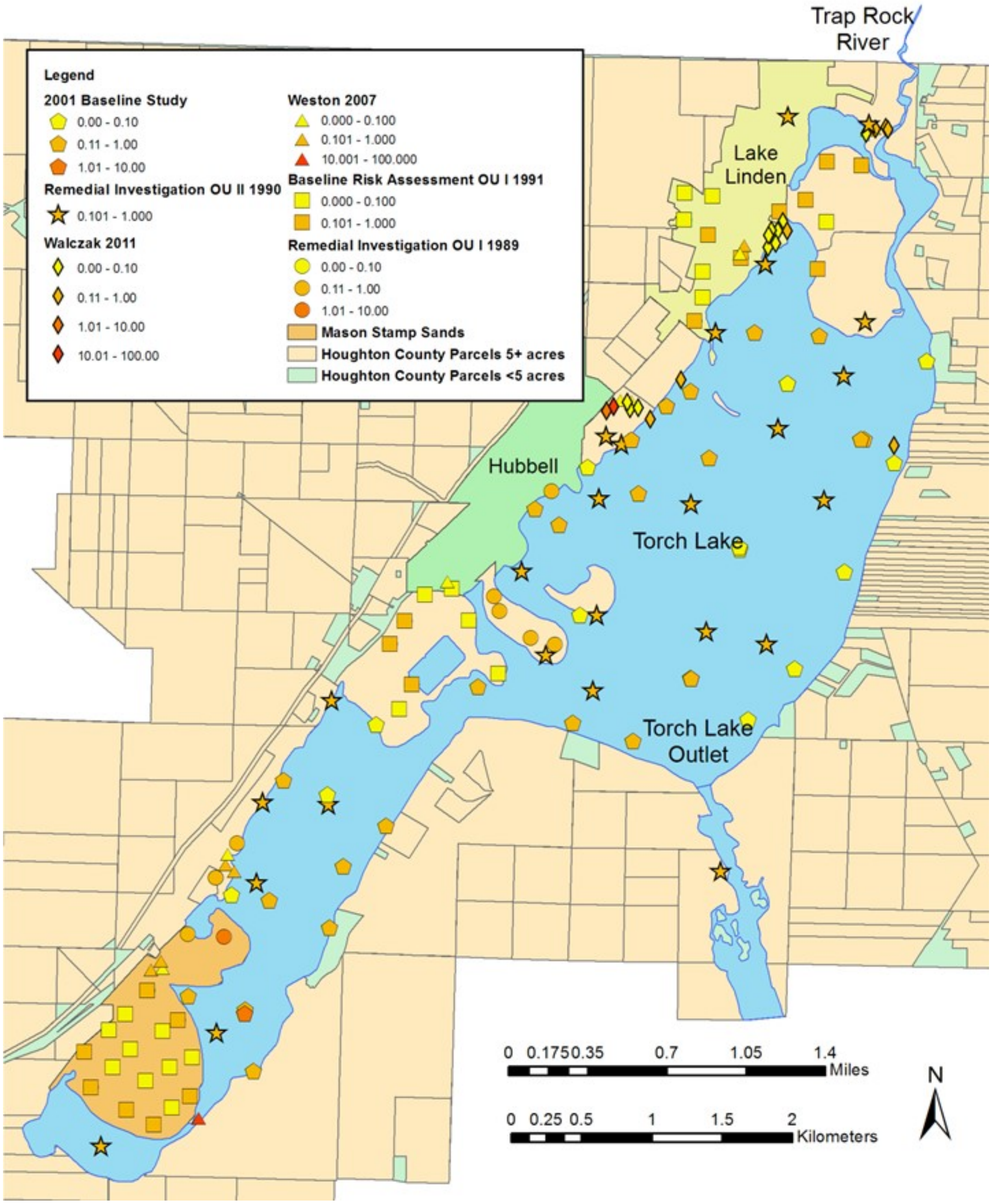


Figure 7-14. Distribution of mercury concentrations in surface sediments of Torch Lake. Data were compiled from EPA and MDEQ reports as summarized in Mandelia (2016). Concentrations are compared to the TEC (0.18) and PEC (1.06) (both in ppm) used by the State of Michigan.

7-6d. Fish

Contaminant surveys conducted in 2007 and 2013 strongly suggest that the MDEQ's previous conclusion (i.e., that the mercury in Torch Lake fish are at concentrations no higher than those in reference lakes) must be re-evaluated. On the basis of their previous comparison of fish Hg concentrations in Torch and reference lakes, the MDEQ concluded that Hg in Torch Lake is not of local provenance. However, as shown in Figure 7-15, large walleye (> 55 cm) from Torch Lake have much higher (up to 3-fold) Hg concentrations than do comparably sized fish from Portage Lake and Huron Bay. Only in 2007 and 2013 were such large walleye captured in Torch Lake; the MDEQ's previous comparison was based on smaller fish. This comparison can only be made for walleye; white sucker, northern pike and small mouth bass have not been routinely captured in the reference lakes, so no comparison is possible for those fish. Clearly, the fish consumption advisory for large walleye must be more restrictive in Torch Lake than in the reference lakes.

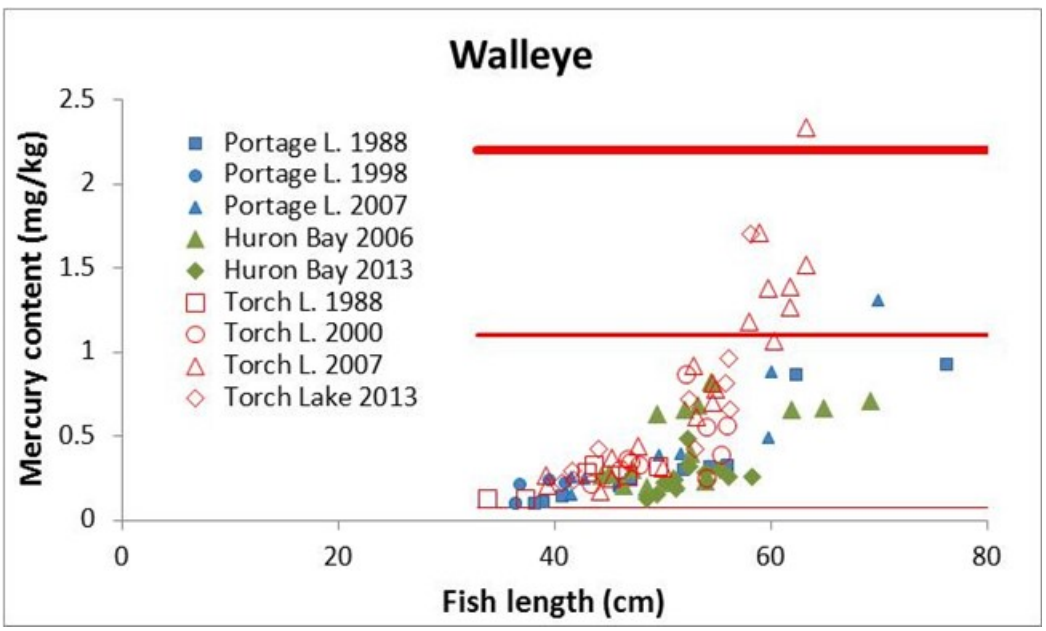


Figure 7-15. Comparison of fish Hg in Torch L. with reference lakes. Large walleye in Torch Lake have higher Hg concentrations than comparably large fish in Portage Lake and Huron Bay.

There is certainly room for discussion as to whether or not Portage Lake and Huron Bay are appropriate reference lakes for Torch Lake. To an even greater extent than PCBs, Hg biomagnification in lakes is affected by lake and watershed characteristics. In particular, methyl mercury concentrations in lakes (and hence in fish) are strongly affected by the amount of wetlands in the catchment, the oxygen concentration in bottom waters, the lake pH, and the lake trophic state (Chen et al., 2005; Clayden et al., 2014; Clayden et al., 2013; Dennis et al., 2005). Arguably, none of these factors are comparable among the three lakes.

There is no evidence of any systematic change in fish Hg concentrations in Torch Lake between 1988 and 2013. Such a change over time would be seen in Fig. 7-15 as successively darker points lying either above or below lighter shaded points. For small mouth bass, the data suggest that concentrations of Hg have increased. The slope of a linear regression of fish length vs. fish Hg increased from 0.037 $\pm$ 0.024 to 0.054 $\pm$ 0.022 ppm Hg per cm of fish (slope $\pm$ 95% Confidence Interval), but, while the correlations are statistically significant ($p < 0.05$), the slopes are not statistically different from each other. For walleye and northern pike, the size classes of fish that were captured each year varied, but there is no clear systematic change in fish Hg concentrations. Clearly, fish Hg concentrations do change with fish size; managing fish contaminant concentrations by managing fish size (fishing pressure, stocking rate) is one option that has not been explored to date.

7-6e. Mercury mass balance and cycling model

A mass balance may be used to identify the major sources of a substance to a lake. Strictly speaking, a mass balance is not required; one need only compare the relative magnitudes of inputs to evaluate whether mining was and is a major contributor of Hg to the lake. There is always considerable uncertainty in estimating the magnitudes of inputs. A complete mass balance (comparison of inputs, outputs, and changes within the system) allows evaluation of the accuracy of flux estimations: if the budget is accurate, the difference between inputs and outputs must equal the rate of storage within the lake.

A preliminary mass balance for Hg in Torch Lake (Fig. 7-16) indicates that mining may contribute substantially to the inventory of total mercury in the lake. The values compiled in this figure indicate that much more mercury is leaving the lake than is entering it with the major sink being burial in sediments. Such a mass imbalance is not possible; average annual inputs must equal average annual outputs because the mass of mercury in the lake water is small. While all of the numbers used in the mass balance have considerable uncertainty about them, the conclusion that either inputs were underestimated or outputs were overestimated is unavoidable. Atmospheric deposition is fairly well quantified for the region (Knauer et al., 2011), so this input is unlikely to be underestimated. An underestimation of inputs might result from use of summer concentrations of mercury in rivers to estimate annual fluxes. In spring when river flow is highest, mercury discharge from mines is also likely at its highest, and retention of mercury within streams and wetlands is at its lowest. In spring, it is likely that nearly the entire discharge from mines flows into the lake, and the snow melt will also be flushing mercury out of wetlands and forests. Mercury concentrations have been well mapped in the lake, so it is unlikely that accumulation within the sediments was greatly overestimated. Evasion of elemental mercury from the lake has not been measured, and hence the accuracy of model estimates is not known, but the value compares well with estimates for other lakes (Fitzgerald et al., 1994; Fitzgerald et al., 1991). The mass balance indicates that mining discharges may contribute a substantial fraction (more than half) of the total input to the lake.

The mass balance for mercury cannot quantify all of the potential inputs of mercury from mining. Potential inputs of mercury to the lake from mining include: drainage from mines; release of legacy deposition (i.e., Hg deposited in locals soils from smelter emissions and coal combustion during the mining era) from wetlands and forest soils in the catchment; release from tailings on the shoreline, within the lake, and within the catchment; and release from coal ash that was dumped into the lake together with the mine tailings. High chloride concentrations in Torch Lake were documented to result from pumping and drainage of brines from mines (MDEQ, 2002; Spain and Andrews, 1970; Yanko, 1969); high Hg concentrations (130-310 ng/L) are known to occur in those mine discharges (Degraeve and McCauley, 2003), but we still do not know how much of the Hg from mine discharges is transported to the lake vs. retained within the stream. Concentrations of mercury have been measured infrequently in the lake water and in the major tributary, the Traprock River, so two of the largest fluxes in the mass balance remain poorly characterized. Release of mercury from mine tailings and subsequent methylation have been well documented in other mining areas (e.g., Blum et al., 2001; Navarro et al., 2009; Pizarro-Barraza et al., 2014), but no measurements have been made in the Keweenaw area. Restoration activities in Scales and Kearsarge Creeks were shown to reduce the release of copper from tailings in the basin, but effects on mercury mobilization were not measured. Much of the copper in surface sediments of Torch Lake is brought there by diffusion from deeper in the sediment; whether any mercury is transported via diffusion remains unknown. Although mobility of mercury has been documented to be limited in lake sediments (e.g., Feyte et al., 2012; Suchanek et al., 2008), that limited mobility results from interactions with organic matter and sulfide (Beck and Johnson, 2014; Schartup et al., 2014), both of which are in very low abundance in the mine tailings that are the major constituent of Torch Lake "sediments". In short, it is the absence of measurements that prevents us from assessing accurately the effects of mining on mercury contamination in Torch Lake fish.

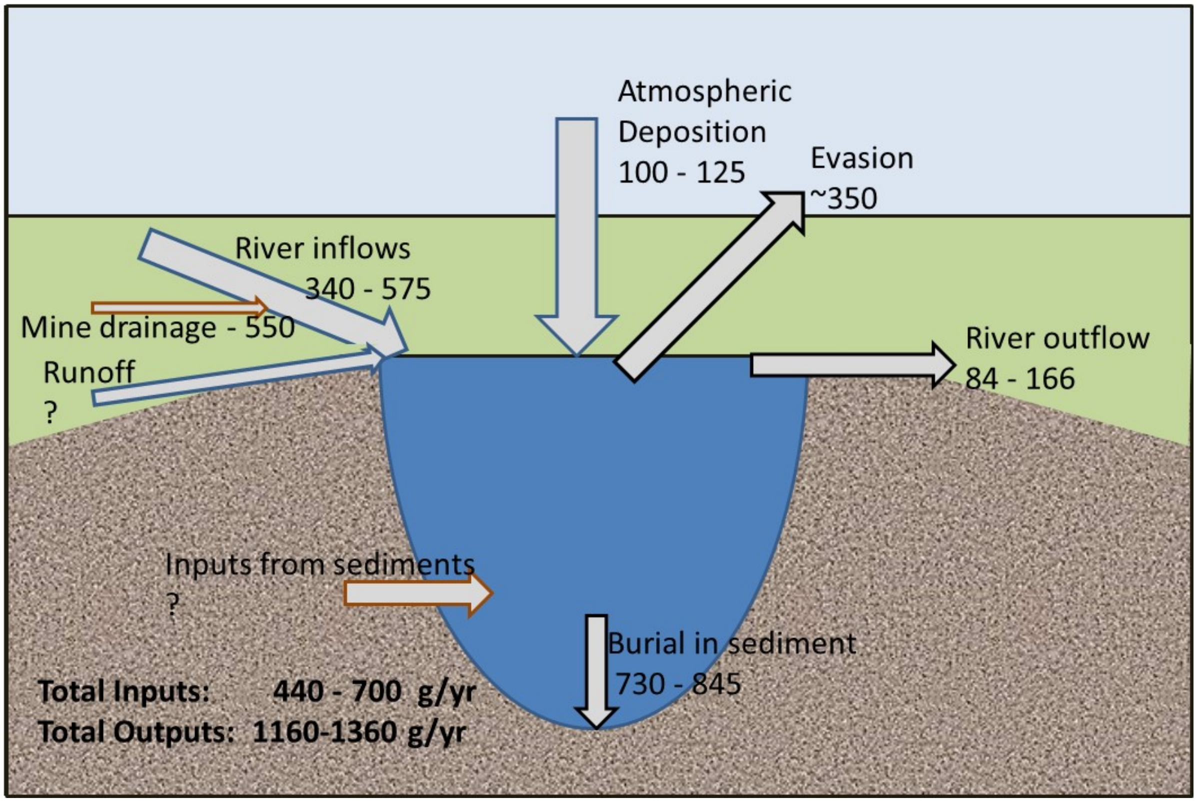


Figure 7-16. Schematic of mercury flows into and out of Torch Lake. All fluxes are in g Hg/yr. Burial fluxes are taken from Kerfoot et al. (2016). Atmospheric deposition to the lake is taken from Drevnick et al. 2012. Mine drainage inputs are from the 2002 survey of mine drainages (Degraeve and McCauley, 2003). River inflows are estimated as a fraction (25%) of annual atmospheric deposition to the catchment or as measured concentration times measured flow. Outflow was calculated as measured concentration range (Degraeve and McCauley, 2003) times lake outflow, and evasion was estimated from application of a simulation model of the mercury cycle in the lake.

The complexity of the biogeochemical cycle of mercury (Fig. 7-17) illustrates why total fluxes of mercury into and out of Torch Lake are not necessarily the factor controlling mercury concentrations in fish. It is primarily methylmercury (MeHg) that is bioaccumulated in fish, and hence it is the factors controlling the production, destruction, and abundance of MeHg that impact concentrations in fish. Previous studies have shown that the abundance of MeHg in lakes is affected by the areal extent of wetlands in the catchment, by the degree of anoxia in lake bottom waters, by lake pH, and by the abundance of dissolved organic carbon (DOC) in the lake. The bottom waters of Torch Lake are oxic year-round which acts to reduce methylation in the lake. Similarly, the lake pH of 7.6 renders it less susceptible to MeHg accumulation. However, the abundance of wetlands in the catchment (13% of catchment area) and the resultant high DOC in the lake (8-12 mg/L) likely result in large inputs of MeHg to the lake. There have been no measurements of MeHg inputs to the lake or of processes creating and destroying MeHg in the lake. Hence, the importance of lake and catchment characteristics relative to mining activities in causing high fish mercury concentrations remains unclear.

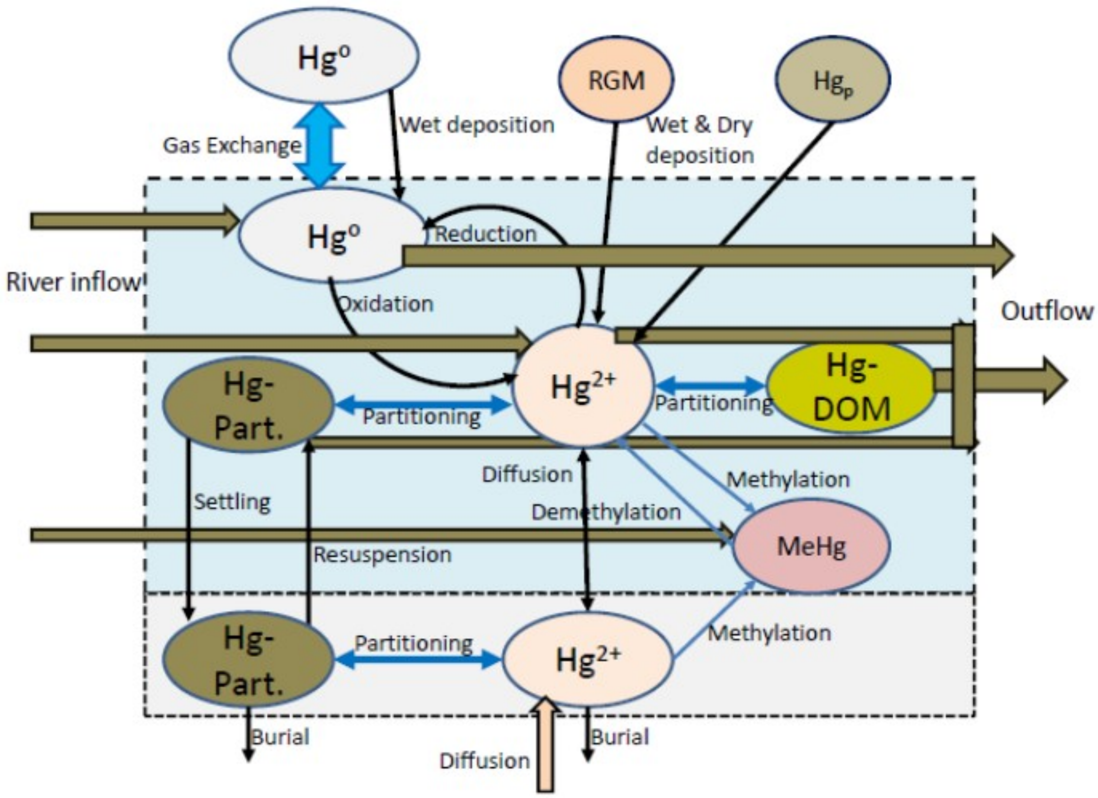


Figure 7-17. Schematic of mercury cycle within a lake. Mercury occurs in two oxidation states (elemental, Hg^0, and oxidized, Hg^{2+}). In the atmosphere Hg^{2+} exists as reactive gaseous mercury (RGM) or bound on particles (Hg_p). In the lake, Hg^{2+} may bind to particulates (Hg-Part) or to dissolved organic matter (Hg-DOM). The toxic form of concern is methyl mercury (MeHg).

Chapter 8. BUI 3: Degradation of the Benthos

8-1. Summary and Recommendations

The toxicity of Torch Lake sediments has been clearly documented; the toxicity most likely results from the high concentrations of copper present in the mine tailings that are found throughout the entire lake area. Sediment traps have shown that erosion of the stamp sand piles around the lake edge are not the source of copper to the sediments. The copper budget for the lake strongly suggests that diffusion of copper upwards from the mine tailings in the sediments is responsible for high metal concentrations in surface sediments. Natural attenuation is predicted to require hundreds of years to mitigate this toxicity. Proof of the source of metals in the surface sediments could be obtained by measurement of diffusive fluxes using porewater equilibrators or benthic chambers. Strategic capping of littoral sediments could be used to enhance populations of benthic organisms, enhance fish spawning success, and increase habitat for juvenile fish.

8-2. Historical Developments: Problem Awareness and Definition

One of the most widely known facts about Torch Lake is that a very large mass of stamp sands was deposited in the lake. Documents from 1970 onward (e.g., MDEQ, 2007a; MDNR, 1970, 1987b; U.S.EPA, 1994, 2001) state that 20% of the lake volume was filled by the dumping of more than 200 million tons of stamp sands into the lake. The original document from which the estimate of 20% was derived, however, makes clear that 20% of the volume was filled between 1946 and 1970, and that the total volume filled between 1845 and 1970 was much greater (MDNR, 1970). Not until a thorough bathymetric survey was performed in 1990 and compared with the bathymetry in the NOAA 1865 (pre-mining) navigation chart, was an accurate estimate made of the total volume of the lake that had been filled. The Remedial Investigation Report (U.S.EPA, 1992e) reported that 51% of the lake volume was filled with stamp sands, 20% of the area of the lake was lost, and the mean depth decreased from 21 m to 12.6 m. This chapter addresses the biological effects of this massive dumping of stamp sands into the lake.

One of the first recorded biological surveys of Torch Lake (Massey, 1970) reported that the benthic community was severely degraded, and that this probably restricted fish production in the lake. Specifically, the author reported:

> "Benthic macroinvertebrates were extremely low in both numbers of species and individuals and consisted primarily of a single species of tolerant midge. The benthic community reflects an early

stage of redevelopment and does not appear to play a vital role in the existing food chain in Torch Lake."

The depauperate benthic community was attributed to high and toxic copper concentrations in the sediments and interstitial pore waters. This report found that the algal community, while diverse, was less dense than the nutrients would allow, possibly as a result of copper toxicity. Nevertheless, the fish community (17 species reported) was found to be diverse, and was presumed to be supported by a pelagic (i.e., water column rather than sediment or benthic) food web.

Since this initial investigation, the degradation of the benthic community in Torch Lake has been repeatedly documented. The implications of this degradation for the lake ecosystem have been speculated to include reduced fish production, reduced mineralization of organic matter and reduced nutrient cycling (U.S.EPA, 1992d). Studies documenting the benthos degradation are summarized below. Equally well documented is the toxicity of the sediments of the lake; the historical sequence of studies on this topic also is reviewed below.

8-2a. Documentation of degradation of the benthos

Monitoring of the benthic community in Torch Lake has been almost as sparse as the community itself. Only four times in the past 45 years has the benthic community been surveyed in a quantitative fashion (Table 8-1). Each of the four surveys has reported that organisms are few, that diversity is low, and that the taxa present indicate degraded habitat conditions. Never has there been a detailed comparison of the benthic community in Torch Lake with that in a non-impacted lake of comparable size. The Ecological Assessment Report (U.S.EPA, 1992d) does provide quantitative enumeration of organism types and abundances in degraded and non-degraded areas of the Keweenaw Waterway taken from the thesis of Sypniewski (1977), but none of those samples were taken from Torch Lake. Comparison of the results from the Baseline Study (U.S.EPA, 2001) with those presented in the Ecological Assessment clearly show that the benthic community in Torch Lake is very limited in organism abundance and diversity relative to unimpacted areas in the southern portion of the Keweenaw Waterway. No quantitative surveys have been performed since the Baseline Assessment, so no evidence exists as to whether the health of the benthos is improving.

Table 8-1. Summary of surveys of the benthic community of Torch Lake.

Year	Organisms	Comments	Document
1968-69	Midge (families *Tendipes, Pentaeura*); Biting midge (*Ceriatopogonidae*); Snail (*Amnicola*)	Organisms sparse; 1-2 types at each site; locations pictorially recorded.	(Yanko, 1969)
1970	Midge (*Procladius culiciformis)*	Organisms sparse; single taxon present at 13 of 26 sites; organisms most abundant (up to 172/m^2) by mouth of Traprock R.; 1-6 taxa per site; locations not recorded.	(Massey, 1970)
1972	Biting midge (*Ceriatopogonidae*)	Animals rare; only biting midge found; locations not recorded.	(Wright et al., 1973)
1999/2000	Chironomids; Oligochaetes; Polychaetes; Snails	Diversity (1-15 taxa/site, mean 4) and abundance (1-205 organisms/site, mean 38) were low; taxa indicated degraded habitat; locations recorded.	(U.S.EPA, 2001)

8-2b. Documentation of sediment toxicity

The first documentation of the toxicity of the mine tailings in sediments was indirect. A series of papers by MTU researchers documented a reduction in sediment faunal populations in nearshore Lake Superior and the Keweenaw Waterway (of which Torch Lake is a part) and attributed the patterns to high copper concentrations due to the presence of mine tailings (Kraft, 1979; Kraft and Sypniewski, 1981; Sypniewski, 1977). Reduced abundance and species richness of benthic organisms were observed down to copper concentrations of ~200 mg/kg. These studies were later cited in support of the argument for copper toxicity in the sediments of Torch Lake.

It is not only the benthic macrofauna that is impacted by sediment toxicity, but also the microflora of the sediments. In the next study of Torch Lake sediment toxicity, Sabol (1981) experimentally demonstrated the inhibition of bacterial respiration rates in Torch Lake sediment slurries. This study used microorganisms from Torch Lake and elsewhere to demonstrate that the microflora in the lake was not "immune" to the toxicity. Acid-leaching of the sediment reduced the toxicity suggesting that metals in the sediment were responsible. While microbial activity in the sediment was shown to be inhibited by unidentified toxins, the areal rate of oxygen consumption in the hypolimnion was found not to be greatly reduced relative to other lakes.

A U.S.EPA study contrasted the toxicity of Torch Lake sediments with that at two other metal-contaminated sites (Malueg et al., 1984). This study used conventional toxicity assays with Daphnia and mayfly larvae; the zooplankton were suspended in water above the sediments, and the mayfly larvae were placed directly in the sediments (see also Malueg et al., 1983). Daphnia mortality was extremely high (97-100%); copper concentrations in the water were in the range of 600-1200 μg/L. Mortality of mayfly larvae, while lower (40%), was much higher than in controls (7%); copper concentrations in the sediments were 1800 mg/kg. The abundance (14-230/m^2) and diversity (1-4 taxa) of organisms in Torch Lake sediments also were reported to be low. This and the previous studies would seem to indicate a more significant level of sediment toxicity than that reported in 1987 by the Michigan Dept. of Natural Resources (MDNR, 1987c):

> "The only component of this ecosystem seriously impacted by the copper ore tailings in the lake is the benthic macroinvertebrates. Sediments are *somewhat* toxic but the phytoplankton, zooplankton and fish communities are indicative of good water quality and meso-oligotrophic conditions."

Subsequently, multiple studies also documented the toxicity of Torch Lake and Keweenaw Waterway sediments to a variety of test organisms including *Photobacterium phosphoreum* (Cusack and Mihelcic, 1999a), *Hyalella azteca* (amphipod, Ankley et al., 1993a), *Chironomus tentans* (midge larvae) and *Lumbriculus variegate* (segmented worms, West et al., 1993), *Ceriodaphnia* (zooplankton) and *Pimephales promelas* (fathead minnow) (Charters, 1991). The EPA's Baseline Study also measured toxicity using standardized test conditions (10-day exposure) with *Hyalella azteca* and *Chironomus tentans*; survival rates for amphipods averaged 37 $\pm$ 13 % (mean $\pm$ 95% CI) with a range of 0-100% while survival for midge larvae was 32 $\pm$ 14 % with a range of 0-96%.

One of the oversights that has occurred in the study of this site has been the failure to adequately evaluate the effect of the mine tailings on fish reproduction. Evans (MDNR, 1990) noted that after initiation of stocking, the abundance of walleye > 38 cm increased dramatically from ~0% to 16% of all walleye; these data may indicate that no successful spawning occurs in the lake. Trace metal concentrations are highly elevated in sediment pore waters relative to lake water (e.g., Cusack and Mihelcic, 1999a; Warburton, 1987), and hence fish eggs as well as benthic macroinvertebrates and resting eggs of zooplankton are particularly susceptible to the contaminated sediments in Torch Lake. The only study to examine effects on fish reproduction in Torch Lake incubated perch eggs with Torch Lake water (Baumann et al., 1990); while this study did find the time to hatching to be longer in Torch Lake than in control sites, the effects of sediment contamination were likely underestimated because of the failure to include sediments. A second direct impact of the stampsands on fish spawning is the paucity of nearshore macrophyte beds and wetlands that would be suitable for spawning of some fish types. The lack of macrophytes and wetlands was detailed in the ecological assessment (U.S.EPA, 1992d) and the RI/FS study (U.S.EPA, 1992e), but implications for fish spawning have never been quantified.

8-3. History of Regulatory Responses

The regulatory response to the degraded benthic habitat and community has been to do nothing. The sparse benthic surveys and the more ample measures of sediment toxicity were enough to convince the IJC to recommend that the MDNR include Degradation of the Benthos among the BUIs in the RAP for the Torch Lake AOC. However, even in that document, the state officials clearly expressed the opinion that the magnitude of the problem was so immense that nothing could be done except to allow the lake to heal itself (MDNR, 1987b):

> "Given the wide distribution and large volumes of tailings deposited in Torch Lake, Portage Lake and Lake Superior, no other remedial actions to improve the benthic community have been considered nor do any seem feasible, practical or necessary. Natural transport, deposition and burial of these copper tailings appear to be the best way to proceed as this valuable aquatic ecosystem continues to recover from past activities."

The conclusion that nothing could possibly be done to ameliorate the situation has pervaded every official investigation (U.S.EPA, 1994) to the extent that no other alternatives besides doing nothing have ever been considered.

In the Records of Decisions (U.S.EPA, 1992c, 1994) it was stated that, because recovery of Operable Unit II (OU II) depended in part on the remedies employed for Operable Unit I (OU I), that an effectiveness assessment would be performed as part of the O&M routine monitoring for OU I. As part of their O&M activities MDEQ contracted with researchers at MTU to evaluate the sedimentation rate in Torch Lake; that study quantified the sedimentation rate in the lake (McDonald and Urban, 2007) and, because the sedimentation is slow, predicted that it would require 800 years for enough sediment to accumulate to slow diffusion of copper out of the stamp sands adequately to prevent surface sediments from being toxic to biota (Kerfoot et al., 2008). The MDEQ further assessed the effectiveness of remediation of OU I by contracting with Great Lakes Environmental Center (GLEC) to have multiple sediment traps installed throughout the lake to measure rates of sediment deposition (Barkach and McCauley, 2006). The sediment traps revealed that sediment deposition rates were slightly higher on the western side of the lake, and that the rates agreed well with the sediment accumulation rates measured by MTU (McDonald et al., 2009). Copper concentrations in sediment trap material were lower than concentrations in surface sediments, thus providing strong evidence that shoreline erosion is not the major source of copper to surface sediments.

While the Baseline Study (U.S.EPA, 2001) did thoroughly characterize the extent of the benthos degradation in order to provide a benchmark against which future changes could be assessed, no benthic surveys have been performed in the 15 years since that study such that no quantitative information exists as to whether the benthos is improving, degrading, or remaining the same. The first and second 5-year Reports reiterated that perceived obligation and stated that an assessment would be performed soon. However, the third 5-year report stated that no effectiveness assessment was required because no remediation for OU II had been performed.

8-4. Requirements for and Headway towards Delisting

The State of Michigan's guidelines for delisting of BUIs recommends that specific criteria be applied to evaluate each BUI. For the Degradation of the Benthos BUI, the guidelines are not based on mitigation or elimination of the problem, but only on completion of planned remedial actions. Specifically, the guidelines state (MDEQ, 2008a):

> "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. Remedial actions and monitoring are conducted under authority of state and federal programs, such as the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund), Resource Conservation and Recovery Act, Great Lakes Legacy Act, or Part 201 of Michigan's National Resource and Environmental Protection Act (NREPA) of 1994."

These guidelines can be construed to indicate that no further actions need be taken at Torch Lake to restore the benthos. The remedial actions planned under CERCLA provisions for this site were the capping of stamp sands in OU I, and the monitoring of those caps. The EPA has clarified in the third 5-year report that no monitoring of the benthos is required to assess the effectiveness of the remedies for either OU I or OU II. According to the State's guidelines, successful improvement of the benthos as a result of the remediation is not a requirement for delisting.

The State's current guidelines are a significant departure from the original guidelines for delisting of the Degradation of the Benthos BUI. According to the IJC's website for Annex 2 of the Great Lakes Water Quality Agreement (http://www.ijc.org/rel/boards/annex2/buis.htm#table1 last accessed on 3 May 2017) the target was to have been achievement of a benthic community comparable to that in a non-impacted site. Specifically:

> "When the benthic macroinvertebrate community structure does not significantly diverge from unimpacted control sites of comparable physical and chemical characteristics. Further, in the absence of community structure data, this use will be considered restored when toxicity of sediment-associated contaminants is not significantly higher than controls."

Clearly, neither of these criteria (healthy benthic community, absence of sediment toxicity) has been met in Torch Lake.

8-5. Options for the Future based on Understanding the Past

It is striking that nowhere in the 35-year recorded history of remediation efforts at Torch Lake was serious consideration given to any approach to remediation of the lake sediments other than natural attenuation. In EPA documents preceding the Record of Decision for OU II, there was no discussion of any remediation alternatives (U.S.EPA, 1992d, 1994). Much more recently, the EPA did have the Army Corps of Engineers evaluate the potential for capping sediments to reduce toxicity to biota (Acevedo-Acevedo et al., 2014). To understand what options might exist, further information on sediment characteristics throughout the lake is helpful.

Virtually the entire bottom of Torch Lake has been covered with mine tailings except for shallow waters along the eastern shore. Although the launder lines that dumped tailings into the lake did not extend to the eastern shore, waves and currents within the lake carried the fine particles away from the immediate dumping spot and distributed them fairly uniformly throughout the lake. Aerial photographs of the lake taken in 1938 and 1951 revealed high turbidity throughout the entire lake as a result of the suspended fine particles (Fig. 8-1). While the aerial photograph reveals particles being flushed from the lake, particles large enough to settle would be distributed throughout the entire lake.

Figure 8-1. Aerial photograph of Torch Lake taken in May 1951. White appearance of the lake results from fine suspended particles throughout the lake. Only water by the inflow of the Traprock River is clear (shown as black in figure).

The current distribution of stamp sands across the lake bottom has been analyzed by two methods. With acoustic profiling, Trisch and Young (2005) were able to characterize the upper 40 m of sediments. An east-west transect located 0.5 km south of the Lake Linden stamp sand pile shows that 15 m of stamp sands lie beneath 25 m of water at this location (Fig. 8-2). Stamp sand thickness has also been estimated by subtracting present day lake depths as recorded on navigational charts from depths recorded in the 1865 navigational chart. Transects across the lake reveal stamp sand thickness of 5 m in the deepest area of the lake and up to 40-m thickness as shorelines of stamp sand piles are approached (Fig. 8-3). The thickness of the tailings deposit has prevented retrieval of any pre-mining, "natural sediments" from which the presettlement conditions and biota of the lake could be ascertained.

The distribution of metal concentrations in sediments across the lake is reasonably well known. However, the apparent distribution has changed slightly with time as a result of different sampling locations and methods used, and as a result of processes occurring within the lake. The two major surveys that mapped metal concentrations occurred in 1988-1992 (U.S.EPA, 1992f) and in 2001 (U.S.EPA, 2001). Results of both of these surveys were summarized in maps showing the locations of sampling sites and the concentrations relative to established sediment toxicity criteria (Mandelia, 2016).

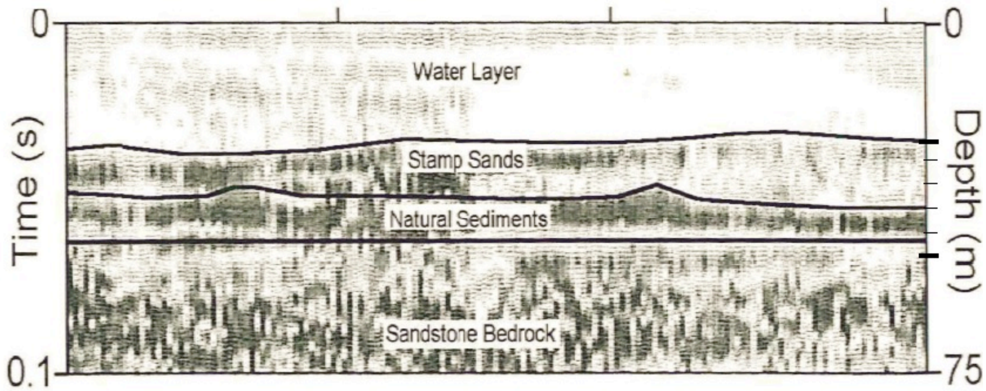


Figure 8-2. Acoustic profile of Torch Lake sediments. Taken from Trisch and Young (2005). Acoustic soundings record the time (left axis) required for sound waves to be reflected back to the transponder. The time of travel of the sound waves corresponds to distance traveled (right axis); sediment layers with different physical properties each cause a reflection. Solid lines have been drawn in the figure to show the inferred divide between water (25-m deep), stamp sands (10-15 m thick), pre-mining sediments (7-15 m thick), and bedrock. The x-axis represents distance across a transect in the lake.

The combined maps of Mandelia are, with the sole exception of mercury, consistent with the metal isopleth maps shown in the Baseline Study (U.S.EPA, 2001). Maps for seven metals (arsenic, cadmium, chromium, copper, lead, mercury, zinc) are shown in Figures 8-4 through 8-10. Copper is the only one of these metals that is present at high concentrations (above the Probable Effects Level, PEC – see definition in Fig. 8-4 caption) throughout the lake. This map suggests that sediment toxicity, also found throughout the lake (Ankley et al., 1993b; Charters, 1991; Cusack and Mihelcic, 1999b; Malueg et al., 1984; Sabol, 1981; U.S.EPA, 2001; West et al., 1993), most likely is due primarily to copper. Arsenic and zinc are at high concentrations through much of the main lake basin, but highest concentrations are found off the Hubbell smelter and coal dock; this distribution suggests both metals were enriched through the smelting process and entered the lake either via dumping of smelter wastes (slag, coal ash) or via atmospheric deposition from the smelter plume. Lead is unique in that concentrations are low (below the Threshold Effects Concentration, TEC) throughout the southern basin and half of the main lake basin but high in the vicinity of the Hubbell smelter and coal dock (Fig. 8-8). This distribution has been interpreted to indicate that lead did not originate in the metal ores, but in the scrap metal shipped to Torch Lake for reclamation (Leddy et al., 1986). A few metals (Cd, Cr, Hg) are present at moderate concentrations (between the PEC and TEC) throughout the lake, probably an indication that they were trace constituents in both the amygdaloid basalt and conglomerate ores.

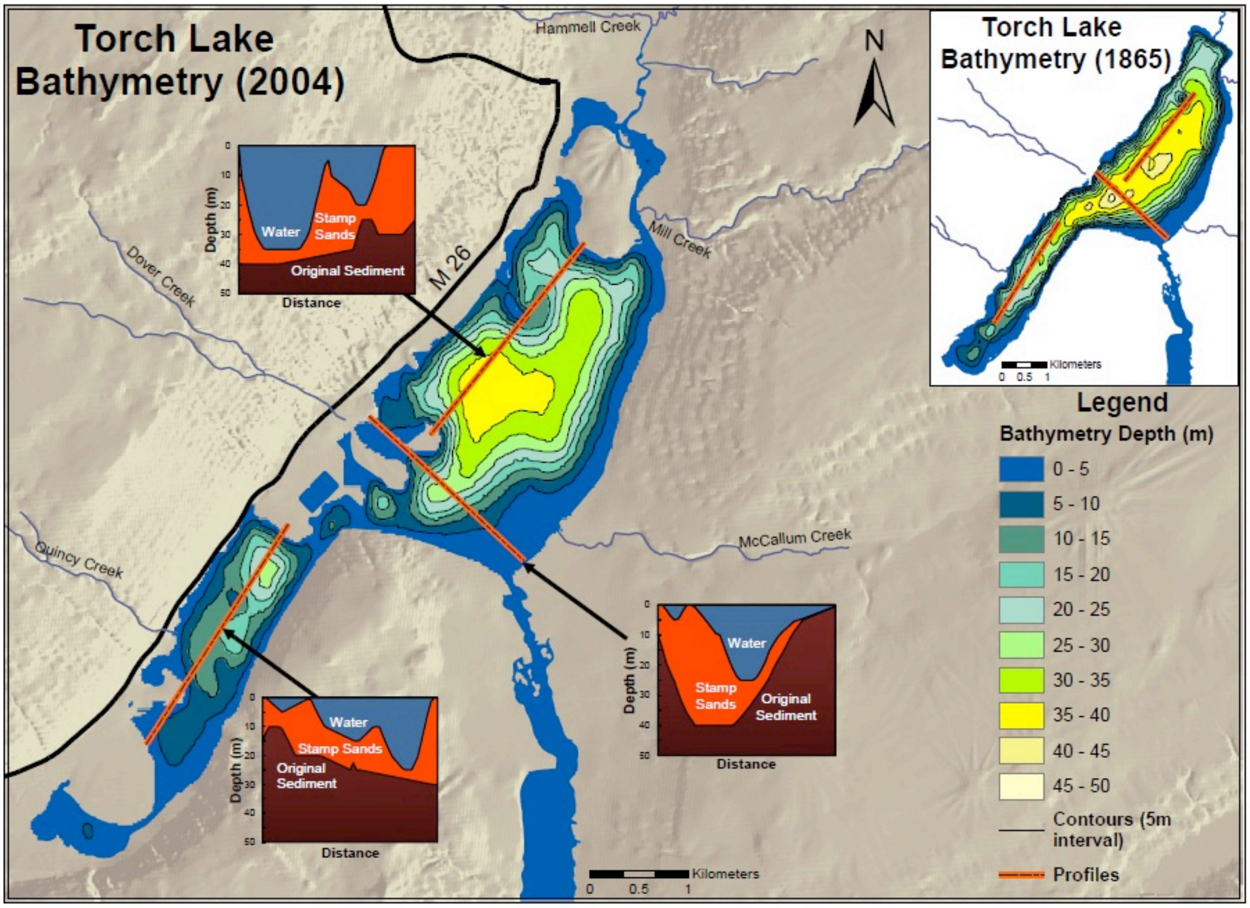


Figure 8-3. Depth of stamp sands in Torch Lake. The original (1865) bathymetry of the lake (inset at upper right) shows a much larger area of deep water than the current (2004) bathymetry indicates. Both bathymetric maps are digitized reproductions of NOAA navigational charts. Comparison of the 1865 and 2004 bathymetries across specific transects of the lake are shown in the small insets; the difference in water depths between the two maps is colored in red and represents the thickness of stamp sand deposits within the lake. The north-south transect in the northern basin indicates that about 5 m of stamp sand underlay the deepest area of the lake. The transect running northwest to southeast indicates that nearly 40 m of stamp sands filled in this formerly deep area of the lake. Subtracting the 2004 lake volume from that in 1865 indicates that 50% of the lake was filled with stamp sands.

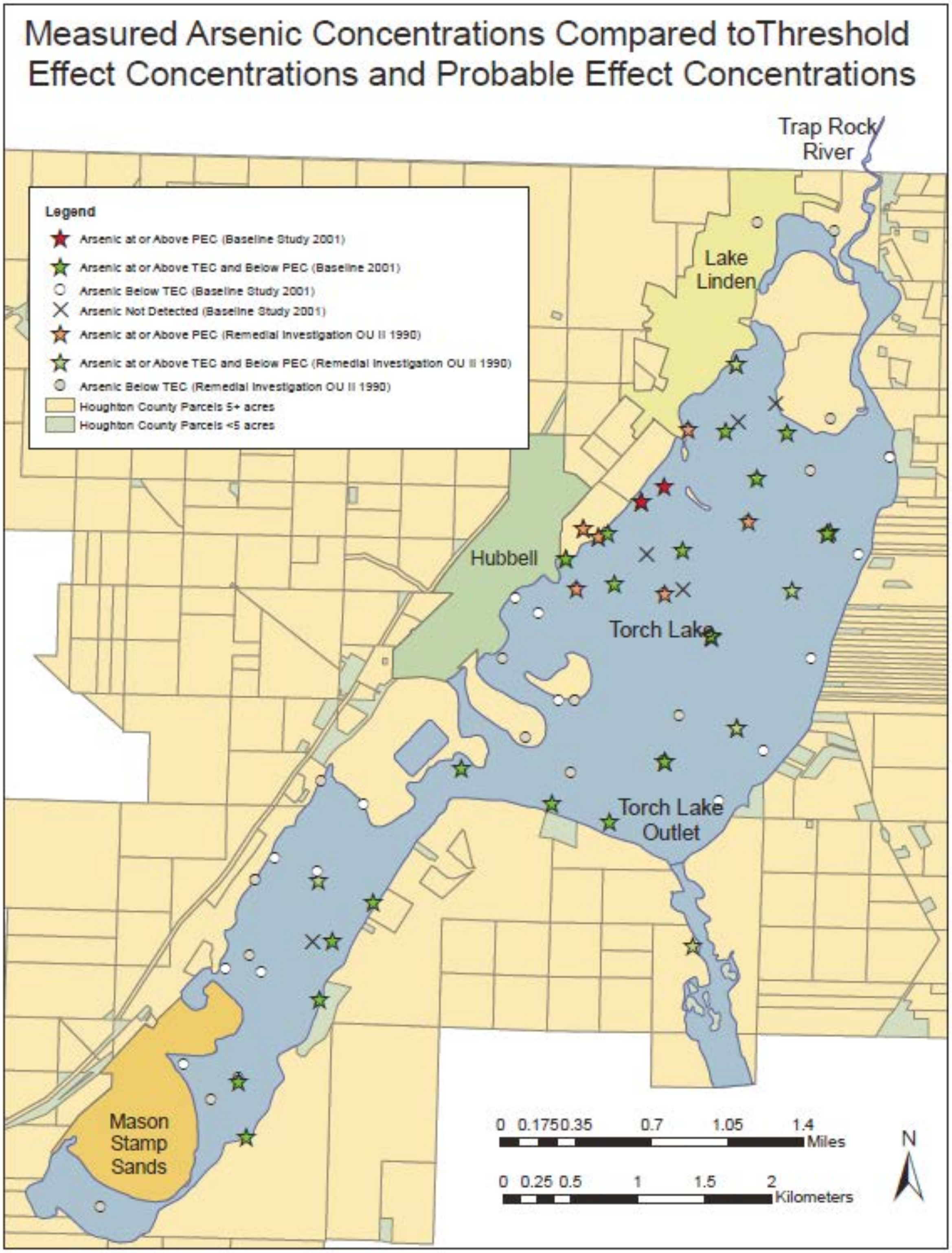


Figure 8-4. Arsenic distribution in Torch Lake sediments. Concentrations are compared to the Probable Effects Concentration or PEC (concentration above which toxic effects are expected to occur frequently) and the Threshold Effects Concentration or TEC (concentration below which toxic effects are expected to occur infrequently). Map reproduced from Mandelia (2016).

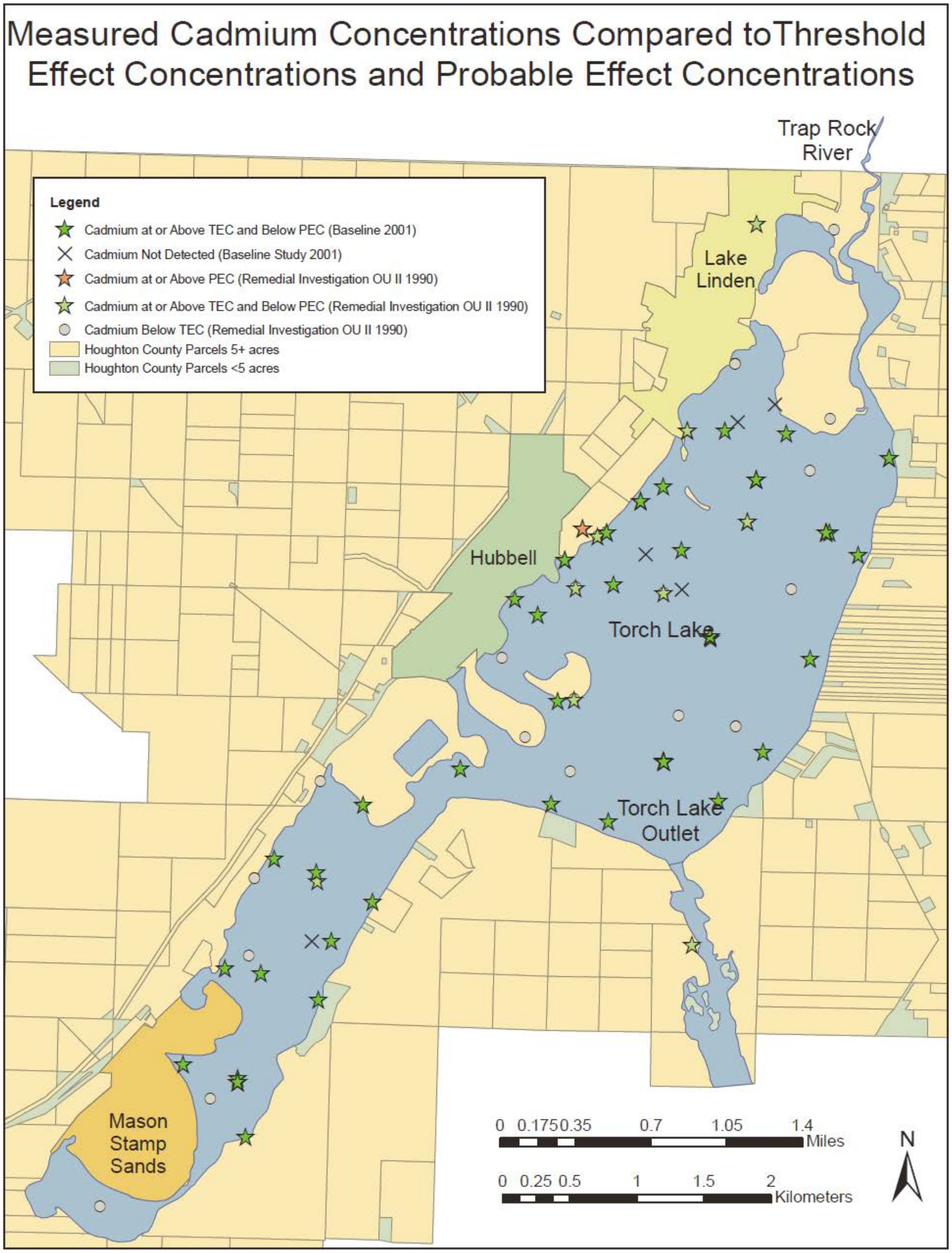


Figure 8-5. Cadmium distribution in Torch Lake sediments. Concentrations are compared to the Probable Effects Concentration or PEC (concentration above which toxic effects are expected to occur frequently) and the Threshold Effects Concentration or TEC (concentration below which toxic effects are expected to occur infrequently). Map reproduced from Mandelia (2016).

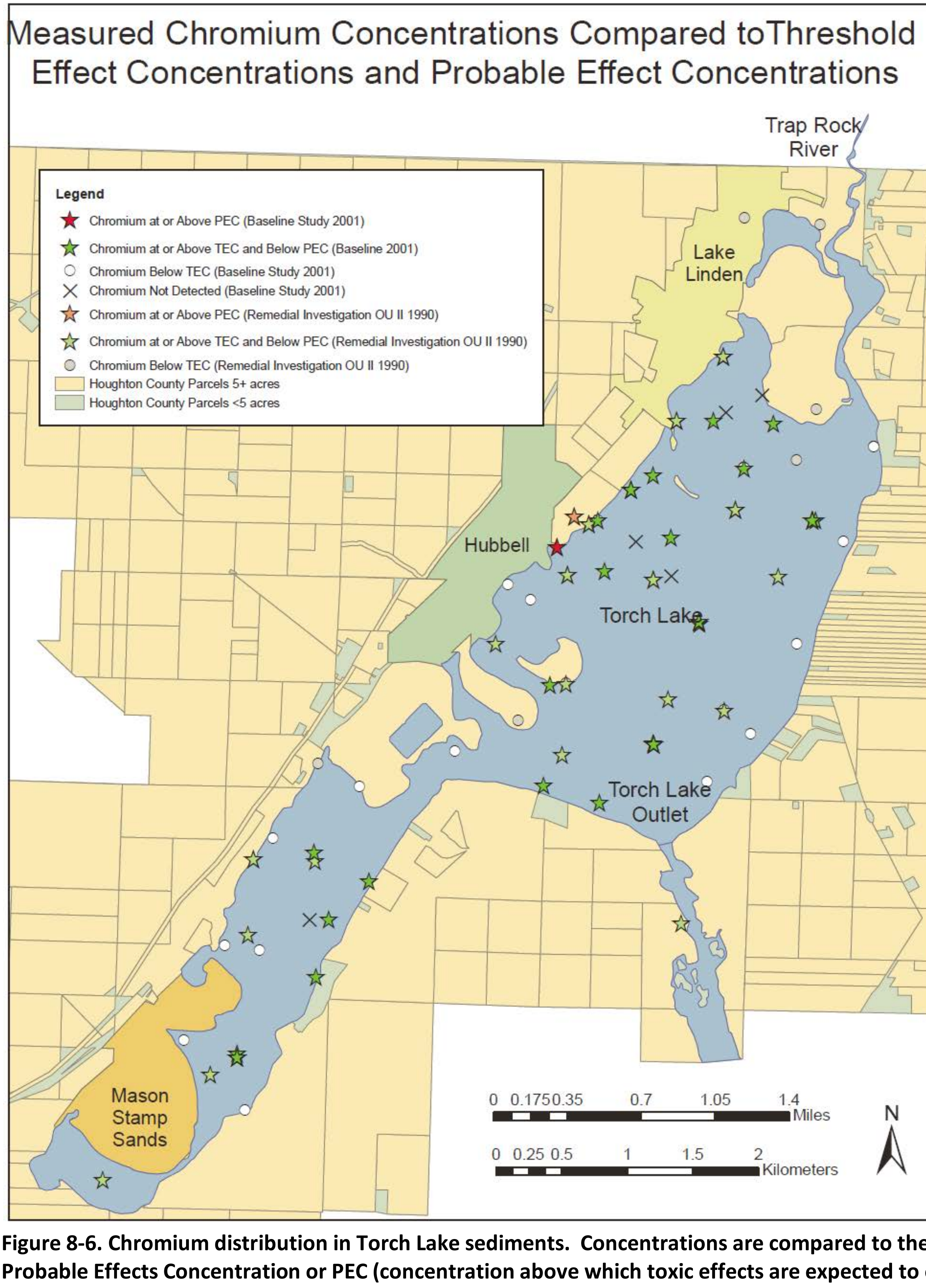


Figure 8-6. Chromium distribution in Torch Lake sediments. Concentrations are compared to the Probable Effects Concentration or PEC (concentration above which toxic effects are expected to occur frequently) and the Threshold Effects Concentration or TEC (concentration below which toxic effects are expected to occur infrequently). Map reproduced from Mandelia (2016).

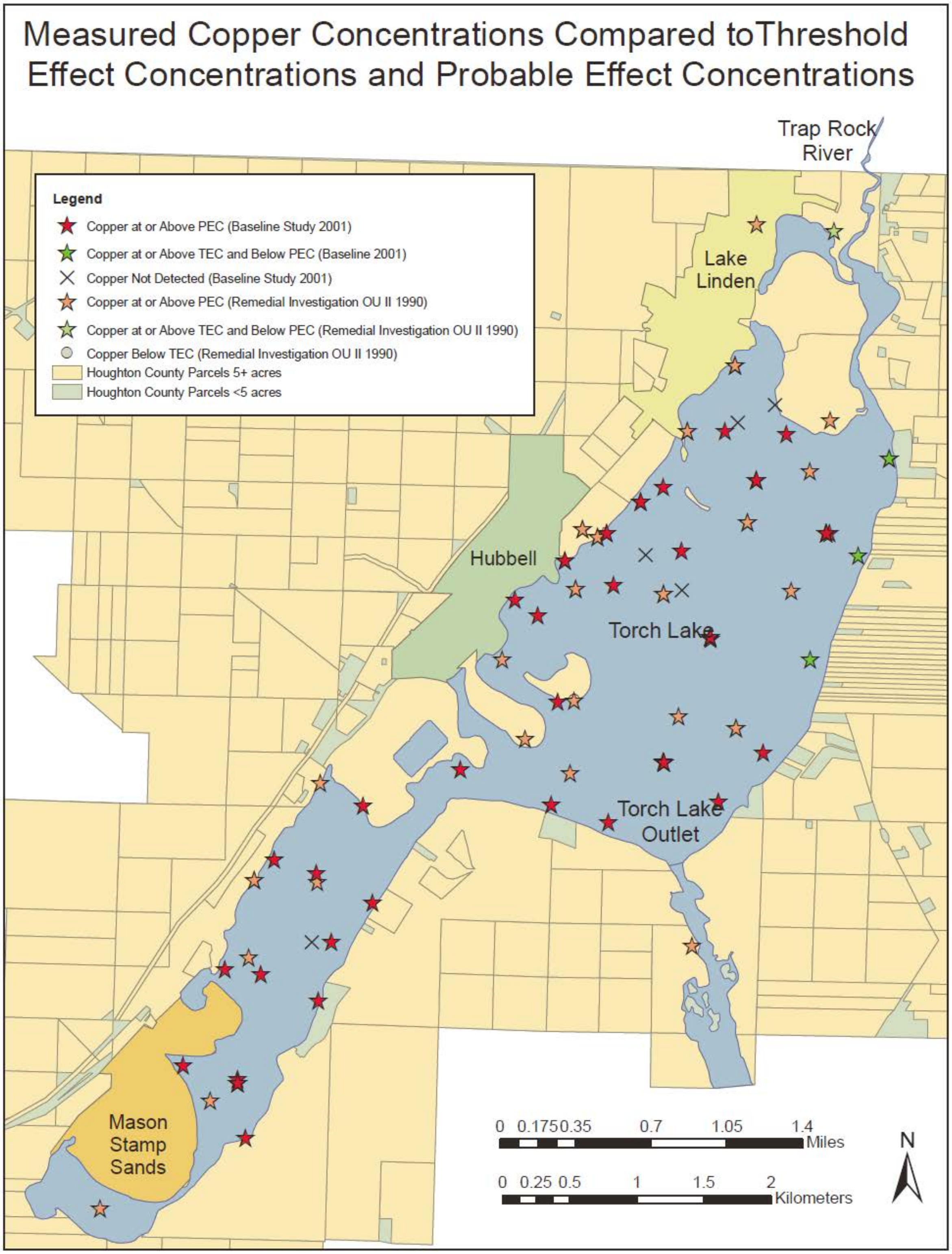


Figure 8-7. Copper distribution in Torch Lake sediments. Concentrations are compared to the Probable Effects Concentration or PEC (concentration above which toxic effects are expected to occur frequently) and the Threshold Effects Concentration or TEC (concentration below which toxic effects are expected to occur infrequently). Map reproduced from Mandelia (2016).

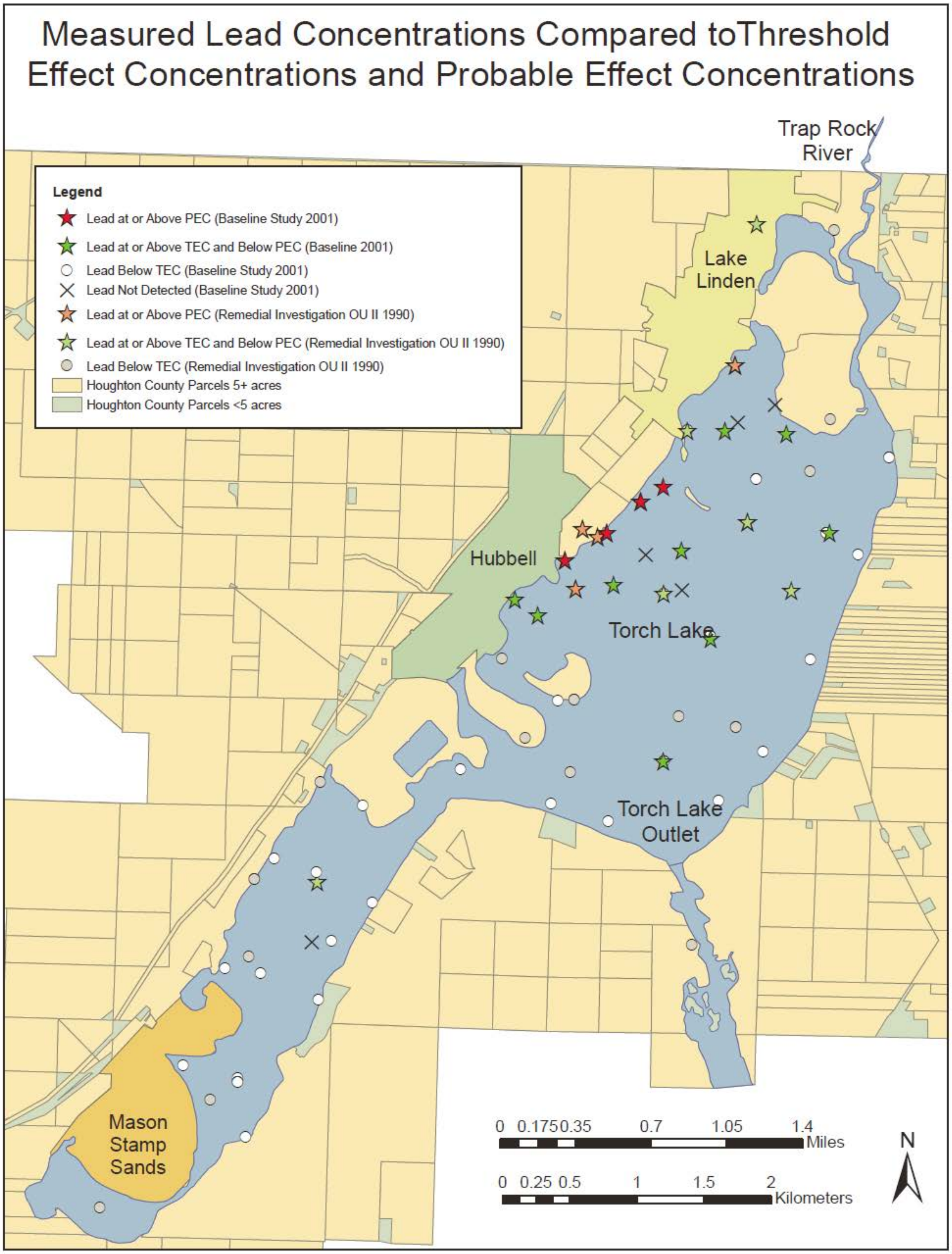


Figure 8-8. Lead distribution in Torch Lake sediments. Concentrations are compared to the Probable Effects Concentration or PEC (concentration above which toxic effects are expected to occur frequently) and the Threshold Effects Concentration or TEC (concentration below which toxic effects are expected to occur infrequently). Map reproduced from Mandelia (2016).

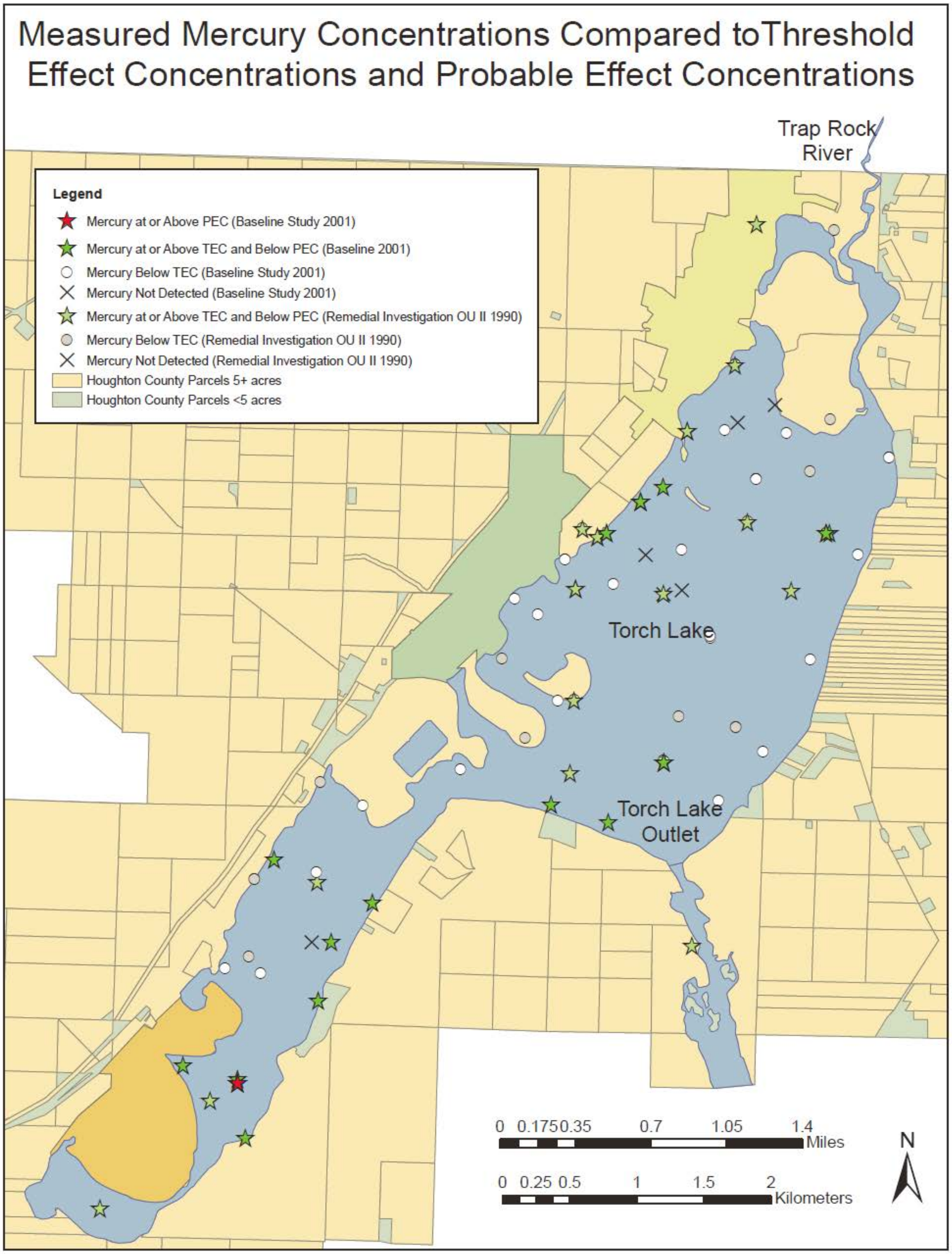


Figure 8-9. Mercury distribution in Torch Lake sediments. Concentrations are compared to the Probable Effects Concentration or PEC (concentration above which toxic effects are expected to occur frequently) and the Threshold Effects Concentration or TEC (concentration below which toxic effects are expected to occur infrequently). Map reproduced from Mandelia (2016).

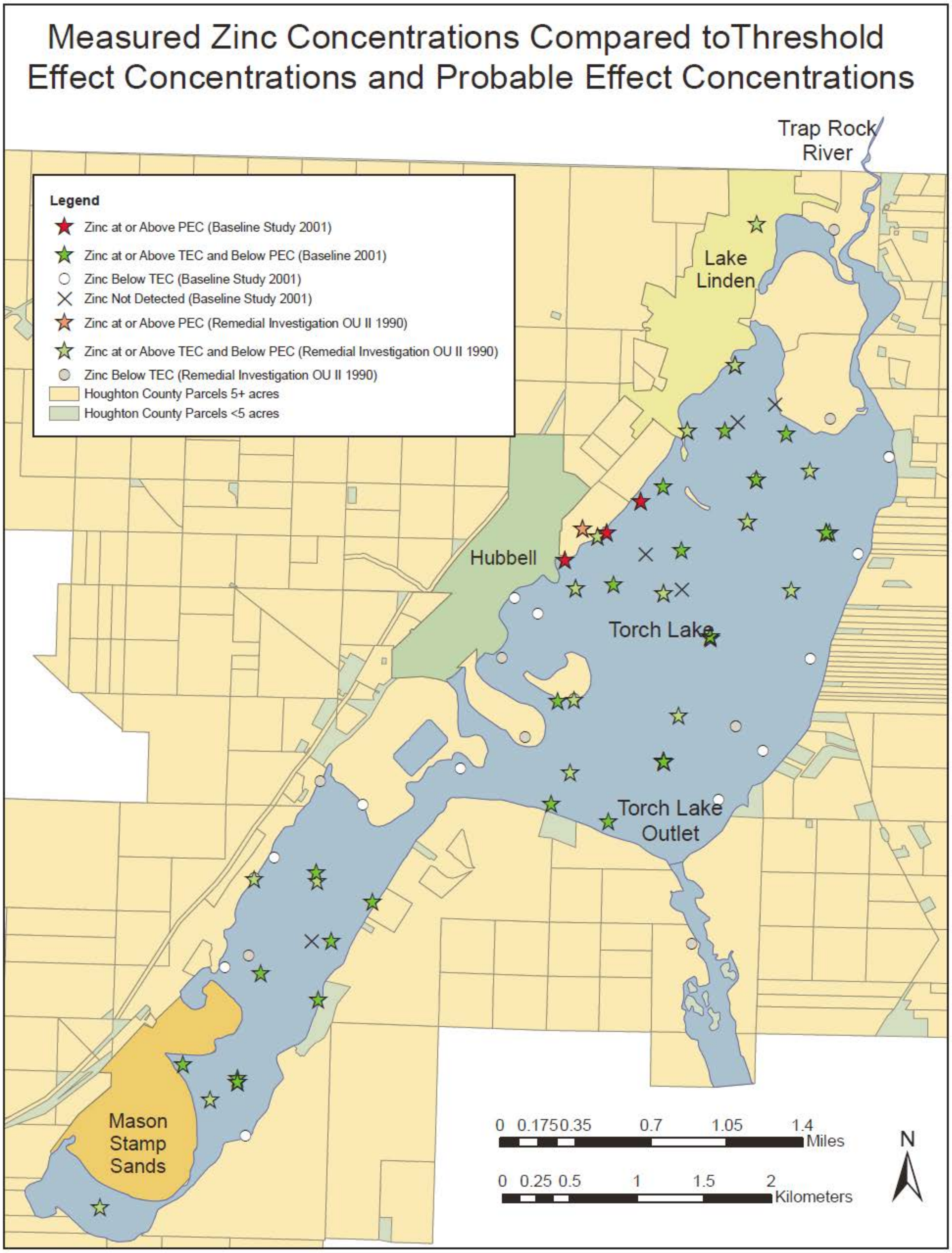
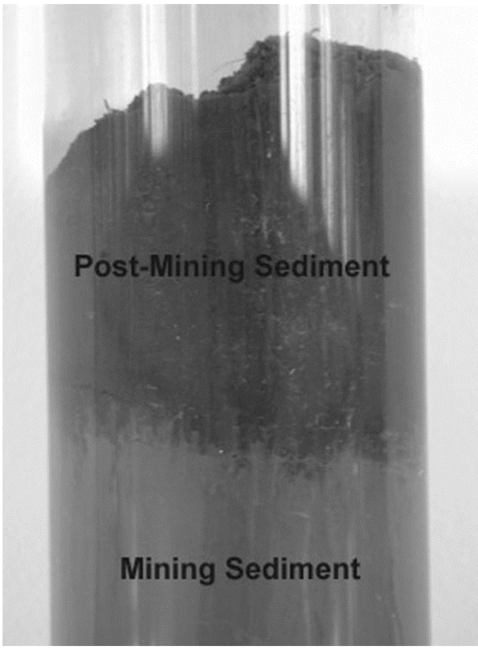


Figure 8-10. Zinc distribution in Torch Lake sediments. Concentrations are compared to the Probable Effects Concentration or PEC (concentration above which toxic effects are expected to occur frequently) and the Threshold Effects Concentration or TEC (concentration below which toxic effects are expected to occur infrequently). Map reproduced from Mandelia (2016).



Across most of the lake, a thin layer of "natural sediment" (see Fig. 8-11) has been deposited since the cessation of ore processing and stamp sand reclamation (1963-1968). The thickness of this layer increases with time, although the increment thickness depends on the location in the lake. The largest increment is in the center of the lake in the deepest water (McDonald et al., 2009). These natural sediments consist of dead algae and riverine sediments eroded from the catchment. It is the accumulation of this fresh sediment on top of the mine tailings that must happen for the sediment toxicity to be attenuated naturally.

Figure 8-11. Photograph of sediment core retrieved in 2004 from 20-m water depth.

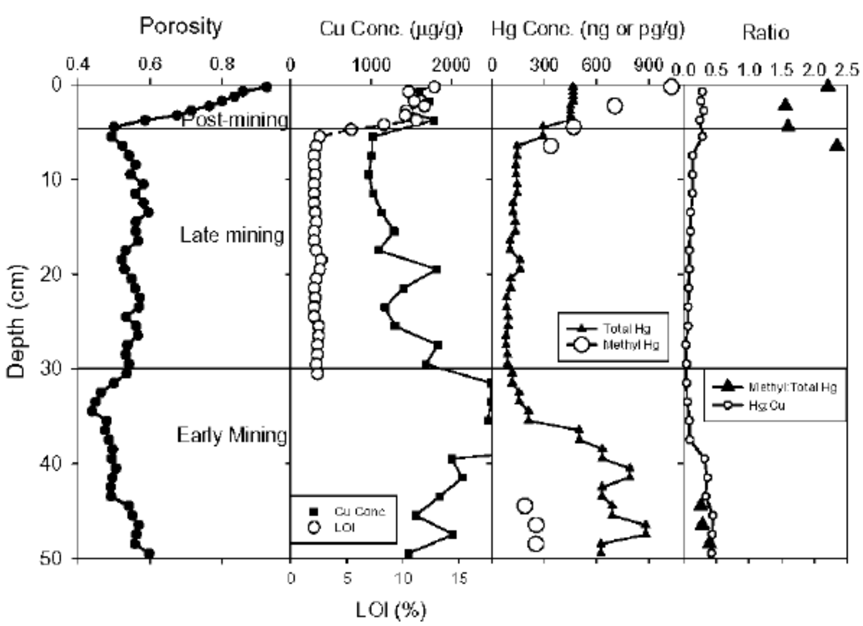


Figure 8-12. . Profiles of porosity, copper, loss-on-ignition (a measure of organic matter content), total and methyl mercury in a sediment core from Torch Lake. Reproduced from Kerfoot et al. (2008).

At present, the "natural attenuation" is not working because the concentration of metals in the new, "natural sediments" is higher than in the underlying stamp sands (Fig. 8-12). The MDEQ has stated that it cannot act until it is known from where the metals in the surface sediments are coming (S. Baker, personal communication.). The possible sources include: (1) erosion of stamp sands from shoreline deposits, a process that should have stopped when the tailings piles were capped; (2) diffusion from the mine residues deeper in the sediments; (3) inputs of copper to the lake via groundwater or river inflows. Sediment trap studies (Barkach and McCauley, 2006) proved that erosion cannot be the major source of copper to surface sediments; copper concentrations are lower in the stamp sand piles and the sediment trap material than in the surface sediments. Modeling of copper diffusion and sorption to natural sediments showed that it would be adequate to explain the elevated copper concentrations (McDonald, 2005) based on porewater profiles of dissolved copper reported by Cusack and Warburton (Cusack and Mihelcic, 1999a; Warburton, 1987). The relative importance of diffusion from sediments and riverine and ground water inputs can be determined from the copper mass balance constructed by Warburton (1987).

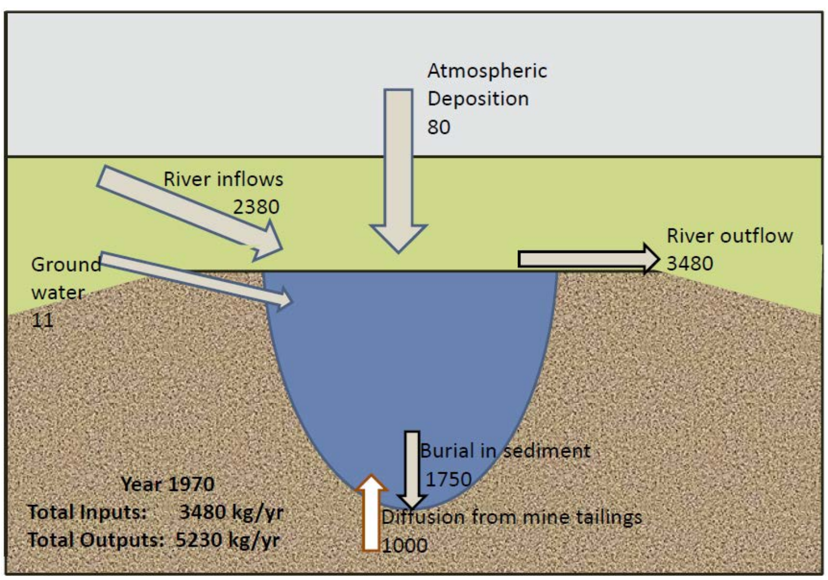


Figure 8-13. Copper Mass Balance for Torch Lake in 1970. All fluxes are in kg/yr. Data from Warburton (1987) are based on measured water flows and copper concentrations. Diffusive flux from McDonald (2005) is based on a mathematical model incorporating diffusion and sorption. Burial flux was based on dated sediment cores.

The copper mass balance for Torch Lake indicates that diffusion from the sediments must be a large source of copper to the lake. The budget for copper flows into and out of Torch Lake shown in Fig. 8-13 appears imbalanced, in part, because most values apply to the 1970s, but the burial term was measured in 2004 (McDonald et al., 2009). The estimated copper flux diffusing out of the sediments into the lake represents about one third of the total input and is ~100 times larger than the rate of copper input via groundwater inflows; while the groundwater input may not be well constrained, it is unlikely to be off by two orders of magnitude. In more recent years, the diffusive flux from the sediment must pass through the recent sediments where much of the copper is sorbed onto the organic matter-rich sediments. While the riverine influx has previously been termed "natural" (MDNR, 1987b), it can readily be shown that this unnaturally large flux results from mining activities in the watershed. Copper concentrations in Keweenaw Peninsula streams unimpacted by mining are typically less than 3 μg/L (Padilla, 2013); the annual flux would be only 110 kg if the Traprock River had only 3 μg/L of copper. The magnitude of the copper outflow from Torch Lake was shown to vary annually and seasonally in response to lake pH (Leddy, 1973; Lopez and Lee, 1977; Warburton, 1987). However, the main point to be seen is that such large outflows are possible only if the sediments are contributing substantial inputs of copper to the lake. The large diffusive flux out of the sediments explains the long time required for recovery of the lake by natural attenuation; the diffusive flux to the surface sediments that causes high and toxic copper concentrations in surface sediments will be stopped only after a thick layer of sediment has accumulated, sediment that traps copper diffusing through it.

8-6. Options for Remediation

If burial of contaminated sediments by natural sedimentation can achieve decontamination of the sediments, then capping of sediments artificially also could probably achieve the same goal. Indeed, sediment capping is a common means of remediating contaminated sediments (Akcil et al., 2015; Choi et al., 2009; Cornelissen et al., 2011; Perelo, 2010; Sparrevik et al., 2011; U.S.EPA, 1998a). The Army Corps of Engineers has already shown in laboratory tests the feasibility of using steel slag and apatite to create reactive caps that retain copper (Acevedo-Acevedo et al., 2014). Because of the large surface area of contaminated sediments in Torch Lake, capping of the entire area would be prohibitively costly. Sediments in deep areas of lakes typically are fine textured and unsuitable for high organism densities because of limitations on oxygen penetration. Capping of these deep areas of the lake would be pointless.

Hence, it is our recommendation that strategic and limited capping of littoral sediments in the lake should be evaluated to ameliorate the degraded benthos, to expand wetland habitats, and to expand areas suitable for fish spawning and habitat. By capping the littoral sediments in proximity to stream mouths, a larger non-toxic area of sediments would be made available for colonization by the influx of organisms from the stream. Sediment caps could provide spawning areas for multiple fish species. Planting of macrophytes in these areas would serve to stabilize the caps (preventing wave-induced erosion), could provide wetlands that might generate DOC that would bind with and further detoxify the copper in the lake, and would improve the caps as habitat for juvenile fish as well as for spawning. While it is unlikely that the entire lake sediment area will ever be capped, that does not mean that it would not be advantageous to cap smaller areas.

Chapter 9. Other Concerns, Conclusions and Recommendations

9-1. Other Concerns

Although we focused the previous three chapters on the three major concerns of the Torch Lake AOC (PCBs in fish, mercury in fish, metals in the sediments), those are not the only issues of concern in and around Torch Lake. Because of legal mandates, limited availability of funds, and prevailing perceptions, agencies necessarily must limit their consideration to a subset of all of the issues present. A number of the issues below have been raised previously by various agencies or local groups, but they have not received enough concerted attention to be solved. Below we briefly mention some of the outstanding issues so that they appear in the official record. We make no effort to prioritize or to assess the severity of these issues.

9.1a. Soil contamination with Hg, Pb, PAHs

It is a well-known fact that metal smelters (and roasting or sintering facilities) and coal-burning facilities release to the atmosphere large quantities of pollutants including mercury, PAHs, lead, and other trace metals. These pollutants are subsequently deposited in terrestrial and aquatic ecosystems or towns downwind of the emission sources. The devastating environmental contamination from such facilities has been documented repeatedly in the scientific literature (e.g., Ek and Renberg, 2001; Gignac and Beckett, 1986; Gordon and Gorham, 1963; Gorham and Gordon, 1960; Ma et al., 2013; Nriagu et al., 1982; Telmer et al., 2004). Soil contamination from smelter and metal refinery plume fallout is a focal point of cleanup at multiple Superfund sites (e.g., Tacoma, WA; Roebling Steel, NJ; Jacobsville Neighborhood, Evansville, IN; Continental Steel, Kokomo, IN; Omaha Lead, Omaha, NE; Cherokee County, Kansas; Madison County Mines, MO; Oronogo-Duenweg Mining Belt, Joplin, MO; Anaconda, MT; ACM Smelter, Black Eagle, MT; El Paso, TX; Hurley, NM). Metal processing is estimated to be the largest source of mercury emissions in Canada (Pirrone et al., 1998). Taconite processing facilities in Minnesota are the second largest source of mercury emissions in Minnesota (GLRC, 2010). There can be little doubt but that substantial emissions of these substances occurred from the metal processing facilities around Torch Lake.

In the initial Feasibility Study conducted by Donohue, Inc. surface soils from nine residential lots were sampled and reported to have contamination, but at levels below the Direct Contact Criteria (U.S.EPA, 1992e). The Agency for Toxic Substances and Disease Registry (ATSDR) reported the PAH concentrations to be potentially of human health concern but at background levels for urban soils (MDCH, 1995). However, a separate technical memorandum on these samples reported that carcinogenic risks were higher than the target (1 in 1 million) due to PAHs and arsenic (U.S.EPA, 1991). The memorandum also reported that concentrations of mercury and lead, two volatile metals, also were above background in multiple soil samples. The memorandum made clear that the sampling done at that time was for the purpose of evaluating spread of contamination from nearby stamp sands; it was not appropriate or adequate to evaluate plume fallout. It is also possible that reference doses or toxicological endpoints have changed in the past 20 years for these substances, just as they have for PCBs and mercury. In short, despite the probability that area soils were impacted by historical emissions from the local mining industry, inadequate measurements have been made to evaluate the risk to humans.

9.1b. Isolated lake sections

As a result of the stamp sand or tailings deposits in the lake, at both the north and south ends of the lake a small body of water has become isolated from the remainder of the lake (Fig. 9-1). Both lake sections are shallow, and have become filled with macrophytes (rooted aquatic plants). In the northern end of the lake, Eurasian Watermilfoil (*Myriophyllum spicatum*) has invaded and become abundant. While these areas represent good habitat for juvenile, warm-water fish, they are prone to developing poor water quality, experiencing periods of low oxygen, and having unpleasant tastes and odors. The real estate value of these sections of shoreline may be reduced by the poor water quality. Increasing the water flow through these areas or enhancing the mixing with open-lake water would improve the water quality.

Figure 9-1. Aerial images of north and south ends of Torch Lake showing isolated sections with large macrophyte beds.

9.1c. Marine debris

The presence of considerable "marine debris" on the bottom of Torch Lake has been known for some time. The EPA reported in 1992 the presence of ~800 "empty" barrels (Kruger and Bartelt, 1992); only 20 barrels were actually removed from the lake at that time. Sidescan sonar surveys, used by EPA (1989-1991), MDEQ (2014-15) and researchers at MTU (2013-14) to "image" the lake floor, recorded the presence of a dumping ground offshore from the present Koppers, Inc. property as well as offshore of the Hecla Mill. Remotely-operated vehicles have been used to photograph some of the debris (Fig. 9-2). In addition to barrels, refuse from building demolition and other miscellaneous debris has been recorded. The contents of relatively few of the barrels have been analyzed; in the major EPA investigation (1989-1992) the contents were categorized, and waste from each category was analyzed. Many of the barrels were reported to have a black, viscous organic substance that was concluded at the time to be a non-hazardous hydrocarbon residue. Whether or not chemical hazards are present in any of the remaining

Figure 9-2. Images of debris at the bottom of Torch Lake. Pictures taken with video camera on an ROV deployed off of the smelter area in Hubbell.

barrels remains unknown. Funding is available through the NOAA marine debris program (http://marinedebris.noaa.gov/funding/funding-opportunities) should it be deemed desirable to remove debris and clean the lake bottom.

9.1d. Metal-rich sludges

Archival research of this study (see Chapter 2) found that metal-rich sludges were a by-product of the metal reclamation process. They were produced by pressure filtration of the leachate at the C&H reclamation plant in Lake Linden and by the flotation processes at Tamarack and Mason. Presumably, they were discarded in close proximity to these plants, although they may have been placed on launder lines and dumped in the lake together with the tailings and other wastes. We speculate that this might have been the origin of the material removed in the Emergency Removal performed in 2007 at the Lake

Linden Recreational Park (Fig. 9-3) and that planned for removal in 2018. The EPA identified a 200x200 foot area with a clay-like material rich in lead (78,000 mg/kg) and a second, smaller area (3'x200') contaminated with arsenic. A total of 1000 cubic yards of material was excavated from the two areas. The Emergency Removal did not attempt to remove all contaminated soil; as stated in the Pollution Report (U.S.EPA, 2007a):

> "The Emergency Removal Action will address direct contact threats. Lead 18-inches below surface, under the LLRP cover, or extending below the sediments of the lake will not be addressed."

Apart from the two deposits in Lake Linden, neither the extent nor exact locations of such sludges are known, although the vicinity of the Tamarack and Mason reclamation plants seems likely. While they have not been identified at the ground surface, it is possible that wave-induced shoreline or sediment erosion might expose such sludges in the future. Similarly, excavation for construction or flood-associated erosion in the vicinity of either of the reclamation plants also might expose such sludges and necessitate emergency clean-up.

9.1e. Calumet Lake and Boston Pond

Both Calumet Lake and Boston Pond were included in both Operable Unit III (on-land stamp sands) and Operable Unit II (below-water sediments) of the Torch Lake Superfund site (Fig 9-3). However, in both locations, the only remediation applied was to exposed tailings/stamp sands. Sediment contamination at both sites, although specifically noted in the Feasibility Study (U.S.EPA, 1992e) , the Remedy Position Paper (U.S.EPA, 1994), the RODs (U.S.EPA, 1992c, 1994), and the third 5-year assessment report (U.S.EPA, 2013), was never remediated; the no-action alternative and delisting in 2002 applied to both of these water bodies as well. There was never a thorough limnological analysis of either water body. While a large portion of Boston Pond was not directly impacted by mine tailings, the extent to which the benthos and fish reproduction were impacted throughout the lake has not been assessed. Because of the smaller size of both water bodies relative to Torch Lake, remediation via capping or dredging might be feasible.

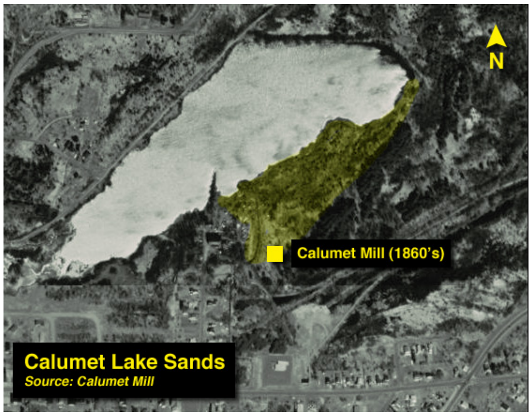


Figure 9-3. Areal images of Calumet Lake (left) and Boston Pond (right). Image on left from CopperCountryExplorer.com; image on right from Google Earth.

9.1f. Physical hazards

As noted by the Michigan Dept. of Community Health in a recent assessment (MDCH, 2013b), the shoreline and vicinity of Torch Lake contain many physical hazards in the form of derelict buildings, the large beached dredge, refuse from demolition of buildings, openings to subterranean passageways, and old industrial equipment (Fig 9-4). Many of the hazards are readily accessible to the public. It is possible and probable that asbestos-containing materials are exposed at some of these sites. It was only in 2014 that asbestos-containing materials were removed from the Ahmeek mill adjacent to the Tamarack City Park (U.S.EPA, 2014). Many of these hazards are on private property.

Figure 9-4. Examples of some existing physical hazards on or near shoreline of Torch Lake.

9.1g. Other waste streams and contaminants (arsenic, fly ash, slag)

As documented in Chapter 2, the metal processing along the shores of Torch Lake generated multiple waste streams (e.g., poor rock, stamp sands, tailings, slag, coal ash, fly ash, metal-rich sludge, spent leaching liquor, acid, etc.). The machinery required lubricants, and degreasing agents were probably used regularly for cleaning. Many of these would be considered hazardous substances today, and their disposal would be regulated. While the local mining industry showed considerable acumen in examining markets and recovering all possible saleable materials, market prices or lack of appropriate technology still resulted in the local dumping of many waste streams. Often these waste materials were put on the launder lines and dumped into the lake. As a result, the large deposits in and around the lake, while dominated by mine tailings and stamp sands, are not exclusively mine tailings or stamp sands. This reality was not reflected in the recent legislation passed by the Michigan legislature and signed by the governor that amended Part 201 of the Michigan Natural Resources and Environmental Protection Act to label the "stamp sands" as "non-hazardous".

As was shown clearly by the Emergency Removals performed in Lake Linden in 2007 and in Mason sands in 2008, some of the hazardous waste streams were deposited en masse in restricted areas. It is unlikely that all such deposits have been located; it therefore remains probable that additional toxic deposits will be located and will require clean-up in the future. Only in the most recent MDEQ actions has there been a concerted effort to plan environmental sampling around knowledge of historical activities.

Arsenic warrants particular mention as a waste material. Arsenic is one of the more toxic metals present in the local copper ores and was a major contributor to the carcinogenic risk calculated by EPA in the Feasibility Study (U.S.EPA, 1992a). Ores from the Osceola and Ahmeek mines were particularly high in arsenic, and were processed at Torch Lake. High arsenic content in the smelted copper was undesirable; to lessen that problem, C&H would charge the smelters with soda ash which would cause the arsenic to combine with carbonate to produce a friable slag. There has not been a concerted effort to identify either the years or the locations in which arsenic-rich ores were processed around Torch Lake. While 30 tons of arsenic-rich material were removed from the Mason sands in 2008 and 64 tons of arsenic-contaminated material from the Lake Linden beach in 2008, the industrial origins of both deposits remain unknown. Because the ore bodies with high arsenic content are well documented as are the records of the mining companies as to when specific ores were processed (and reprocessed following dredging), it seems likely that historical research could clarify where additional deposits of arsenic-rich material are likely to occur.

9.1h. Water quality impairments

Torch Lake is in violation of Michigan's water quality standards for several constituents. The 2014 report to EPA of the State's impaired waters (MDEQ, 2014) lists only the violations due to elevated mercury and PCBs in fish. The EPA's Baseline Study reported concentrations of multiple metals above the state's water quality criteria (Table 9-1). The Record of Decision (ROD) for OU I and III (U.S.EPA, 1992c) reported that:

> "The contaminant level of arsenic, copper, lead, and mercury found in Torch Lake are above the human health and aquatic life protection criteria under the Clean Water Act."

At a minimum, further sampling using modern, clean sampling techniques should be performed to determine if the lake is still in violation of water quality standards. Although the state has made no effort to develop a plan (Total Maximum Daily Load, TMDL) for bringing Torch Lake into compliance with the water quality criteria, that is the legally-required course of action. The Clean Water Act provides one of the Applicable or Relevant and Appropriate Requirements (ARARs) that cleanup of Superfund sites must meet. Failure to meet these conditions could provide one basis for asserting that clean-up of OU II was not successful.

Table 9-1. Concentrations of metals measured in Torch Lake compared with Michigan's water quality criteria for the protection of aquatic life.

Metal	Range of Conc. (µg/L)	FCV[a] (µg/L)
Copper	17-44[b], 74[d]	4-6
Arsenic	< DL – 2.6[c], 3.4[d]	150 (MCL 10)
Lead	< DL – 14[c], 7.2[d]	8.5-12
Mercury	< DL – 1.7[c], 98[d]	0.77

a. FCV = Final Chronic Value, Rule 57 Water Quality Values. (MDEQ, 2014)
b. Values from (Brandt, 1973; Leddy et al., 1986; Lytle, 1999; U.S.EPA, 2001)
c. Values from (U.S.EPA, 2001)
d. Values reported in 1992 ROD (U.S.EPA, 1992c)

9-2. Conclusions

In part because an individual is likely to live near and have direct experience with a single Superfund or AOC site in his/her life, the public may well perceive everything related to the site as unique or exceptional. Certainly, part of what motivated this study was the perception that the cleanup at this site had required a very long time, that cleanup had been less than complete, and that the agencies and local stakeholders had not had a good working relationship. Although a detailed comparison of this site with other contaminated sites is beyond the scope of this document, the research team has become aware through this project that prolonged times for cleanup, partial solutions, and contentious interactions are not uncommon. Nevertheless, this project has also clarified some of the reasons for these failings at this site. Our conclusions attempt to answer the question of how optimally to approach remediation of a complex, large contaminated site such as Torch Lake. Because the remediation is in no sense complete, these conclusions remain relevant to ongoing efforts at this site.

9-2a. The importance of history

In contrast to a single facility site, a complex, multi-facility site has a greater potential for multiple types of wastes, and for the location and type of waste generation to have changed over time. The types of wastes present and their spatial distribution around Torch Lake are the result of the historical activities associated with industrial development, re-purposing, and demolition that were conducted before remediation began. Much of the failure to adequately remediate this site can be attributed to a failure to consider the history of activities on the site. The locations of PCB usage were not considered prior to this project. The scale and locations of arsenic waste generation still have not been considered. The existence of plumes of metal- and PAH-laden particulates emitted from the boilers and smelters still has never been considered. The generation of specific types of wastes (metal-rich sludges, spent leachate liquor, arsenic-bearing slag, fly and coal ash, etc.) was scarcely considered. The consideration of creosotes and xanthates was driven by the narrow focus on fish tumors, rather than a broad consideration of all possible types of human and environmental risk. Consideration of policy and implementation history is also important for continued review and revision of remediation plans.

9-2b. The importance of problem definition

Because the solution to a problem depends on the perception or definition of the problem, a broad perspective and holistic approach are likely to result in more complete resolution of the problems at contaminated sites as large and complex as Torch Lake. The Superfund program has a ranking system that puts human health risks (carcinogenic and noncarcinogenic) as the major concern and ecosystem health as a secondary concern. This approach caused the EPA to consider the widely-disseminated wastes that generated air-borne contaminants as the principal concern. The nature of this industrial site and the history of emergency contaminant removals have shown that localized hotspots are common, and that a systematic mapping of the historical activities and historical waste generation locations is required to locate and to reduce contaminant exposure.

9-2c. The potential of integration

Arguably, the U.S. has the most comprehensive laws protecting the environment and human health, but the shortcoming of this system is its lack of integration. As enumerated in the third fact sheet assembled by this project, there are at least five government agencies supervising compliance with federal and state laws. However, within the EPA there are two offices involved (Superfund Division, Great Lakes National Program Office), and within the MDEQ there are at least five offices involved. This project found that communication among these offices ranged from regular to sporadic. There has been no concerted effort to bring all available monetary or human resources to the table to solve the problem in the most efficaciously possible manner. Although the ARARs provision of CERCLA is supposed to compel Superfund sites to be cognizant of other laws (besides CERCLA) affecting a Superfund site, there is not provision for establishment of multi-office teams that might be able to leverage more resources as well as to ensure that remediation meets all relevant and applicable requirements.

9-2d. The importance of public participation

In the absence of integration on the part of regulatory agencies, it falls to local stakeholders to prioritize, to coordinate, and to leverage efforts among the multiple agencies involved. The AOC sites that have progressed most successfully towards delisting are those with a strong local oversight committee that have applied to the multitude of separate grants available for remediation. In addition, early community involvement in scoping, research, and remediation planning has proven in other Superfund sites to quicken the lengthy process and introduce questions not considered by hired consultants. Each agency or office within an agency has its own narrow legal mandate. There is often pressure on these government programs to show success; integration among multiple agencies is not one of the criteria for success on which they are evaluated. Integration generally requires more time than fulfilling a narrower mandate. It is the local stakeholders who have financial, cultural, or spiritual investments in the contaminated area. It is that vested interested that can provide incentive to look for and identify solutions that could bridge the mandates of all agencies.

9-3. Recommendations

Our recommendations follow directly from the Conclusions above. The recently initiated watershed planning activities will be most successful, in our opinion, if they can follow these recommendations.

9-3a. Take a big-picture look to be sure all components of the problem are defined.

As discussed above, once a problem has been defined, the possible solutions are circumscribed. We argue that starting with a broad definition of problems is better than starting with a narrow list of high-priority items. Given a broad list, it is still possible to prioritize items on the list by whatever criteria may be desired. Starting with a narrow list makes it difficult to raise additional issues, because it seems like a fault of the initial planning if additional problems are identified later. In the case of Torch Lake, the Superfund program was touted as a major success; residents were skeptical when the AOC program claimed that major problems remained.

9-3b. Assemble a diverse group of local stakeholders with the commitment to work toward remediation. Include these stakeholders in planning and decision-making for future work at Torch Lake.

Both the local record as well as the history at other AOC and Superfund sites make abundantly clear the importance and power of local stakeholders. The Public Advisory Council (PAC) is an element of the AOC program, not of the Superfund program. Nonetheless, it was the TLPAC that brought pressure on government officials that resulted in the procuring of the $15M spent on Superfund remediation efforts. It was the TLPAC that brought pressure on state regulatory officials that resulted in the ongoing efforts to locate sources of PCB contamination. The commitment of local individuals to improving their surroundings is generally stronger than that of government officials for whom the site is remote.

However, the local history also shows the dangers of not having the full diversity of stakeholders at the table. While the TLPAC as originally constituted did represent a diversity of stakeholders, that diversity dwindled until only two groups (real estate owners, local township officials) were represented. This narrow constituency has neither the desire nor the ability to attract additional sources of support (e.g., historical research or preservation grants, habitat restoration grants) that would help to more fully remediate the area.

9-4c. Learn from history lest we repeat it.

In a site as large and complex as Torch Lake, it is hopelessly expensive to try to find sites of contamination by statistically-based sampling protocols. Using historical evidence to guide the sampling is likely to save considerable time and money. A comprehensive effort to identify hazardous wastes generated by the industries around Torch Lake is possible given the existence of extensive archives of industrial records at Michigan Tech and the Keweenaw National Historic Park.

9-4d. Specific actions to be taken:

a. Identify and remove local sources of PCB contamination.
b. Make required measurements of mercury fluxes and species to enable construction of a mercury mass balance. This will help to show the importance of local vs. distant sources of mercury to the bioaccumulation of methyl mercury in the fish.
c. Determine the health and viability of the fish community with regards to spawning. It remains unclear which species of fish are able to successfully reproduce in Torch Lake. Habitat restoration grants are premature in the absence of such knowledge.
d. Perform rapid screening of soils to test for fall-out of smoke stack plume constituents.
e. Support the organization of an umbrella watershed stakeholder group with resources to organize a membership, conduct a watershed study, and educate members on Torch Lake contamination and remediation history.

Epilogue

The AOC program had little funding for the first twenty years, and did little by way of remediation in that time. It did, however, initiate local involvement in the form of a Public Action Council. The problem definition espoused by the AOC program prevented it from delisting the site despite the remediation performed by the Superfund program. State agency personnel with both the Superfund and AOC programs recognized that contamination still existed; the MDEQ RRD office sought to obtain funding through the Great Lakes Restoration Initiative in 2010 and 2011, and, failing that, through the emergency cleanup arm of the Superfund program to remove contamination (2012-2017). It was the recognition of ongoing problems that led the state AOC personnel to support the funding of this Integrated Assessment project.

Beginning in 2013, the MDEQ began a concerted effort to document the extent and locations of contamination remaining around Torch Lake. These efforts were put under the direction of the Calumet Branch Office of the Field Operations Section (Marquette office) of MDEQ's Remediation and Redevelopment Division. This effort came to be called the Abandoned Mining Waste (AMW) Project. The project divided the western shoreline into three sections (Calumet & Hecla – Lake Linden (CHLL); Calumet & Hecla – Tamarack City (CHTC); Quincy – Mason (QM)), and sequentially mapped the contamination remaining in each area (2014-15 CHLL; 2015-16 CHTC; 2017 QM). The AMW Project documented the extent of metal, asbestos, PCB, and other industrial contamination of upland soils. In addition, it performed extensive side-scan sonar reconnaissance of the lake sediments and performed some limited sediment sampling to better define the extent of sediment PCB contamination in Lake Linden and Hubbell. As a result of this work, the Lake Linden beach area will be dredged in summer 2018. Project personnel worked with other programs to effect cleanup of asbestos contamination at the Calumet mill in Lake Linden and at sites in Tamarack City. The project documented considerable contamination on the smelter property in Hubbell, and in 2016 oversaw actions to reroute water flow through the site as well as to prohibit public access. Groundwater contamination with PCBs was identified at the smelter site, and a container leaking PCBs was removed from the shoreline in Hubbell. The public beach in Hubbell was closed in response to findings by the AMW project of rubble from a former municipal landfill. The public was generally supportive of the AMW project, although the pace of the work was deemed by some residents as slow. The 2017 summer has been devoted to additional sampling near the Hubbell smelter and a complete sampling of soils at the Quincy/Mason mills and reclamation plant.

The local involvement of stakeholders initiated through the AOC program also evolved significantly after the end of the IA project. From 1998-2014, the TLPAC had focused on delisting both as a means of removing unwanted government oversight of local affairs and as a means of promoting local development of highly desirable lakefront real estate. The TLPAC was often frustrated by the slowness of the delisting process, and pursued other avenues such as the state legislature to bypass environmental regulations (e.g., Senate Bill 872 passed in June 2014). The IA project succeeded in informing the local public of the incomplete status of remediation, and led to discussion about formation of a second public oversight group in the form of a Watershed Management Council. The TLPAC decided to work with this second group, and added several new members as it absorbed the new group. Through spring of 2016, the TLPAC continued to seek funding for development of a watershed management plan in coordination with the local Conservation District. TLPAC Support grants administered by the MDEQ OGL were not, however, adequate to achieve this goal. Although the OGL originally backed the idea of developing a Watershed Management Plan, that support evaporated in late 2016 and 2017. In summer 2017 the TLPAC was awarded a grant to hire a contractor to identify and evaluate possible strategies for delisting of the BUIs.

In spring and fall of 2016, upper management from MDEQ assessed the extent of public consensus regarding cleanup of Torch Lake. In both instances, assessment was performed by meeting with the TLPAC and a few other individuals from MTU and the community. On both occasions, MDEQ personnel concluded that there was no community-wide consensus regarding future work at the site, and for that reason it would be premature for MDEQ to invest major efforts and funding into a concerted cleanup effort. While the AMW project was seen as an important step in the cleanup, it was acknowledged that, by itself, the AMW project would not be sufficient to lead to delisting of the remaining BUIs.

Consequently, as of summer 2017 the Torch Lake AOC still has two BUIs (restrictions on fish consumption, and degradation of the benthos) in place. To date, there has been no effort to develop a comprehensive plan that would move the site towards delisting of these BUIs. Also, as documented in Chapter 9, there remain a number of other problems in the watershed and around the lake. While the AMW project has made some headway towards mitigating soil contamination, the other problems have not been addressed.

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Appendix A. A Timeline of Torch Lake Industrial and Environmental History

Introduction

Torch Lake is the site of a historical copper processing center in the Keweenaw Peninsula and, as a result, also the site of environmental pollution. It hosts a status as a Superfund site under the EPA and an Area of Concern under the Great Lakes Water Quality Agreement (GLWQA). This timeline covers the period of 1860 to the present, providing information on the industrial development of Torch Lake, documentation of pollution problems, remediation efforts, and the more recent activity to address newly identified problems.

The timeline is divided into these periods:

1860-1900	Opening Torch Lake to Mining Commerce
1900-1940	Reclamation and Consolidation of Operations
1940-1970	Dependence on Secondary Copper
1970-1990	Identification of Environmental Problems
1990-2017	Remediation and New Problems

1860-1900: Opening Torch Lake to Mining Commerce.

The first mill (Hecla Mill) is built in Lake Linden as the South Entry is dredged from Keweenaw Bay to Portage Lake in the mid 1860s. Quincy moves its mill to Mason in the 1880s as the US Army Corps of Engineers establishes harbor lines in the waters between Houghton/Hancock and discourages continued dumping of tailings. By 1900 there are seven mills and a smelter operating from Lake Linden to Mason along the western lakeshore. Stamp sands (tailings) still rich with copper and other metals, begin to fill the lake offshore from Lake Linden, Tamarack, and Mason. C&H mills (including Osceola and Tamarack) produce stamp sands from conglomerate rock. Quincy mills produce stamp sands from amygdaloid rock. Torch Lake, although part of the public Keweenaw Waterway, remains the responsibility of C&H to maintain it as an open waterway. Torch Lake is exempted (under 1890 Rivers and Harbors Act) from enforcement of harbor lines and the anti-dumping clause.

1860s

- C&H builds Hecla Mill
- South Entry to Portage Lake opened/dredges

1870s

- C&H builds Calumet Stamp Mill
- Torch Lake Canal Co. (C&H) dredges canal between Torch and Portage Lakes to accommodate large vessels and charges tolls for entry/exit
- North Entry to Portage Lake opened/dredged

1880s

- C&H builds Hubbell Smelter (including power plant, electric shop, coal dock)
- Tamarack Mining Co. builds Tamarack Mill
- Quincy Mining Co. builds Quincy Mill #1 near Mason

1890s

- US assumes control over Keweenaw Waterway North & South Entries from private companies
- US Army Corps exempts Torch Lake from dumping and harbor line rules for Keweenaw Waterway (1890 Rivers and Harbors Act)
- Tamarack Mining Co. builds Tamarack Mill #2
- Osceola Mining Co. builds Osceola Mill in Tamarack City
- Quincy Mining Co. builds Quincy Mill #2 near Mason

1900-1940: Reclamation & Consolidation of Operations

C&H consolidates all mine processing operations from Lake Linden through Hubbell and Tamarack areas under one corporate organization. By 1940 there are only three mills in operation: Quincy #1, Ahmeek (built in early 1900s), and Calumet. Reclamation of stamp sands becomes a major contributor to C&H copper product from its Hubbell smelter.

Electrical power, supplied by a centralized coal-fired power plant in Lake Linden, replaces steam/boiler facilities at individual facilities. C&H imports all its coal into the Hubbell coal dock, pulverizes it for the smelter and power plant, and expands electrical production. After 1930, PCB-laden oils replace mineral oils in electrical transformers. The coal-based electrical power system introduces pollutants into the Torch Lake environment: PCBs (transformer oil), Hg (gaseous, particulate) and PAHs (fly ash).

C&H begins reclamation of stamp sands at Lake Linden (1915) and then Tamarack (1920) through a process of dredging, regrinding, leaching, and flotation of copper-rich sands. The very fine re-ground sands are re-deposited in Torch Lake in new locations, spreading more widely throughout the lake bottom. Flotation and leaching plants (reclamation facilities) introduce new chemicals into the Torch Lake environment: xanthates, pine oils, ammonia. Sludge discharged from flotation plants along with stamp sands contains waste chemicals and heavy metals. Periodic leach liquor spills from leaching plants occur.

1900s

- C&H builds Lake Linden Power Plant
- C&H starts reclamation plants in Lake Linden: Regrinding #1
- Ahmeek Mining Co. – builds Ahmeek Mill in Tamarack City (includes pump house and power house)

1910s

- C&H builds Regrinding #2 in Lake Linden; substation; dredge
- C&H builds Leaching and Flotation Plants in Lake Linden
- C&H builds Electrolytic Plant and Acid Treating Plant near Smelter in Hubbell
- Discharge of fine grained tailings and sludge into Torch Lake - Lake Linden from reclamation activity begins

1920s

- C&H consolidates holdings from Osceola and Tamarack Mining Companies
- C&H closes Electrolytic and Acid Plants
- C&H closes Hecla Mill – Lake Linden
- C&H builds Mineral House near Hubbell Smelter
- C&H builds Coal Pulverization Plant near Smelter
- C&H builds Tamarack Reclamation Plant (includes substation, classifying, leaching, flotation – all under one roof)
- Discharge of fine grained tailings and sludge into Torch Lake – Tamarack from reclamation activity begins
- Quincy closes Mill #2

1930s

- PCBs introduced into electrical transformers (power plants, substations, dredges)
- Ahmeek Mill undergoes major renovation
- Most mines closed or operated sporadically due to Depression
- Tamarack Reclamation Plant closes for seven years; Lake Linden Reclamation Plant stays open

1940-1970: Dependence on Secondary Copper

After a slowdown of operations and some mine closures during the Depression, the war effort buoys and subsidizes copper production. The Mineral Reserve Corporation finances building of the Quincy reclamation plant, which C&H constructs from the remnants of its Lake Linden facilities. C&H adds Quincy Reclamation to its power plant based in Lake Linden. C&H begins to import and reclaim scrap copper at smelter yard and leaching facilities in 1940s. After 1945, only Ahmeek mill operates on Torch Lake with increased capacity that includes flotation. C&H begins to produce copper oxide and sulfide products at Lake Chemical Co for fertilizer, paint, and wood preservative markets (1950s-60s in Tamarack reclamation plant). Production slows in 1960s at Quincy and C&H. All operations close during 1968 strike. C&H (now Universal Oil Products) and Quincy operations liquidated in 1970-72.

1940s

- Quincy Mining Co. builds Reclamation Plant in Mason (regrinding, flotation, dredge)
- Discharge of fine grained tailings and sludge into Torch Lake – Mason from reclamation activity begins
- Quincy closes Mill #1

- C&H closes Calumet Mill – Lake Linden
- C&H forms Secondary Department: makes copper scrap a major input into reclamation plants
- C&H partners with Harshaw Chemical Co. to form Lake Chemical Co. Production of copper chemicals in Tamarack Reclamation building
- Flotation introduced at Ahmeek mill; participates in processing scrap copper
- Ahmeek Mill becomes only operating mill on Torch Lake

1950s

- Lake Chemical Co. stops production (dissolves in 1965)
- Tamarack Reclamation Plant reduces operations to recovery of copper from Ahmeek stamp sands
- C&H closes Lake Linden Flotation and Regrinding Plants. Continues leaching operation.

1960s

- Universal Oil Products (UOP) merges with C&H - 1968
- C&H and Quincy buildings cease operations during 1968 strike and never reopen.
    - C&H Torch Lake operations in 1960s:
        - Power House - Lake Linden
        - Leaching Plant – Lake Linden
        - Smelter - Hubbell
        - Coal Dock – Hubbell
        - Mineral House - Hubbell
        - Coal Pulverization Plant - Hubbell
        - Ahmeek Mill in Tamarack City
        - Tamarack Reclamation Plant (small crew)
    - Quincy Torch Lake operations in 1960
        - Quincy Reclamation facilities closed permanently in 1967, prior to the 1968 strike.

1970-1990: Identification of Environmental Problems

Environmental awareness creates new laws and institutions to protect and clean up waterways and communities. The US passes environmental laws for water, air, hazardous waste, and toxics (1970-1980). The 1972, 1978, and 1987 Great Lakes Water Quality Act (GLWQA) and amendments establish Area of Concern (AOC) program for listing and remediation of contaminated sites.

Environmental problems emerge soon after operations cease at Torch Lake: fish tumors, chemical spills, water quality compromised by salinity and copper, heavy metal in sediments. Research by MTU scientists and MDNR investigations continue for a decade to determine parameters of the problems. The EPA and the International Joint Commission (IJC) each list Torch Lake as a contaminated hazardous waste site, triggering an intensified study of the character and toxicity of mine waste and strategies for cleaning it up. EPA identifies three areas for remediation: stamp sands in Torch Lake; sediments in Torch and Portage Lake; additional sites (stamp sands) in Houghton County (Point Mills, Michigan smelter, Isle Royale, North Entry, Boston Pond, Calumet Lake).

1970s

- 1970 – US Congress passes the Clean Water Act and the Clean Air Act
- 1970 - USGS & MDNR complete groundwater study of Keweenaw, biological survey of Torch Lake
- 1970-1972 – MTU research on water quality, conductivity, and stamp sands
- 1972 – Great Lakes Water Quality Agreement - US and Canada
- 1972 – Leach liquor (cupric ammonium carbonate) spill in Lake Linden from Leaching Plant - 27,000 gallons
- 1973 - Fish tumors identified in Torch Lake walleye and sauger (internal and external tumors)
- 1973-1983 – Continued research at MTU on Torch Lake fish tumors, water quality, sediments, stamp sands

1980s

- 1980 – US Congress passes CERCLA (Superfund).
- 1983 – Fish consumption advisory imposed for sauger and walleye from Torch Lake because of tumors on these fish
- 1981-1984 – EPA conducts preliminary investigations for possible listing of Torch Lake as Superfund site
- 1985 - IJC designates Torch Lake an AOC site
- 1986 – EPA lists Torch Lake on the National Priority List (NPL) under Superfund (CERCLA)
- 1987 – GLWQA designates procedure for listing Areas of Concern (AOCs)
- 1987 – MDNR issues the Remedial Action Plan (RAP) for Torch Lake
- 1988 – EPA starts the Remedial Investigation/Feasibility Study (RI/FS) phase of Superfund work; Hires Donohue and Associates (Chicago)
- 1989 – EPA samples drums located near Hubbell Smelter

1990-2018: Remediation and New Problems

EPA approves a remediation plan and begins cleanup. Stamp sands are targeted for covers to prevent public exposure to contaminants from wind erosion. Sediments in Torch and Portage Lakes (OU II) are delisted with the argument that natural processes will generate cover for toxic sediments. As fish tumors disappear, continued fish advisories reflect presence of PCBs and mercury in Torch Lake fish tissue. EPA takes the lead in remediation efforts with capping the stamp sands. However, several instances of emergency removal of toxic soils and additional research on PCBs in fish tissue highlight the need for further investigation. MDEQ begins study of historic industrial site locations for C&H and Quincy and sampling of Torch Lake waterfront soils and sediments to determine the source of PCB and heavy metal contaminants.

1990s

- 1990 - EPA collects samples from drums at Tamarack
- 1991 – EPA and responsible parties remove drums with toxic waste
- 1992 (May) – Donohue study completed (RI/FS) for EPA Torch Lake Superfund site Alternatives for Operating Units (OU) I, II, III outlined and presented for public comment.
- 1992 (September) – Record of Decision (ROD) for OU I and III signed by EPA

- 1993 – Michigan Dept. of Public Health (MDPH) removes Fish Advisory for tumors on sauger and walleye in Torch Lake; Fish Advisory for Mercury in Torch Lake added
- 1994 (September) – ROD for OU II signed by EPA
- 1997 – Torch Lake Public Action Council (TLPAC) formed
- 1998 – EPA obligates $15.2 million for remedial action work
- 1999 (Summer) – Remediation of sands at Lake Linden begins.
- 1998 Fish advisory for PCBs in Torch Lake added

2000s

- 2000 (Summer) – Remediation of sands at Hubbell/Tamarack begins
- 2001 (Summer) – Remediation of sands at Mason begins (continues into 2002)
- 2001 – EPA completes Baseline study
- 2002 –- OU II (sediments in Torch/Portage Lakes) delisted; partial Lake Linden sands removed from NPL (delisted)
- 2003 – EPA - First 5-year Review
- 2004 – Hubbell/Tamarack sands removed from NPL (delisted)
- 2005 – SPMD study contracted by MDEQ
- 2007-8 – Additional core surveys by MDEQ, EPA to define PCB contamination
- 2007 – RAP update by MDEQ
- 2007 – Lake Linden sands removed from NPL (delisted)
- 2007 – Superfund Emergency Removal (PCBs, metals) in Lake Linden
- 2008 – Removal of Mason sands from NPL (delisted)
- 2008 – Superfund Emergency Removal of arsenic wastes & chemicals in Mason
- 2008 – EPA – Second 5-year Review

2010s

- 2011 – Beginning of remediation of C&H Power Plant; continued to 2014
- 2013 – EPA Third 5-year Review
- 2013 – Urban, MacLennan, and Perlinger begin Integrated Assessment of Torch Lake for Michigan Sea Grant (completed August, 2015)
- 2014 – MDEQ – begins Abandoned Mining Waste investigation of PCBs and other contaminants in Torch Lake soils and sediments. First sampling completed Summer 2014 in Lake Linden region.
- 2015 – Emergency removals of asbestos (Ahmeek Mill, Tamarack Mill, Calumet Mill), barrel with PCBs,
- 2015 - MDEQ continues summer sampling in Hubbell/Tamarack City region.
- 2016 – MDEQ continues summer sampling in Hubbell/Tamarack City region. MDEQ releases report from 2014 (and 2015) summer sampling. Remediation in coal dock area performed to reduce surface water flow, erosion.
- 2017 – MDEQ continues summer sampling in Mason/Quincy Mill region; sampling of waste piles at Mineral House in Hubbell
- 2018 – Emergency removal: Plan for dredging of Lake Linden beach area to remove PCBs, metals

Appendix B. Fact Sheets

PCBs in Torch Lake: What's the Story?

Mercury in Torch Lake: What’s the Story?

Metals in and Around Torch Lake: What's the Story?

Who is Doing What at Torch Lake?

Appendix C. Annotated Bibliography

Part 1. Undated documents

A Mining Legacy: Torch Lake, An Area of Concern: Its History and Future. Pamphlet. Houghton-Keweenaw Soil and Water Conservation District. Torch Lake, Area of Concern, Houghton-Keweenaw Soil and Water Conservation District, Public outreach.

Pamphlet contains timeline up to 1995 of activities on Torch Lake.

Map: Laurium Quadrangle. Map., Torch Lake.

Map showing town of Laurium and most of Torch Lake. Appears to be an early map due to lack of mapped stamp sand piles on western shore.

NPL Candidate Narrative Summary. U.S. EPA (inferred), Torch Lake, Superfund.

A one-paragraph description of Torch Lake, the historical mining activities, the sediment contamination, and the fish tumors.

U.S. EPA. **EPA Preliminary Assessment Site Investigation**. Superfund, Lake Linden, Calumet & Hecla.

A completed site assessment form about the Calumet & Hecla site in Lake Linden to determine what contamination and hazards are present. Notes copper and other metals contamination, fish tumors, and C&H leachate spill.

D. Chellaraj, U.S. EPA. **Superfund Preliminary Site Closeout Report Final Remedial Action for Torch Lake Superfund Site, Houghton County, Michigan**. Torch Lake, U.S. EPA, Superfund.

P. Gallichio and D. Novak. **Torch Lake: EPA Superfund Site Monitored by Michigan Students**. Pamphlet. U.S. EPA. Torch Lake, stamp sands, monitoring, public outreach.

Pamphlet gives an overview of the history of mining activities, Torch Lake contamination, remediation actions taken by the EPA, and organized monitoring of this remediation by local high-school students.

City of Hancock, et al. **General Comments Of The Community Regarding EPA's Proposed Remedy**. Personal Communication. J. Kuhns, U.S. EPA, D. Novak, U.S. EPA and R. Campbell, Michigan Department of Natural Resources. Torch Lake, Superfund, Operable Unit II, public outreach.

All authors of these comments support the no action alternative for OU II.

U.S. Department of the Interior. **National Wetlands Inventory, Houghton County Road Systems**. Map. Torch Lake, map, wetlands, roads.

File includes two maps: one of the wetlands surrounding Torch Lake, and another one of the roads surrounding Torch Lake.

T. Kipela. **The native copper mining era of the Keweenaw copper country : lodes and mining locations, 1846-1968 / drawn & prepared by Tauno Kilpela**. Map. Copper, mining history, map.

Map of principal lodes on the Keweenaw Copper Range.

Life Systems Inc., U.S. EPA (assumed). **ICAIR Responses To EPA And MDNR Comments On Torch Lake OUII Draft Baseline Risk Assessment**.

NPS. **Timeline of Michigan Copper Mining**. http://www.nps.gov/kewe/learn/historyculture/copper-mining-timeline.htm. 4/30/2015.

Summary of major events within and affecting the life of the mining industry in the Keweenaw Peninsula.

WUPPDR, Torch Lake Township. **Torch Lake Township Recreation Plan 2009-2013**.

A. F. Taggart, John Wiley & Sons, Inc., Chapman & Hall, Limited. **Floatation**. 12-01 to 12-10. industrial process, floatation.

Chapter from a book explaining the process of floatation in detail.

Weston,Inc. **Project Plan for Characterization of Bank Anomalies**. Torch Lake, Weston, copper.

Plan for a project to characterize bank anomalies detected through a proton magnetometer operation performed by

EPA Region 5 and to identify a gradient of copper contamination within the sediment and determine its impact upon aquatic biota.

Weston Solutions, Inc. **SITE LAYOUT MAP, Quincy Smelter Site, Franklin Township, Houghton County, Michigan**. Map. Quincy Smelter, map.

(After 1940 (inferred)). Quincy Mining Company Stamp Mill Branch, **Assay of Waste Sands**. copper, stamp sands, Quincy Mining Company.

Report generated by Quincy Mining Company summarizing copper content of stamp sands from 1902 to 1940.

Part 2. Chronological listing of dated documents, 1888-2013

(1888). L. G. Emerson. **Topographical Map of the Portage Lake Mining District**. Map. mining history, map.

(1909). Gay and Sturgis (inferred). **Direct Exclusive Private Wires to the Lake Superior District**. Map. Houghton County, Keweenaw County.

Map of Houghton and Keweenaw Counties, showing towns within the counties.

(1910, 1920, 1930, 1940). USGS, Washington Government Printing Office. copper, financial reports.

Summary of mining output and production costs and returns in various states, including Michigan.

(1911). **Plat Book of Houghton Co. MI**. Torch Lake, Boston Pond, mining history, plat book.

Plat map of northern Houghton County from 1911.

(1955, 1960, 1975). U.S. Bureau of Mines, copper, financial reports.

U.S. Bureau of Mines reports on production and output of mines throughout the country, including Michigan.

(1960 to 1980). U.S. Census Bureau, **Table 5: Population of Places**.

Table showing populations of various cities in Michigan in 1960, 1970 and 1980.

(1967, 1957, 1947, 1937, 1927, 1917, 1907). Calumet & Hecla. **Annual Report**. Calumet & Hecla.

Annual Reports for C&H company stakeholders.

(1969). J. M. Yanko. **The Biological and Chemical Effects of Saline Mine Water on the Receiving Water System**. Thesis. Michigan Technological University, Master of Science.

This research examined the effect of saline waters pumped from the Osceola Mine No.13 on the distribution of invertebrates in Torch Lake and other connected waters. In the thesis it stated "In the lakes affected by the saline waters the distribution of invertebrates appears to be dependent on the substrate rather than the chloride or calcium concentrations.

(1969, 1984). *Moody's Industrial Manual pages on Universal Oil Products for years 1969 and 1984.*

(1970). C. J. Doonan et al., MDNR, U.S. Department of the Interior. **Ground Water and Geology of Keweenaw Peninsula, Michigan**. Keweenaw Peninsula, groundwater.

Report by MDNR and USGS to determine what groundwater can be used for drinking water in the Keweenaw Peninsula. The following is a part of the summary of the report:
"About half the wells in Houghton County and a few in Keweenaw County obtain water from sand and gravel. The Jacobsville Sandstone underlies the glacial drift in most of the southern and southeastern parts of Keweenaw and Houghton counties. It yields small to moderate supplies of fresh water to most wells drilled into it. Water from most wells in drift and bedrock is satisfactory for domestic use, but many yield water with objectional amounts of iron. A few of the deeper wells in bedrock yield water too salty for drinking. Most public water supplies in the two counties are obtained from Lake Superior or from mine shafts, but a few are obtained from wells and springs."

(1970). A. D. Kennedy, Michigan Technological University. **Recovery of Copper From Michigan Stamp Sands: Volume II: Physical and Chemical Properties of Stamp Sand**.

(1970). A. D. Kennedy and F. J. Chernosky, Michigan Technological University. **Recovery of Copper From Michigan Stamp Sands: Concentration Tests**.

(1970). Michigan Water Resources Commission, MDNR. **Biological Evaluation of Torch Lake, Houghton Michigan, October 1970**. Torch Lake, copper, benthics.

This evaluation was designed to assess the effect of both the original and reprocessed stamp sand tailings on the physical environment and biological community of Torch Lake. On October 26-28, 1970, the following water quality indicators were sampled in Torch Lake: 1. water chemistry, 2. sediments, 3. coliform, 4. algae, 5. benthic invertebrates, 6. fish. Analyses of chemical and bacteriological water samples indicate that copper and chlorides were substantially elevated above normal background levels. Most of the lake bottom is covered in stamp sands. Benthic community reflects an early stage of redevelopment and does not appear to play a vital role in the existing food chain in Torch Lake. Phytoplankton is diverse but not dense. 17 species of fish are present in the lake. Copper concentration in Torch Lake fish ranged from 0.5-4.5 mg/L with a mean of 2.05 mg/L. Discharge of stamp sands has had significant effects on the lake ecosystem.

(1972). R. M. Wilson. **The Effects of Fertilization on Interstitial Water Quality in Copper Mine Tailings**. Thesis. Michigan Technological University, Master of Science. Torch Lake, groundwater.

From the thesis:
"This project was designed to determine if significant amounts of these nutrients (phosphorus and nitrates), as well as copper, were leaching through the sands and entering Torch Lake…. It appears that applied fertilizer is not entering the lake, but that the sands themselves are contributing nutrients and other dissolved solids to the lake through natural processes."

(1973). D. J. Brandt. **Factors Controlling Soluble Copper(II) Levels in the Keweenaw Waterway**. Thesis. Michigan Technological University, Master of Science.

This thesis examines the copper content and the factors controlling it in Torch Lake and the remainder of the Keweenaw Waterway.

(1973). E. Evans, Michigan Water Resources Commission, MDNR. **An Evaluation of a Cupric Ammonium Carbonate Spill Into Torch Lake, Houghton County, Michigan, September 29, 1972.** Torch Lake, emergency removal, Lake Linden Leach Liquor Spill.

Summary from Document:
"1. Personnel of the Michigan Water Resources Commission from Lansing conducted an Investigation on September 29, 1972 of a spill of cupric ammonium carbonate in Torch Lake, Houghton County. The discharge of at least 27,000 gallons was from the Lake Linden Leaching Plant of the Calumet Division of Universal Products. Discoloration of several acres of lake bottom indicated previous discharges of a larger magnitude.
2. Due to the delay between the spring spill and the tine of this investigation, no deleterious effects to the lakes waters, algae, benthic macroinvertebrates or fish could be ascertained.
3. Since 1970 chloride concentrations have decreased by more than a third to about 25 mg/1, due to lake flushing and the termination of mine dewatering.
4. Dissolved copper concentrations have remained relatively high (.04 - .08 mg/L) and similar to the 1970 levels of .05 mg/L."

(1973). I. B. Joralemon, Howell North Books. **The Copper Country**. 41-69. copper, Keweenaw Peninsula, history.

Historical overview of copper use and mining in the Keweenaw Peninsula from early Native American use through the 1930s.

(1973). D. G. Leddy, Michigan Technological University. **Factors Controlling Copper(II) Concentrations in the Keweenaw Waterway: A Project Completion Report**. Keweenaw Waterway, copper.

From the document:
"This study attempts to describe the most important factors involved in the solution chemistry of copper in the aquatic environment of the Keweenaw Waterway. Observations of Torch Lake from July, 1972 through January, 1973 suggest that a number of physical and chemical parameters have undergone striking changes since 1970."

(1973). J. M. Lopez Diaz. **Aqueous environmental chemistry of copper and other heavy metals in Torch Lake and selected waters of the Keweenaw Peninsula area of Lake Superior**. Thesis. University of Wisconsin, Master of Science. copper.

University of Wisconsin master's thesis analyzing the water quality of Torch Lake, particularly for copper and other heavy metals.

(1973). J. G. Prather. **Vegetative stabilization of reclaimed copper stamp-sands**. Thesis. Michigan Technological University, Master of Science.

(1973). T. D. Wright, et al, **Water Quality Alternation of Torch Lake, Michigan by Copper Leach Liquor**. Torch Lake, copper.

From the document:

"In the summer of 1972, Torch Lake was found to have very high Ievels of copper, carbonate alkalinity, pH and ammonia nitrogen in comparison to previous years. In addition, unusual oxygen depletion in the hypolimnion was noted. Bioassays indicated that portions of the lake were toxic to macroinvertebrates. Behavior of the chlorides in the lake indicated that observed conditions were not caused by accumulation in the basin, but probably resulted from spills of cupric ammonium carbonate known to have occurred in late fall 1971 and early summer 1972. Volumetric calculations indicate that the spill could have resulted in copper values much greater than those observed and could have (through conversion of ammonia nitrogen to nitrate nitrogen) been significantly involved in oxygen depletion. There is also evidence of change in the phytoplankton community, but the causal mechanism is not clear. Theoretical calculations indicate that Torch Lake, which has one of the highest copper concentrations in the United States, should not support aquatic life. That it does illustrates a hiatus in the role of various ionic species of copper and aquatic life."

(1974). D. A. Tomljanovich. **Growth Phenomena and Abnormalities of the Sauger, Stizostedion Canadense (Smith), of the Keweenaw Waterway**. Thesis. Michigan Technological University, Master of Science. fish.

From the abstract:

"This study began as an attempt to determine whether distinct populations of sauger, Stizostedion canadense (Smith), exhibiting different growth rates, existed within the Keweenaw Waterway and adjoining waters.... However, significant sexual differences in size prevailed throughout the waterway."

(1974). T. T. Virnig. **Long-Term Water Quality Analysis of Torch Lake, Michigan**. Thesis. Michigan Technological University, Master of Science.

From the abstract:

"This study was meant to elucidate the chemical condition of Torch Lake and the impact of past mining practices on it."

J. M. Lopez and G. F. Lee, ENVIRONMENTAL CHEMISTRY OF COPPER IN TORCH LAKE, MICHIGAN. *Water Air and Soil Pollution* **1977,** *8* (4), 373-385.

(1977). S. G. Shetron, et al, MDNR. **Establishing Vegetation on Alkaline Iron and Copper Tailings**.

The objective of this research was to determine if vegetation could be established on Alkaline Iron and Copper Tailings, and if so, how to effectively execute this vegetation. According to the Summary and Conclusions section of the report, it was found that "[the] wastes are capable of supporting vegetation, with additions of fertilizer to raise the available macronutrients to meet the demands of plants to be established."

(1977). R. H. Sypniewski. **Benthos, particle size composition, and sediment copper comparisons between the North and South Keweenaw Waterway Entries.** Thesis. Michigan Technological University, Master of Science.

K. J. Kraft, Pontoporeia distribution along the Keweenaw shore of Lake Superior affected by copper tailings. *Journal of Great Lakes Research* **1979,** *5* (1), 28-35.

(1981). L.M. Miller and Associates Consulting Engineers and Geologists. **Hydrogeolocical Evaluation for Houghton County Wastewater Disposal**. Lake Linden stamp sands, Tamarack stamp sands, wastewater treatment plant.

The purpose of this investigation is to determine the propriety of operating the wastewater treatment facilities utilizing one lined cell, one seepage cell and irrigation. Conclusions:

1) The utilization of a seepage cell at the Tamarack and Lake Linden disposal sites will maximize the aerobic soil zone beneath the wastewater lagoons.

2) Maintenance of an aerobic soil zone aids in the renovation of wastewaters and thus minimizes effects on ground and surface water quality.

3) Modest rates of irrigation (1± "/week) during the warm summer month periods of low soil moisture and high evapotranspiration will serve to provide an effective sink for the water applied and will further the management goal of maximizing the unsaturated zone thickness.

4) Irrigation would also serve to maintain the existing grasslands and therefore limit aeolian soil erosion potentials.

5) The overall quality of Torch Lake is good and will not be substantially altered as a result of implementing the proposed seepage cell disposal plan.

K. J. Kraft and R. H. Sypniewski, Effect of Sediment Copper on the Distribution of Benthic Macroinvertebrates in the Keweenaw Waterway. *Journal of Great Lakes Research* **1981,** *7* (3), 258-263.

From the document abstract:

"Benthic macroinvertebrates, sediment copper, and sediment particle size were examined in two areas of the Keweenaw Waterway. The north area is downdrift from deposits of copper tailings. South area sediment averaged 27% silt and clay and north area sediment 66%. South area sediment had an average copper content of 33 mg/kg and north area sediment 589 mg/kg. The number of invertebrates was 4.3 times greater in the south than the north. The average number of taxa at south stations was 20 and at north stations 8."

(1981). L. D. Lankton and C. K. Hyde, 78-83, 127, 133 144, 146, 147, 149, 151-154. Quincy Mining Company.

Overview of Quincy Mining Company operations.

(1981). B. M. Sabol. **Effects of copper-bearing stamp sands on benthic microbial decomposition**. Thesis. Michigan Technological University, Master of Science.

J. J. Black, et al, EPIZOOTIC NEOPLASMS IN FISHES FROM A LAKE POLLUTED BY COPPER MINING WASTES. *Journal of the National Cancer Institute* **1982,** *69* (4), 915-926.

Article discusses details of contamination of Torch Lake sauger and walleye. A revised manuscript of this article can also be found in the EPA disk.

(1983). J. Goffin, **Are Lake Linden residents drinking Torch Lake water?** Lake Linden, drinking water.

Article discusses residents' issues with quality of their drinking water (specifically taste and smell). Residents express concern that the cause is the use of water from the test wells, that are located "near Torch Lake in an area where water coming down from Calumet to the Traprock River and Hammell Creek empties into the lake."

(1983). G. R. Smith, Director of Michigan Department of Public Health. Personal Communication. R. W. Davis, U.S. Congressperson for Lake Linden in 1983. Lake Linden, drinking water.

Letter from MDPH to Congressman Davis explaining that despite pollution in Torch Lake, the public drinking water supply in Lake Linden is safe for consumption.

(1984). L. V. Coppa, U.S. Bureau of Mines. **Division of Minerals Availability Open File Report: Waste Disposal Activities and Practices: Copper, Lead. Zinc, Gold, and Silver Waste Disposal Activities and Practices in the United States**. copper disposal output.

Abstract from Report:

"This Bureau of Mines open file report is an inventory of the amount and type of mill tailings created from the lode-mine commodities (copper, lead, zinc, gold, and silver) on a State and county basis between the years 1911 and 1981. The report contains tables and base maps cataloging the amounts of tailings created in each county on a decade basis. Mine waste and mill tailings disposal practices and technological advances and changes in the milling are discussed. Also included is a discussion of the material content typical to tailings produced from these five commodities".

(1984). C. Courchaine, Chief, MDPH Division of Upper Peninsula. Personal Communication. A. C. Sause. Lake Linden, drinking water.

Information regarding safety of groundwater well in Lake Linden.

J. M. Glime and R. E. Keen, The importance of bryophytes in a man-centered world (Proceedings of the World Conference of Bryology, Tokyo, Japan, May 23-28,1983.Part 1.) -- (Recent Aspects of Physiology and Ecology.(Symposium 2)). *Journal of the Hattori Botanical Laboratory* **1984**, p133-146.

(1984). T. R. Harvey. Personal Communication. Village of Lake Linden. Torch Lake, Lake Linden, fish.

Letter from descendant of Lake Linden residents giving the Village of Lake Linden to use family health records to "help establish proof needed to get a massive clean-up of your lake to protect present and future generations there."

(1984). R. P. Juetten, District Fisheries Biologist, MDNR. Personal Communication. J. M. Aittama, Chairman, Lake Linden Village Water Committee. Torch Lake, Lake Linden, fish.

Letter from MDNR to Lake Linden explaining that restocking Torch Lake is not possible at this time due to tumors on fish and associated human health hazards.

(1984). D. G. Leddy. Personal Communication. S. Haralson, Village Clerk. Torch Lake, Lake Linden, recreation.

Letter from Michigan Tech to Lake Linden confirming Western Upper Peninsula District Health Department's decision that the beach may remain open despite the existence of the fish consumption advisory.

(1984). D. G. Leddy. Personal Communication. T. Thomas, U.S. EPA. sediment.

Letter enclosure includes data from a sediment study conducted by Michigan Tech in the Keweenaw Waterway.

(1984). C. Levin, U.S. Senator for Michigan. Personal Communication. J. M. Aittama, Chairman, Lake Linden Village Water Committee. Lake Linden, drinking water.

Letter from Senator Levin to Mr. Aittama regarding continued funding of studies of the water pollution problem in Torch Lake.

K. W. Malueg, et al., Toxicity of sediments from three metal-contaminated areas. *Environmental Toxicology and Chemistry* **1984,** *3* (2), 279-291.

From the abstract:

"Sediments from Phillips Chain of Lakes (Wisconsin), Torch Lake (Michigan), and Little Grizzly Creek System (California) were tested for acute toxicity using the water flea, Daphnia magna, and the burrowing mayfly nymph, Hexagenia limbata.... In general, numbers of organisms, biomass, species diversity and dominant types of organisms correlated with metal content and acute laboratory toxicity."

(1984). K. E. Rowe, Medical Director, WUPPDR. Personal Communication. V. Jolly, President, Village of Lake Linden. Torch Lake, Lake Linden, recreation.

Letter from WUPDHD to Village of Lake Linden confirming decision that the beach may remain open despite the fish consumption advisory.

(1984). A. C. Sause. **Preliminary Assessment, Michigan/R05-8312-05-327: Hubbell/Torch Lake (No U.S.E.P.A. Identification Number Assigned)**. Personal Communication. File/U.S. EPA Region V.

From document:

"The Michigan Dept. of Natural Resources (MDNR) has taken many samples of the water, fish and lake sediments with the last sampling in October, 1982. While the sediment and water samples from Torch Lake have a greater copper concentration than background sample from Lake Superior, the MDNR feels the copper concentration is not at a level which would be toxic to humans. Tumors have been detected in two species of fish, Saugers and Walleyes, and the MDNR has thoroughly investigated the triggering mechanisms of these tumors. To date, they do not know what has triggered the tumors in these fish, but feel it is not the copper concentration per se."

(1984). B. Swift, The Daily Mining Gazette. **Industrial discharge copper contaminated**. Torch Lake, PCI, wastewater.

PCI discharged copper-contaminated process waters into the sewer system.

(1984). B. Swift, The Daily Mining Gazette. **Copper-laden lagoon concerns Torch Lake officials**. Torch Lake, PCI, wastewater.

(1984). B. Swift, **Torch clean-up hits snag with PCB discovery**.

(1984 (inferred)). Lake Linden Village Water Committee. **Re: Torch Lake Trout Stocking**. Personal Communication. MDNR. Torch Lake, Lake Linden, fish.

Request to restock Torch Lake with Trout so that sport fishing can be restored, despite studies suggesting that this should not happen due to tumors found on fish.

(1986). D. H. Clarke, **Copper Mines of Keweenaw No. 14 Albany and Boston Mining Company**. 1-19. Copper, mining history

Synopsis of the operations of the Albany and Boston Mining Company.

(1986). E. D. Evans. Personal Communication. J. M. Aittama. Torch Lake, Lake Linden, fish.

Letter from MDNR to Village of Lake Linden stating conditions for fishing in Torch Lake. At this time, the tumors in the fish were subsiding, and the water quality was improving.

(1986). D. G. Leddy, et al., Michigan Technological University. **Torch Lake study: a project completion report prepared for the Michigan Department of Natural Resources**.

The report is comprised of 5 studies. Brief notes from each study follow:

1) Tumor Induction Study: Recognizing the high incidence of liver tumors in Torch Lake sauger and walleye, research was conducted to explore the possible connection between exposure to the flotation agents (xanthates and creosote) and the occurrence of liver tumors. Given the limited duration of this experiment, and the possibility that the micronodules could further differentiate, it is possible that exposure to/creosote could result in liver tumors.
2) Environmental Fate of Xanthates and Creosotes: Xanthates and creosotes, were studied to determine what their expected lifetimes would be in the Torch Lake environment and if they still persist in that environment. Xanthates would not be expected to persist in the environment beyond one year. The source of the PAH present could not be determined from this study but it is suspected that PAH detected came from combustion of solid and liquid fuels.
3) Tumor Incidence and Parasite Survey of Perch, Walleye and Sauger from Torch Lake: Twenty-five perch, walleye, and eleven sauger were examined for the presence and possible interrelationship of parasites and tumors. A direct relationship between the parasites and host tumors was not found. However, a physio-chemical association cannot be ruled out as the possibility of a carcinogenic relationship between hosts, parasites, and environmental pollutants exists.
4) Heavy Metals in Sediments and Mining Wastes of Torch Lake: Sediments and tailings adjacent to Torch Lake and airborne dust samples from above the tailings have been analyzed for metal concentrations and mineral compositions. Even though the sediments are contaminated with heavy metals, the metals do not readily dissolve into the water and Torch Lake is not directly contaminated with heavy metals. Winds from the lake stir up dust clouds from stampsands around the lake, but the most highly contaminated areas around Hubbell do not contribute much and it is unlikely that airborne heavy metals represent a serious human health problem.
5) Copper Budget for Torch Lake: A hydrologic and copper budget have been calculated to determine the amount and source of copper entering Torch Lake via its watershed and sediments. The budget shows that 32 of the total mass of copper input comes from precipitation on the lake surface, 96.5Z is from surface runoff, while only 0.5% is from the ground water. The annual input of dissolved copper from external sources is 2470 kilograms.

(1986 (inferred)). U.S. EPA (inferred). **National Priorities List Site**. Torch Lake, Superfund.

Paragraph describing the Torch Lake Superfund site. States presence of sediment contamination and fish tumors, status of remediation and reason for listing as a Superfund site.

(1986 (inferred)). W. I. Rose, Michigan Technological University. **Heavy Metals in Sediments and Mining Wastes of Torch Lake, Michigan**. Torch Lake, sediment, copper, metals.

From the document:
"The main objectives of this study are: 1) to determine the bulk chemical composition of the Torch Lake stamp sands and sediments; 2) record the distribution and identify the source or sources of any enriched toxic and/or mutagenic elements that occur in the Torch Lake sands and sediments; and 3) determine whether there is a potential health hazard to residents in the area as a result of the proximity of several towns to the stamp sand areas and the transport of tailings by wind. The sediments and sands of Torch Lake are significantly enriched in Cu, Pb, Sn, Zn, As, Rb, La, Cr, K, Zr, Ce, and Ba when compared to the local basalt bedrock of the area. These enrichments are probably natural. Large enrichments of Pb, Sn, Zn, and Cr in Torch Lake sediments are apparently due to dispersal of contaminated wastes (electrical debris and associated slag) at the old Torch Lake Copper Reclamation Plant near Hubbell. The heavy metals do not readily dissolve into the Torch Lake water and the water is not directly contaminated. Winds at Torch Lake stir up dust clouds from stamp sands around the lake, but the most strongly contaminated areas around Hubbell do not contribute much to the dust clouds and it is unlikely that airborne heavy metals represent a serious human health problem."

(1987). D. Klemans, State of Michigan Areas of Concern Coordinator. **Update on the Torch Lake AOC**. Personal Communication. Individuals interested in the Torch Lake Area of Concern. Torch Lake, Area of Concern, Beneficial Use Impairment, Fish Tumors.

Letter includes a status update on the Torch Lake AOC. It is recommended at this time that the fish consumption advisory be lifted based on the absence of tumors in the Sauger and Walleye. Particularly, they may have been caused by the presence of floatation chemicals in the lake, but those chemicals are no longer present in the water or sediment, and they should have degraded after six months. The enclosure also mentions the construction of wastewater lagoons on the stamp sands and the plan to provide wastewater treatment on the Trap Rock River.

(1987). MDNR. **Michigan Department of Natural Resources Remedial Action Plan for Torch Lake Area of Concern**. MDNR, Torch Lake, Area of Concern, Fish Tumors.

From the document summary:
"Two Impaired uses exist in Torch Lake at this time: a consumption advisory based on tumors in sauger and walleye and a degraded benthic macroinvertebrate community due to sediment copper toxicity.... A high incidence of liver

tumors have been found in sauger (100%) with lower incidences in walleye.... Tumor induction studies using fish revealed liver abnormalities when exposed to xanthates and creosote.... Copper concentrations in the water of Torch Lake are high due to natural loadings from its major tributary, the Trap Rock River, and the release of sediment bound copper. Copper concentrations in the water exceed the IJC water quality objective and Michigan's Water Quality Standard NPDES permit limitations. High concentrations of copper are widespread in Torch Lake and Portage Lake sediments. Near the smelter site on Torch Lake, lead, tin and zinc are also elevated in the sediments. The biotic communities of Torch Lake, other than benthic macroinvertebrates, do not seem to be greatly inhibited by the unusually high copper concentrations."

(1987). J. A. Spence. Personal Communication. T. D. Martin, Director, Office of the Great Lake, MDNR. Torch Lake, barrels.
Letter from Michigan Tech to MDNR requesting the investigation of barrels and other debris dumped into Torch Lake. Letter explains where barrels were found and that they may be linked a continued release of carcinogenic substances to the lake.

(1987). P. D. Zugger. **Michigan Water Resources Commission Authorization to Discharge Under the National Pollutant Discharge Elimination System**. Michigan Water Resources Commission. Torch Lake, PCI, NPDES.
Permit to PCI granted by the Michigan Water Resources Commission to discharge effluent via storm sewer into Torch Lake.

(1987, 2005). MDNR. **Torch Lake, Michigan Area of Concern**. Map. Torch Lake, Area of Concern.
Map of the Torch Lake Area of Concern

W. H. Clements, D. S. Cherry and J. Cairns, Structural alterations in aquatic insect communities exposed to copper in laboratory streams. *Environmental Toxicology and Chemistry* **1988,** *7* (9), 715-722.
From the abstract:
"The effects of copper on aquatic insect communities were examined using rock-filled trays colonized in the field for 30 d, transferred to laboratory streams, and dosed with CuSO4.... results [of the study] indicate that the artificial substrates employed in this study are amenable to experimental manipulation and will provide a unique opportunity to examine the community responses of aquatic insects to toxicants under environmentally realistic conditions."

(1988). C. Courchaine and D. J. De Grand. Personal Communication. J. Lee. Torch Lake, groundwater.
Enclosure contains the following:
1. Water well records for Sections 5-8, 17, and 19, T55N, R32W; Sections 12-14, 23, 24, 26, and 27, T55N, R33W; and Sections 31 and 32, T56N, R32W.
2. Copies of plat book pages for that area.
3. Lake Linden water supply Inventory (partial).
4. Chemical analysis results for Lake Linden wells including volatile organic chemicals, metals, herbicides, pesticides, and inorganic chemistry.
5. Mason (Osceola Township) water supply inventory.
6. Mason water supply chemical analysis results including volatile 1 organic chemicals, metals, and inorganic chemistry.

(1988). Donohue and Associates, Inc. **Torch Lake, Michigan Compository Summary**. U.S. EPA
This document is an overview of several aspects of the Torch Lake site. The summary includes overview of the following: history of environmental problems and studies, history of regulatory actions, history of response actions, hazardous materials sources and affected media, and regional and local site characteristics.

(1988). The Center for the Great Lakes and The Centre for the Great Lakes Foundation, **Fact Sheet Great Lakes Areas of Concern: Torch Lake, Michigan**. Torch Lake, Area of Concern.
Fact sheet describes BUIs and progress on the remedial action plan. At the time the IJC was concerned that the cause of the fish tumors had not been identified, that there was a lack of a plan to achieve the goal of eliminating the fish tumors, and that no monitoring, surveillance or remedial actions had been planned.

(1988). NPS. **Options for National Park Service Involvement in the Management of Historic Copper Mining Resources on Michigan's Keweenaw Peninsula**. mining history, National Park Service, Quincy, C&H.
From the document:
"This report presents several options for preserving and managing the historic copper mining resources on the Keweenaw Peninsula of Michigan. The document summary states the following options with the site designated as a National Historic Landmark: 1. Advisory/Coordinating Council with Congressional Trust; 2. Foundation with Recurring

Funding; 3. National Historic Sites with Historic Preservation Commission; 4. National Historical Park."

(1988). J. A. Spence, **THE KEWEENAW WATERWAY: A status report with suggested remedial investigation and feasibility study options for developing a comprehensive remedial action plan.** Keweenaw Waterway, remedial investigation.

Report describes physical conditions in Torch Lake and also status of investigations on benthics. Summary from Report:

"An extensive body of information exists concerning the many environmental problems of Torch Lake (see attached bibliography). However, the causative agent(s) for tumors in the resident fish populations has not yet been identified and conflicting evidence exists for both increases and decreases in tumor incidence. One preliminary study indicated that bottom sediments may be carcinogenic in mammals but more carefully controlled studies have not been carried out. Vegetative stabilization of the stampsands has not been very successful though experience to date has delineated problem areas and points to possible solutions. The existence of heavy metal contaminants in enriched onshore stampsands and lake sediments has been verified qualitatively but not yet quantified. Magnetometry studies along the perimeter of a rumored barrel dump site in the Tamarack stampsands has revealed the presence of several magnetic anomalies that have a high probability of being barrels."

(1989). U.S. EPA **Superfund Fact Sheet Torch Lake Superfund Site Houghton County, Michigan**. U.S. EPA. Torch Lake, U.S. EPA, Superfund.

This appears to be the first Superfund Fact Sheet created about Torch Lake. The sheet gives background on the industrial history of the site, what contamination the industrial activities caused, and what Remedial Investigation / Feasibility Study activities are planned for the site.

(1989). A. A. Anderson and F. C. Beodray. **Re: Torch Lake**. Personal Communication. J. B. Lee. Torch Lake, groundwater.

Enclosure contains well/sample data sheets that were completed from July 17-21, 1989.

(1989). Donohue and Associates, U.S. EPA. **Volume 2: Field Sampling Plan: Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan Revision I**.

From the document:

"The purpose of the RI field investigation activities described in this Field Sampling Plan (FSP) is to satisfy the data needs associated with the following objectives:

1. Characterize the nature and extent of contaminant sources in Operable Unit (OU) I and II.

2. Determine the potential for contaminant migration by identifying and evaluating chemical and physical processes affecting migration.

3. Provide data needed to evaluate human health risk associated with the site.

4. Provide data necessary to assess the feasibility and cost effectiveness of remedial action alternatives."

The field investigation activities described include sampling the following media: drums, tailings, soil, air, sediment, floc, surface water, groundwater, and biota.

(1989). Donohue and Associates, Inc., U.S. EPA. **Volume 1a: Final Work Plan: Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan Revision 1**. Torch Lake, Superfund, Remedial Investigation.

From the document:

"Donohue & Associates, Inc. (Donohue) is submitting this Work Plan to the U.S. Environmental Protection Agency (EPA) to conduct a Remedial Investigation/Feasibility Study (RI/FS) for the Torch Lake site in response to Work Assignment No. 02-5LS8 under Region V ARCS Program Contract No. 68-W8-0093....

This Work Plan and the associated project control plans are contained in five volumes. Volume 1A presents the technical scope of work and includes a discussion of the site background and setting, an initial evaluation of the site including the types and volumes of waste present and the potential pathways of contaminant migration, the Work Plan rationale including data quality objectives and data needs, and the Work Plan approach. Also included in Volume 1A are a discussion of the 15 RI/FS tasks to be completed, a schedule for completion of the tasks, and a discussion of project management. The Preliminary Endangerment Assessment and Endangerment Assessment Plan are included in Appendices A and B, respectively. The costs and key assumptions associated with the RI/FS are contained in Volume IB."

(1989). Donohue and Associates, Inc. U.S. EPA. **Volume 4: Health And Safety Plan: Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan Revision 1**. Torch Lake, Superfund, Remedial Investigation.

From the document:

"This Health and Safety Plan (HASP) has been prepared in accordance with the ARCS V Program Health and Safety Guideline HAS-1, and the regulatory requirements of 29 CFR 1910.120, "Hazardous Waste Operations and Emergency

Response." It addresses those activities associated with the Remedial Investigation/Feasibility Study (RI/FS) to be conducted at Torch Lake in Houghton County, Michigan, under U.S. Environmental Protection Agency (EPA) Work Assignment 02-5LS8. The HASP will be implemented by the Health and Safety Officer (HSO) and the Assistant HSO during site work."

(1989). Donohue and Associates, Inc. U.S. EPA. **Volume 3: Quality Assurance Project Plan For Phase 1 Remedial Investigation Activities: Torch Lake Remedial Investigation/Feasibility Study, Houghton County, Michigan, Revision 1**. Torch Lake, Superfund, Remedial Investigation.

From the document:
"The purpose of a Quality Assurance Project Plan (QAPP) is to present the planned system of activities and expected level of data quality for the site. The precision, accuracy, completeness, representativeness, and comparability of the environmental data collected must be known and documented according to this plan. Presented in this QAPP are the personnel responsible for quality assurance, the data quality objectives, and the specific quality control measures to be taken to reach the objectives."

(1989). Donohue and Associates, Inc., U.S. EPA. **Revisions/Additions to Field Sampling Plan**. Torch Lake, Superfund, Remedial Investigation.

Describes revisions to soil and air sampling plans that were outlined in Volume 2 of the final work plan: the Field Sampling Plan.

(1989). U. S. EPA, **EPA: Water From Mason and Lake Linden Municipal Wells OK To Drink**. Torch Lake, groundwater.

This was an EPA news release.

(1989). E. Evans. **Review Comments MTU Torch Lake Report**. Personal Communication. J. M. Aittama. Torch Lake, MTU report.

Contains comments on the 1986 MTU report. Critiques on sampling and analysis methods as well as flaws in the report are provided by MDNR staff.

(1989). E. Evans. **Torch Lake — Portage Lake Fish Tumor Data**. Personal Communication. J. Hesse. Torch Lake, fish tumors.

Data strongly suggest that liver tumor inducing agents above background concentrations no longer exist in the Torch Lake — Portage Lake fishery.

(1989). Weston/Gulf Coast Laboratories. Personal Communication. M. O'Mara, Roy F. Weston Incorporated.

Sample analysis results from what appears to be a groundwater study conducted by Weston.

(1989). T. Irvin. **Torch Lake Air Monitoring**. Personal Communication. D. Gruben. Torch Lake, air sampling.

Enclosure contains data from air sampling.

(1989). J. D. Maletzke. **Documentation of Soil/Tailings Samples during Phase 1 RI Work at the Torch Lake Super fund Site Houghton County. Michigan Donohue Project No. 20011.031**. Personal Communication. L. Ransome, et al., Torch Lake, Remedial Investigation, sampling.

This memo details the documentation of the samples, including sample identification numbers, completion of EPA sample tags, chain-of-custody forms, and packing and transport to Donohue Analytical in Sheboygan, Wisconsin.

(1989). J. D. Maletzke. **Operable Unit III (OU-III) Archive Search and Field Reconnaissance (August 24 and 25, 1989) Torch Lake Superfund Site Houghton County, Michigan Donohue Project Mo. 20011.031**. Personal Communication. L. Ransome, et al.

The source of OU-III tailings and stampsand piles were from various stamp mills and smelters associated with respective mines. OU-III tailings and stampsands apparently do not represent any reprocessing and subsequent redistribution.

(1989). J. D. Maletzke. **Soil/Tailings Sample Shipment Phase I RI Work Torch Lake Superfund Site Houghton County, Michigan Donohue Project No. 20011.031**. Personal Communication. L. Ransome, L. Trick, R. Stenson, M. Whittington and J. Lee. mine tailings.

Memo concerns logistics of sample transport from field to lab.

(1989). P. B. Markelz, Donohue, U.S. EPA (inferred). **Site-Specific Health and Safety Plan Torch Lake Geophysical Investigation**. Superfund.

(1989). Roy F. Weston, Inc., U.S. EPA. **Drum Search: Torch Lake Drum, Houghton Michigan**.

From the document:
"The objective of this investigation was to locate submerged drums in Torch Lake. Once these drums were located, a Remotely Operated Vehicle (ROV) with a video camera was used to enumerate and determine whether the drums were intact. Water samples were obtained to help determine whether any hazardous substances had entered the lake environment.

The drums found both on shore and in the lake were either empty or contained solidified substances. Since the water analysis and water quality study did not indicate any disturbances, the contents of the drums were either diluted below the detection limits, were not soluble in water, or were contaminants that would not be detected by the analysis used."

(1989). D. Ray. Personal Communication. J. Lee. Torch Lake, Area of Concern.
Enclosure contains fact sheet about Torch Lake AOC, the BUIs and the RAP.

(1989). D. Rector, Deputy Director, MDNR. Personal Communication. V. V. Adamkus, Regional Administrator, U.S. EPA, Region V. Torch Lake, air sampling.
Enclosed is the State of Michigan's Multi-Site Cooperative Agreement, Amendment V005843-01-6, for Technical Assistance to the U.S. Environmental Protection Agency on the Torch Lake air sampling program.

(1989). S. Reith. **EPA Region V ARCS Contract 68-W8-0093, EPA Work Assignment No. 02-5LS8, Donohue Project No. 20011.002, Torch Lake CR Trip Information**. Personal Communication. M. A. Croce et al.. Torch Lake, community relations.
Memo from Donohue to EPA concerning a community relations trip in Houghton County in March 1989.

(1989). D. Richardson. **Health and Safety Program at Torch Lake (Donohue Project No. 20011)**. Personal Communication. P. Markelz, et al.. Torch Lake, Remedial Investigation, health and safety.
This memorandum describes the health and safety procedures Implemented during the Phase I Field Program at Torch Lake, Houghton, Michigan.

(1989). D. Richardson et al. **Surface Tailing Sampling at Torch Lake, Houghton. Michigan**. Personal Communication. L. Ransome, R. Stenson and L. Trick. Torch Lake, sediment, sampling procedures.
This memorandum describes the procedures, documentation, packaging, and decontamination of equipment employed during the surface tailings sampling at Torch Lake, Hough ton, Michigan.

(1989). R. Stenson. **U.S. Bureau of Mines Site Visit Torch Lake Superfund Site Houghton County, Michigan Donohue Project No. 20011.031**. Personal Communication. L. Ransome. Torch Lake, mine tailings, U.S. Bureau of Mines.
Communication within Donohue & Associates that the U.S. Bureau of Mines is visiting Torch Lake as part of their research on mine tailings disposal in water as a means of eliminating the oxidation and leaching which occurs when tailings are exposed to the atmosphere.

(1989). R. Stenson. **Torch Lake Superfund Site Houghton County, MI Donohue Project No. 20011.031: Shallow Surface Tailings Sampling**. Personal Communication. L. Ransome. Torch Lake, mine tailings.
This memo describes the shallow subsurface tailing sampling program.

(1989). R. Stenson and D. Richardson. **EPA Region V ARCS Program Donohue Project No. 20011.031: Inventory of Existing Wells, Torch Lake. Torch Lake Superfund Site Houghton County. Michigan**. Personal Communication. L. Ransome. Torch Lake, groundwater.
"This memorandum describes the well inventory conducted from August 22 to August 24, 1989. The Lake Linden Lagoon water table varies from 604.12 feet In L-l (background well) to 601.32 feet in L-3 which Is a difference of 2.8 feet. Wells L-2 through L-6 are in the lagoon area and the water table elevation varies by 1.15 feet. The depth of the wells vary from 1982 to the present (Table 1). The maximum change is 5.91 feet in L-2. It is unclear if the well has silted in or if our popper was caught on the top of the screen. Water level measurements at the Tamarack Lagoon monitoring wells indicate a 3-foot difference in the water table from 604.16 feet in T-l (background well) and T-6 to 600.85 feet In T-4. The depth to the bottom of the wells has changed since 1982 by approximately 4 to 4.5 feet (Table 2). It is unclear if the veil has filled with sediment or if the popper was caught on top of the screen. However T-l, the background well, has not changed in depth since 1982".

(1989). R. Teoh. **RI/FS air sampling at Torch Lake site, Houghton County**. Personal Communication. D. Gruben. Torch Lake,

Superfund, Remedial Investigation, air sampling.

Communication within MDNR containing Torch Lake air sampling program.

(1989 (inferred)). ATSDR, United States Public Health Service. **Preliminary Health Assessment for Torch Lake, CERCLIS No. MID980901946, Houghton County, Michigan**. Torch Lake, public health.

From the document:
"Based upon the information reviewed, this site is of potential public health concern because of the risk to human health that could result from the possible exposure to presently unknown etiologic agents at the levels that may result in adverse health effects over time.... Although Torch Lake is polluted with copper and other contaminants, no known health effects have been linked to the problem. The incidence of cancer deaths over a period from 1970 to 1981 Indicates that all but stomach cancer were at or below the state average for age-adjusted cancer mortality.... Rumors regarding the dumping of chemicals and barrels into the lake during the 1950's and 1960's should be investigated.... Fish populations in Torch Lake should be studied to determine: (1) if other species have abnormally high incidence of tumors, as do the walleye and sauger, (2) the causative agent of the tumors, (3) why certain species are apparently unable to reproduce in the lake, and (4) the risk to human health from the consumption of the fish...."

(1989 (inferred)). T. J. Kubiak, U.S. Fish and Wildlife Service. **PROPOSAL: Reproduction in Gulls and Bald Eagles in the High Copper Environment of Torch Lake, Michigan**. Torch Lake, copper, Gulls, Bald Eagles.

The objectives of the study, as detailed in the following section of the proposed monitoring program, are as follows:
o Determine reproductive success in resident colonies of Herring gull and ring-billed gull.
o Measure exposure via forage items and embryonic exposure via egg content analyses of copper.
o Compare productivity and egg copper levels on site and with existing information- base.

(1990). **Federal Register**. Health Hazards.

Federal register entry on the system to rank human health hazards through overland/flood migration and groundwater to surface water migration.

(1990). P. C. Baumann, et al., U.S. EPA. **Effects of High Copper Concentrations on Reproduction by Yellow Perch in Torch Lake, Michigan**. Torch Lake, Superfund, copper, fish.

From the document:
"It was hypothesized that the elevated levels copper in Torch Lake led to the decline of the Walleye and Sauger populations with little or no recruitment. This study used yellow perch (Perca flavescens) to determine if chronic exposure to elevated copper concentrations has reduced the reproductive success of percids. Although copper concentrations found in Torch Lake did not significantly reduce hatching success, a larger sample size may have revealed different results. P values of $p = 0.157$ and $p = 0.10$ suggest that more data may indicate a significant difference in hatching success. Duration of hatching was significantly longer for Torch Lake egg masses than was for reference lake egg masses, indicating that copper may be affecting hatching rates."

(1990). Donohue and Associates, Inc., U.S. EPA. **Final Community Relations Plan Torch Lake Superfund Site Houghton County, Michigan**. Superfund, community relations.

From the document:
"This Community Relations Plan (CRP) presents an overview of the community concerns regarding the Torch Lake Superfund site and a description of community relations activities that the U.S. Environmental Protection Agency (U.S. EPA) will conduct during the Remedial Investigation/Feasibility Study (RI/FS) process." (page 1) Planned activities listed on pages 14-16 of the document are the following: "(1) Designate a central contact person at U.S. EPA... (2) Establish an information repository... (3) Develop a mailing list of individuals and organizations interested in receiving information regarding the site... (4) Contact local newspapers, radio stations, and television stations for news releases... (5) Develop and distribute fact sheets during the RI/FS process... (6) Provide information about public health... (7) Hold public meetings... (8) Provide opportunities for the public to comment on the remedial actions proposed for the site... (9) Prepare a responsiveness summary... (10) Announce and explain the selected remedial action."

(1990). Donohue and Associates, Inc., U.S. EPA. **Volume 3 Final Quality Assurance Project Plan for Operable Unit II Remedial Investigation Activities - Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**.

(1990). Donohue and Associates, Inc., U.S. EPA. **Volume 2: Final Field Sampling Plan Revision 2 - Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**. Superfund, remedial investigation.

Describes activities planned for sampling tailings, soil, air, surface water, sediment, and groundwater. Addendum appears to include revisions to the following sections: Section 4 - Media Specific Sampling Plans; Section 5 - Sample

Identification Numbers; Section 6 - Chain of Custody; Section 7 - Packaging and Shipping; and the appendices.

(1990). Donohue and Associates, Inc., U.S. EPA. **Volume 4: Final Health And Safety Plan Revision 2 - Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**.

(1990). Donohue and Associates, Inc., U.S. EPA. **Volume IA: Final Work Plan Revision 2 - Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**. Superfund, remedial investigation.

From the document executive summary (page vi):
"This work plan and the associated project control plans are contained in five volumes. Volume 1A presents the technical scope of work and includes a discussion of the site background and setting/ an initial evaluation of 'the site including the types and volumes of waste present and potential pathways of contaminant migration/ and the work plan rationale and approach. Also included in Volume 1A are a discussion of the 15 RI/FS tasks to be completed, a schedule for completion of the tasks, and a discussion of project management."

Also according to the document, Revision 2 specifically accounts for the addition of project plans for OU II.

(1990). Donohue and Associates, Inc., U.S. EPA. **Final Remedial Investigation Report Operable Unit I - Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**.

Conclusions from the remedial investigation include the level of human health risk of surface tailings and slag materials, debris and drum deposits, physical characteristics of submerged tailings, groundwater contamination by inorganic compounds, contamination at a "hot spot" at Hubbell, contamination of surface waters, and human health risk of groundwater.

(1990). U. S. EPA. **Guidance on Remedial Actions for Superfund Sites with PCB Contamination**. Superfund, PCB, groundwater MCL.

(1990). U. S. EPA. **Early Findings from 1989 Torch Lake Investigation Available; Further Studies Planned For This Summer**. United States Environmental Protection Agency, R. Office of Public Affairs. Torch Lake, Superfund, public outreach.

News release.

(1990). D. Gruben. Personal Communication. B. Wilder.

(1990). E. Helmer, Ecologist. **Torch Lake NPL Site Photos from Wetlands Investigation**. Personal Communication. J. Lee, remedial Project Manager. Torch Lake, Superfund, wetlands, photos.

Enclosure includes photos taken during August, 1990 wetlands investigation. These photos go with the Wetlands Investigation Report dated October 19, 1990.

(1990). E. Helmer and D. Beltman, U.S. EPA. **Torch Lake NPL Site Wetlands Investigation**. Superfund, wetlands, OU I, OU II.

There is a memo at the beginning of the document that summarizes the report. The findings include the following:
"1. Wetlands were developing over some tailings around Torch Lake, usually near stream inlets.
2. Natural wetland area near the southern and southeastern portion of the lake do not seem to be affected by tailings deposits.
3. Some possible natural wetlands near Lake Linden may be affected by tailings deposits.
4. Wetland areas around Boston Pond may have been filled in with tailings."
Recommendations include the following:
"1. Apparent natural wetland areas around Boston Pond, the Portage Canal and the "MTU pile" may require restoration and enhancement activities depending on their size.
2. Boston Pond does not necessarily require restoration/enhancement activities because filling occurred before 1975 (and therefore the filling activities were not subject to Section 404 of the Clean Water Act)."

(1990). J. L. Hesse. Personal Communication. W. F. Nied. Torch Lake, AOC, BUI, fish consumption advisory.

Letter stating that the fish consumption advisory can be removed and that the sunken drums need to be further investigated before determining if they must be removed.

(1990). R. T. Kavetsky, Acting Field Supervisor, USFWS. Personal Communication. J. Lee, Remedial Project Manager, U.S. EPA. Superfund, eagles, gulls.

Memo from USFWS to U.S. EPA describes sampling of eagles, gulls and yellow perch. Hatching rates for eagles and gulls were are normal levels, while the hatching rate for yellow perch increased.

(1990). M. A. Kuehl and I. Donohue and Associates, U.S. EPA. **Addendum No. 1 To Quality Assurance Project Plan For Phase 1 Remedial Investigation Activities Torch Lake RI/FS Houghton County, Michigan**. Superfund, remedial investigation.

This addendum to the QAPP was prepared as a result of a meeting regarding data quality objectives and format involving the EPA RPM.

(1990). J. D. Maletzke. **Boring Geotechnical Sampling and Monitoring Well Installation, Torch Lake Superfund Site Houghton County, Michigan Donohue Project No. 20011.230**. Personal Communication. L. Ransome, Site Manager. Superfund, OUII.

Sampling locations and methods are described. Enclosure includes field forms.

(1990). J. D. Maletzke, et al.. **Operable Unit III Tailings Sampling Torch Lake Superfund Site Houghton County, Michigan Donohue Project No. 20011.330**. Personal Communication. L. Ransome. Superfund, OUIII.

Sampling procedures and locations were described.

(1990). MDNR, **Staff Report: Fish Growth Anomalies in Torch and Portage Lakes 1974-1988 Houghton County, Michigan**. Torch Lake, fish.

"The purpose of this report is to present the fish contaminant and tumor data and compare it to other data where appropriate. Only four (4) of the 56 fish samples analyzed for mercury had concentrations that exceeded the 0.5 mg/kg consumption advisory action limit and none exceeded 1.0 mg/kg. The incidence of liver neoplasms has apparently declined and may now be near normal background levels, however, additional study is needed to more accurately determine normal or background tumor frequencies, especially in older and larger fish. Saugers were not collected in 1988 following an extended period of population decline which began in the 1960's. Sauger are a turbid water fish and once the waters cleared, as copper ore milling decreased and then stopped, sauger were apparently no longer able to outcompete other game fish. Bloassays of the water and sediments of Torch Lake, have not indicated the presence of a carcinogenic substance. The data do not support the basis for the continuance of this specific fish consumption advisory."

(1990). U.S. Bureau of Mines. **Torch Lake Tailings Leachability Evaluation**. Torch Lake, metals, U.S. Bureau of Mines.

From the document overview (page 1):

"The Spokane Research Center (SRC) has performed laboratory evaluations of tailings and water samples from Torch Lake and vicinity to aid in determining the potential for metals to adversely affect Torch Lake. This laboratory evaluation does not include an assessment of potential discharge from drums or other industrial chemicals within the tailings or potential for concentration of metals in lake waters through metal-organic complexation or other biological processes."

From the document conclusions (page 6):

"In general, metal concentrations in leachates from the samples were extremely low when compared[sic] to tailings at over 30 other sites studied at SRC (see reference list). This is attributable to the tailings being highly oxidized and originating from a non-sulfide ore body. Results indicate that very little metal is being released from the Torch Lake tailings.

However, this evaluation did not include an assessment of potential discharge from drums or other industrial chemicals within the tailings or potential for concentration of metals in lake waters through metal-organic complexation or other biological processes."

(1990). U.S. Bureau of Mines. **Metal Contamination Characteristics of Subaqueous Tailings at Torch Lake**. Torch Lake, metals, U.S. Bureau of Mines.

This document is a duplicate of the Torch Lake Tailings Leachability Evaluation with a cover letter from the Bureau of Mines to the EPA attached. There are also six pages of what appears to be another document, which is what this entry is named for.

(1990). K. Rubsam. **Groundwater Sampling Torch Lake Superfund Site Houghton County, Michigan Donohue Project No. 20011.230**. Personal Communication. L. Ransome, Site Manager. Torch Lake, Superfund, Operable Unit II, groundwater.

This technical memorandum describes sampling procedures, documents data collection, and notes deviation from project plans. Prior to sample collection, static water levels and depth to bottom measurements were recorded for each well. The pump was started and initial pH, conductivity, temperature, color, odor, and turbidity measurements were recorded.

(1990). P. C. Eder Associates Consulting Engineers, **Draft Health and Safety Plan, Torch Lake, Keweenaw Peninsula, Michigan**. Superfund, remedial investigation.

(1990). Weston, Inc., U.S. EPA. **Site Assessment for Torch Lake, Houghton County, Michigan**. Superfund.

This report includes an overview of the physical conditions of the site, the results and methods of the drum, groundwater and soil sampling that has taken place up to that time, and the concluded threats to human health and the environment.

(1990). Weston, Inc.. **Torch Lake Site Investigation, Hubbell, Michigan**. Personal Communication. D. Heaton and U.S. EPA. Superfund, OUI, drums.

Report on methods, locations and results of drum sampling. Various organic chemicals, including VOCs, were found.

(1990 (inferred)). M. Vendl, U.S. EPA. **TORCH LAKE HOUGHTON COUNTY, MICHIGAN Ground Penetrating Radar Survey May 9-11, 1989**. Torch Lake, drums.

A ground penetrating radar (GPR) survey was conducted at Torch Lake, Houghton County, Michigan on May 9-11, 1989. This survey was conducted by geologists with the Technical Support Unit, Waste Management Division, Region V, U.S. Environmental Protection Agency, with the purpose of locating possible buried drums at three separate locations near Torch Lake as well as 1n the lake itself. It was found that a number of point targets were located both on the bottom of Torch Lake, and in the mine tailings at the three sites that may or may not be drums. The targets on the bottom of Torch Lake and at the Sewage Pond site have the most likelihood of being drums. Only test pits can verify this.

(1991). Ebasco Environmental (inferred) and Donohue and Associates, Inc., U.S. EPA. **Alternative Array Memo: Torch Lake Rl/FS Houghton County, Michigan**. Superfund, OUI, OUIII, Feasibility Study.

Purpose, from page 1-1 of the document:
"The purpose of this alternative array memo is to summarize the identification, screening and evaluation of remedial technologies, and to present preliminary potential Applicable or Relevant and Appropriate Requirements (ARARs) which are relevant for the feasibility study of residual copper tailings and slag piles at the Torch Lake Site."

(1991). R. E. Bartlet, Geraghty & Miller, Inc. **Scope of Work Outline for Drum Removal Effort**. Personal Communication. W. Nied, On-Scene Coordinator, U.S. EPA and P. Felitti, Assistant Regional Counsel, U.S. EPA. Torch Lake, drums.

Outlines drum sampling plan. Proposed date of sampling not specified. Activities outlined in the document include the following (from the document):

"1) Stage all visible drums, sample the drums, and remove those containing hazardous materials.
2) Sample drum location soils and remove aft soils contaminated with Hazardous Substances.
3) Conduct a geophysical investigation to determine If any buried drums are located on site including offshore to a depth of 30 feet.
4) Conduct an underwater survey to determine if any drums are located along the shoreline in Torch Lake to a depth of 30 feet contiguous to Respondent's property or place of business operation."

(1991). S. Casey. Personal Communication. R. H. Haralson. Torch Lake, PCI, wastewater.

Enclosure gives results of PCI wastewater sample analysis. To PCI from MDNR.

(1991). Donohue and Associates, Inc., U.S. EPA. **Volume 2 Appendices A, B, and C, Draft Remedial Investigation Report Operable Unit II, Torch Lake Remedial Investigation / Feasibility Study, Houghton County, Michigan**. Superfund, remedial investigation, Operable Unit II.

Appendices for the OU II Remedial Investigation report. Appendix A consists of technical memoranda associated with field sampling. Appendix B consists of technical evaluation memoranda. Appendix C consists of analytical chemistry data tables, in which metal and organic chemical sampling results can be found.

(1991). Donohue and Associates, Inc., U.S. EPA. **Final Remedial Investigation Report Operable Unit I - Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**. Superfund, remedial investigation, Operable Unit I.

From the document:
"This baseline risk assessment (risk assessment) is an analysis of the potential adverse health effects (current and future) resulting from releases of hazardous substances from tailings deposited on the western shore of Torch Lake."

(page 1-1)

"Based on a review of site conditions including land use, contamination patterns and human activity patterns, the populations most likely to be exposed are:
• Current and future off-site residents (adults and children).
• Workers - lagoon and sludge spreaders.
• Campers (adults and children).
• Future on-site residents.

The most important exposure pathways are judged to be
• Inhalation of particulates from the contaminated tailings.
• Ingestion of contaminated tailings." (page 7-2)

(1991). Donohue and Associates, Inc., U.S. EPA. **Amendment No. 1 To Final Work Plan (Revision 2) - Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**. Superfund, remedial investigation.

From the document:
"This Amendment (No. 1) to the FINAL WORK PLAN (Revision 2) for the Torch Lake Remedial Investigation/Feasibility Study addresses changes to the Work Plan as authorized in Work Authorization Form (WAF) 02-5LS8, Revision 12. These changes include proposed supplemental sampling of surface waters and sediments along the Keweenaw Waterway as part of the Operable Unit II Remedial Investigation and limited approach feasibility study for a slag pile in Operable Unit I. In addition/ this addendum addresses changes for the baseline risk assessment for OU I, as specified and authorized by the RPM. The costs and LOE associated with this amendment are presented in the Cost Pricing Proposal, Revision 3." (page 1)

(1991). Donohue and Associates, Inc., U.S. EPA. **Addendum No. 1: Final Remedial Investigation Report Operable Unit I - Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**. Superfund, remedial investigation, Operable Unit I, drums.

From the document:
"This addendum summarizes test pit excavations performed to supplement geophysical data to locate potential buried drums in OU I tailings. This introductory section briefly summarizes the 1989 geophysical survey activities documented in the Torch Lake Superfund RI Report (Donohue, 1990). Subsequent addendum sections present details of test pit excavation procedures, results, and conclusions." (page 1)

(1991). Donohue and Associates, Inc., U.S. EPA. **Addendum No. 1: Final Field Sampling Plan Revision 2 - Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**.

The difference between this document and its original is unclear.

(1991). Donohue and Associates, Inc., U.S. EPA. **Addendum: Final Quality Assurance Project Plan For Operable Unit II Remedial Investigation Activities - Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**. Superfund, Remedial investigation, OUII.

From Section 3.1: Project Description Introduction:
"The purpose of this Quality Assurance Project Plan {QAPPJ Addendum is to document the necessary modifications to the existing approved QAPP dated June 1990 to provide for the collection and chemical analysis of additional surface water, sediment, and smelter slag samples to further define the Operable Unit II Keweenaw Waterway as described in the Work Plan Addendum. Only those sections of the approved QAPP that apply to the addition of surface water, sediment, and slag locations to the sampling and analysis program are included in this addendum."

(1991). Donohue and Associates, Inc., U.S. EPA. **Amendment No. 1a To Final Work Plan (Revision 2) Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**. Superfund, remedial investigation.

From the document:
"This Amendment (No. 1) to the FINAL WORK PLAN (Revision 2) for the Torch Lake Remedial Investigation/Feasibility Study addresses changes to the Work Plan as authorized in Work Authorization Form (WAF) 02~5LS8, Revision 12. These changes include proposed supplemental sampling of surface waters and sediments along the Keweenaw Waterway as part of the Operable Unit II Remedial Investigation and limited approach feasibility study for a slag pile in Operable Unit X. In addition, this addendum addresses changes for the baseline risk assessment for OU I, as specified and authorized by the RPM. The costs and LOB associated with this amendment are presented in the Cost Pricing Proposal, Revision 3." (page 1)

(1991). P. Drake, U.S. Bureau of Mines. Personal Communication. J. B. Lee, U.S. EPA. Torch Lake, stamp sands.

Enclosure includes the assay results for the twenty-four solid samples that were collected during the February 1991 sampling trip. The results of a "maximum leachability assay" on each of the solid samples are given in the attached table.

(1991). E. J. Dupuis. **Torch Lake Superfund Site (Public Input)**. Personal Communication. U.S. EPA. Torch Lake, drums, public outreach.

Letter from resident requesting that an area near the Lake Linden swim area be investigated due to the presence of heavy black sludge found there during the recovery of a dead body a few years earlier.

(1991). U. S. EPA. **Superfund Program Information Update: Torch Lake Superfund Site, Houghton County, Michigan**. Torch Lake, Superfund.

Fact sheet updating stakeholder on status of Superfund actions on Torch Lake. Includes a description of the Superfund process, what the individual Operable Units are, the announcement that the first cleanup plan should be complete by the next year, a discussion of the drum removal, and the announcement of a public meeting.

(1991). Geraghty & Miller, Inc., Universal Oil Products Company, Inc. et al. **Final Work Plan Torch Lake Drum Removal Houghton County, Michigan**. Superfund, drums.

This is the Work Plan developed by the lawyers of the parties identified as responsible for the cleanup of the drums in the Torch Lake site. The plan describes the following tasks: contractor procurement, terrestrial drum removal, contaminated soil removal, offshore geophysical investigation, underwater survey, underwater drum removal, hazardous material disposal, and reporting. Also included in the report is a Health and Safety Plan and a Sampling and Analysis Plan.

(1991). D. Gruben. Personal Communication. J. Lee. Torch Lake, soil samples.

Enclosure contains various soil sample results.

(1991). T. Hartsig, Donohue Site Manager. **EPA Region V ARCS Contract No.- 68-W8-0093, EPA Work Assignment No. 02-5LS8, Donohue Project No. 20011, Torch Lake RI/FS: Addendum No. 2. Final Field Sampling Plan Smelter Slag and Groundwater Sampling Plan Torch Lake Superfund Site Houghton County. Michigan**. Personal Communication. J. Lee, EPA Region V RPM. Torch Lake, Superfund, Remedial Investigation.

This memorandum describes standard procedures to be followed while collecting soil samples at OU III Location 6 (Quincy Smelter) and groundwater samples at OU III Location 7 (Isle Royale Tailings).

(1991). T. Irvin, Site Management Unit 3 ERD. **Torch Lake**. Personal Communication. D. Gruben, Site Management Unit 2 ERD. Torch Lake, Superfund, arsenic, cyanide.

Memo within MDNR stating that an informant told the author of arsenic and cyanide discharge points to the Portage Canal that existed during the operation of the Quincy stamp mill and smelter.

(1991). R. Komula, **EPA Finds Barrels in Torch Lake**. Torch Lake, barrels.

Article describes drum search and removal activities in Mason, Hubbell, Tamarack City and Lake Linden.

(1991). K. D. Kozie and T. J. Kubiak, USFWS, U.S. EPA. **Reproduction in Bald Eagles and Gulls in the High Copper Environment of Torch Lake, Michigan**.

Gulls and Bald Eagles feed on Torch Lake fish. Short-term reproductive biology appears normal. Long-term productivity on Portage Lake Bald Eagle nest is poor but this is an old problem (since at least 1981) but this may be due to organochlorine and/or PCB contamination. In short, analysis results do not show that copper contamination is the cause for reproductive issues in gulls and Bald Eagles, but contaminants such as PCBs and PAHs may be.

(1991). J. B. Lee. Personal Communication. Various families within Torch Lake Superfund site boundaries. Torch Lake, groundwater.

Gives results of residential well sample analysis.

(1991). Life Systems, Inc., Donohue and Associates, Inc. **Final Baseline Risk Assessment Report For Torch Lake, Operable Unit I**. Superfund, OUI, risk assessment

From the summary of this document:
"This baseline risk assessment is an analysis of the potential adverse health effects (both current and future) resulting from exposures to hazardous substances in tailings along the western shore of Torch Lake (OUI)....

The most important exposure pathways are judged to be
• Inhalation of particulates from the contaminated tailings.
• Ingestion of contaminated tailings....

No calculated chronic hazard indices exceed one for any exposure pathway evaluated at Torch Lake.

Calculated subchronic hazard indices exceed one for several exposure pathways Involving children at the campground, at current residences near the slag pile/beach and future residences assumed to be built on the tailings piles. Only one chemical, copper, at the slag pile/beach scenario contributed an HQ that exceeded one...."

It... appears that lead is not a source of concern at this site."

(1991). K. Manty, The Daily Mining Gazette. **Torch Lake drum removal complete**. Torch Lake, emergency removal, drums.
This articles states that the drum investigation results are expected soon.

(1991). Soil Conservation Service, USDA. **Preliminary Cost Estimates for the Vegetation of the Copper Mine Tailings at Torch Lake**. Torch Lake, mine tailing vegetation.
Presents cost estimates for various vegetation options.

(1991). W. S. Sottile, MDPH Upper Peninsula Laboratory. Personal Communication. D. Gruben, MDNR Environmental Response Division. Lake Linden, waste removal.
Letter from MDPH to MDNR that medical waste found in Lake Linden is not hazardous.

(1991). E. Zahl and P. Drake. Personal Communication. J. B. Lee.
U.S. Bureau of Mines September Status Report

(1991 (inferred)). The Daily Mining Gazette. **Editorial: Wrong place & time**. Torch Lake, public outreach.
Editorial states that U.S. EPA should have public meetings about Torch Lake within the region of Torch Lake so that residents who are most affected by the problem have more accessibility to the meeting.

(1991 (inferred)). D. W. Charters, Environmental Response Team, U.S. EPA. **Final Report for Torch Lake, Michigan**. Torch Lake, drums.
From the document:

"Objectives of the Study
The objective of the study was to determine both acute and toxic effect levels in the sediments of Torch Lake. The study was devised to evaluate, not only copper toxicity "but if other variables such as mercury and variations ' in site sediment parameters were contributing to or ameliorating toxic effects. Sediment samples were collected, screened by X-Ray Fluorescence (XRF) for copper and stored so that a site specific gradient of copper could be evaluated for toxicity. Other tasks included, collection of surface water samples for metals analysis and toxicity testing by the U.S. EPA Region V."

CONCLUSIONS
"Based on the toxicity evaluation of Torch Lake and the extent of contamination survey delivered to ERT by Region V Project Manager Jae Lee, it is apparent that the vast majority of the sediments in Torch Lake are toxic and not able to support a normal benthic community. The benthic macroinvertebrate community is an integral part of the base of a complex foodweb in a lacustrine system and a severely impacted benthic community would impact the entire foodweb. Unfortunately, the area impacted by the copper contamination may make a complete restoration of the lake to a pre-mining state unfeasible. Alternate proposals should be entertained including remediation of portions of the lake. Studies of these alternate possibilities should be undertaken as soon as possible."

(1991 (inferred)). K. Manty, The Daily Mining Gazette. **Torch Lake plan done by September: EPA**. Torch Lake, Superfund, U.S. EPA.
Discusses EPA contaminant findings and community meeting.

(1991 (original), 1992 (revision)). T. Hartsig. **Occurrence of Polynuclear Aromatic Hydrocarbons (PAHs) in Residential Soils at Torch Lake, Michigan**. Personal Communication. J. B. Lee. Torch Lake, PAH.

The purpose of this technical memorandum Is to address the occurrence of polynuclear aromatic hydrocarbon (PAH) compounds in the soils of local residences along the western shore of Torch Lake, Houghton County, Michigan. Polynuclear aromatic hydrocarbons were identified in soil samples from Hubbell and Mason. The geographic distribution of these compounds does not readily suggest derivation from a single contaminant source.

(1992). U.S. EPA (assumed). **U.S. EPA Proposed Plan for Torch Lake Site**. Torch Lake, Superfund, public outreach.

This document is a fact sheet explaining the remediation decision for Operable Units I and III and the reasoning behind them. The remediation option chosen for Operable Unit I is the soil and vegetation cap of the protruding stamp sand piles in Torch Lake itself. The remediation option chosen for Operable Unit III is the soil and vegetation cap of the slag piles and the beach in Hubbell. It was determined that these options were the most practicable and beneficial to the protection of human health.

(1992). C. R. Baillod, Portage Lake Water and Sewage Authority, **Comments on USEPA Proposed Cover-Up Plan for the Torch Lake Superfund Site**. Torch Lake, Portage Lake Water & Sewage Authority, U.S. EPA, Superfund.

Document states that separation of Operable Units I and III from II is not logical. Also states that risk and toxicity from various contaminants including background concentrations of metals and other elements in soils, airborne particulates, copper, and chromium and human ingestion of stamp sand are grossly over estimated. Concludes that the cover-up plan is not justifiable as remedial action and urges the EPA to select the "No Action" alternative and to proceed to remove the Torch Lake Site from the NPL.

(1992). D. Christian, Lake Linden - Hubbell Public Schools. Personal Communication. P. Schutte, U.S. EPA. Torch Lake, Superfund, public outreach.

Request to extend public comment period on proposed plan because the comments and questions from the May 12, 1992 demonstrated a "profound misunderstanding of the EPA remediation proposal and also reflect fears of possible liability litigation threatened by one of the PRPs.

(1992). D. Christian, Lake Linden - Hubbell Public Schools. Personal Communication. P. Schutte, U.S. EPA. Torch Lake, Superfund, public outreach.

Request from Lake Linden - Hubbell Public Schools to EPA to have a second public meeting about the Torch Lake proposed plan for OUs I and III.

(1992). Donohue and Associates, Inc., U.S. EPA. **Appendix C: Final Baseline Risk Assessment Final Remedial Investigation Report Operable Unit III Torch Lake Remedial Investigation / Feasibility Study Houghton County, Michigan**. Torch Lake, U.S. EPA, Superfund.

"This document is an analysis of the potential adverse health effects (current and future) resulting from releases of hazardous substances from and direct exposure to tailings deposited at 12 locations on the Keweenaw Peninsula...." The carcinogenic risks for residents are generally 1-2 orders of magnitude greater than the values required to be considered not significant, 1 order of magnitude greater than this value for current workers, and not significant to just greater than significant for scavengers and recreational visitors. There is some risk from gastrointestinal irritation in children due to copper ingestion and hematological effects due to antimony, but it is not certain that these would occur.

(1992). Donohue and Associates, Inc., U.S. EPA. **Volume 1: Final Remedial Investigation Report Operable Unit II: Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**. Torch Lake, Superfund, Remedial Investigation.

From the Executive Summary (pages vii-viii):
"The OU II RI was performed to collect and evaluate data to assess to physical characteristics of OU II, the type and extent of contamination of OU II, environmental and human health risks associated with OU II, and the need for and methods to remediate OU II. Activities documented in this report include waste characterization of groundwater chemistry, evaluation of aquifer characteristics, and assessment of human health impact....

Inorganic contaminants of potential concern in groundwater samples were generally above background concentrations and for a limited number of analytes, above maximum concentration limits (MCLs).

Both inorganic and organic analytical results for Torch Lake sediment samples suggest a "hot spot" directly offshore-of the Hubbell area…. However, with the exception of this single sampling location, contaminant levels detected in Torch Lake sediment were not dramatically higher than those reported for background samples....

A baseline risk assessment for the Torch Lake Superfund Site was conducted to analyze the potential adverse health effects resulting from exposures to hazardous substances in groundwater, surface water, and sediment at the site.

Risk associated with dermal contact of surface water is attributable to arsenic and beryllium. Risk associated with ingestion of sediment is attributable to arsenic. Noncarcinogenic risk exists via ingestion of groundwater by hypothetical future residents."

(1992). Donohue and Associates, Inc., U.S. EPA. **Final Remedial Investigation Report Operable Unit III Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**. Superfund, remedial investigation, OUIII.

From the Executive Summary of the Document:

"This report summarizes the RI performed for OU III which includes primary contaminant sources in surface tailings in Houghton County. The OU III RI was performed to collect and evaluate data to assess the physical characteristics of OU III, the type and extent of contamination of OU III, environmental and human health risks associated with OU III, and the need for and methods to remediate OU III. Activities documented in this report include waste characterization of OU III tailings, limited characterization of soil, and assessment of human health impacts."

"The compounds detected in OU III surface and subsurface tailings included bis(2-ethylhexyl)phthalate, polycyclic aromatic hydrocarbon (PAH) compounds, and inorganic compounds. The concentration and distribution of metals appeared similar among surface and subsurface tailings. Slag material exhibited higher concentrations of arsenic, chromium, copper, and lead. Neither the semi-volatile organic nor inorganic compound levels measured on OU III tailings are dramatically higher than those found in naturally occurring soils. Metal levels were generally similar in background soil samples and tailings samples."

(1992). Donohue and Associates, Inc., U.S. EPA, **Addendum No. 1: Final Remedial Investigation Report Operable Unit II - Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**. Superfund, remedial investigation, OUII.

From Section 1.1 - Purpose of Addendum:

"This addendum summarizes surface water and sediment sample collection performed to supplement analytical data presented in the OU II RI Report (Donohue, 1992a). Activities documented in this addendum include characterization of Keweenaw Waterway surface water, submerged tailings, and sediment."

From Section 7.1 - Summary:

"A variety of inorganic (most notably arsenic, barium, chromium, nickel, vanadium, and zinc) and organic (acetone and PAHs) contaminants were found in concentrations higher than background at locations along the Keweenaw Waterway. In addition, metals including aluminum/ arsenic, barium, chromium, copper, iron, lead, and vanadium were present in Keweenaw Waterway sediments in higher concentrations than found in Torch Lake sediments (except for location SD-9 at Torch Lake). Most of the inorganic and organic contamination in the Keweenaw Waterway is found adsorbed to sediments."

(1992). SEC Donohue, U.S. EPA. **Final Feasibility Study Report Operable Units I and II Torch Lake Remedial Investigation / Feasibility Study Houghton County, Michigan**. Torch Lake, U.S. EPA, Superfund, Copper.

Presents the results of the Feasibility Study completed for Operable Units I and III. The study identifies and evaluates applicable technologies and process options. Options are first identified based on site-specific information and human health and environmental considerations. They are then screened based on technical feasibility, then implementability, effectiveness and cost. The alternatives considered for the tailings are: 1. No Action and 2. Soil Cover/Vegetation/Deed Restrictions. The alternatives considered for the slag piles/beaches are: 1. No Action, 2. Fencing / Deed Restrictions, 3. Soil Cover and Vegetation / Deed Restrictions, and 4. Excavation and Off-Site Disposal.

(1992). J. A. Duchene. **Revision of RfD - Arsenic**. Personal Communication. J. Lee. Torch Lake, arsenic.

Revision of Torch Lake arsenic hazard quotient based on change in Arsenic reference dose.

(1992). J. A. Duchene, Life Systems, Inc. **Torch Lake Risk Assessment Issue - Tailings as Road Friction Material**. Personal Communication. J. Lee, U.S. EPA. Torch Lake, Superfund, stamp sands, roads.

Letter to EPA from Life Systems, Inc., stating that the use of stamps sands as road friction material in the winter is not a cause for health concern. This is because (1) the tailings themselves are not highly contaminated, and (2) the road-spreading scenario provides a low potential for exposure.

(1992). Life Systems, Inc., **ADDENDUM TO THE DRAFT BASELINE RISK ASSESSMENT REPORT FOR TORCH LAKE OPERABLE UNIT III: Assessment of Potential Risks Based on Development of Quincy Smelting Works as Part of a National Historical Park Torch Lake Risk Assessment Support**. Superfund, public health, Operable Unit III.

From the document:

"This addendum to the baseline RA assesses potential risks to future populations who might be exposed to the tailings

and slag deposited at the Quincy Smelting Works if the site were developed as a national historical park. This assessment is limited to potential exposures after the park development is completed; populations potentially exposed during construction and development are not considered. Potential risks from other media (surface water, sediments, groundwater) are not addressed in this assessment or in the OUIII RA." (page I-I)

(1992). Environmental Consultations, Inc., Michigan Technological University. **Public Comments Relative to the US EPA Proposed Plan and Supporting Documentation - Operable Units I, II and III Torch Lake Superfund Site Houghton County, Michigan**. Torch Lake, Superfund, public outreach.

This document was prepared on behalf of the MTU administration. The MTU administration agreed with the drum removal completed by the EPA in 1991. They do not support the planned activities in any of the three Operable Units in the Houghton/Hancock area because the planned activities are "based upon a data base and health/risk assessment process which appear to have significant shortcomings..." (Section III, Summary). "The MTU administration recommends that the US ERA fully review their data and evaluations of the Torch Lake Site and significantly modify their existing planning to reflect the realities of local remediation and restoration efforts, the native geology of the region and the historical and economic resources of the region." (Section III, Summary) Based on the data available at that time, the MTU administration believed that a "no action" Record of Decision was warranted. (Section III, Summary)

(1992). U. S. EPA. **Guidance for Performing Site Inspections Under CERCLA**. U.S. EPA, CERCLA, Site inspections.

(1992). U. S. EPA. **U.S. EPA Proposed Plan for Torch Lake Site**. Torch Lake, U.S. EPA, Superfund, copper.

This is a fact sheet that presents the chosen remedial actions for the Torch Lake Superfund site. The fact sheet explains the criteria the EPA used to reach its decision and presents a cost analysis of the different alternatives. Site background and a summary of the Remedial Investigation are included. Also, a space for comment is provided.

(1992). U. S. EPA. **Responsiveness Summary Torch Lake Superfund Site Operable Units I and III Houghton County, Michigan**. Torch Lake, U.S. EPA, MDEQ, Superfund.

Public comments to Torch Lake remediation options presented to them by the U.S. EPA and the MDEQ at a public meeting on May 12, 1992.

(1992). U. S. EPA. **Torch Lake Site, MI Operable Units I and III Declaration for the Record of Decision**. Torch Lake, U.S. EPA, Superfund, Operable Unit I, Operable Unit III.

This document states the selected remedial action for Operable Units I and III. The action includes the following: deed restrictions to control the use of tailing piles, removal of debris in the tailing piles to effectively implement the soil cover with vegetation, and implement soil cover with vegetation in the Lake Linden, Hubbell/Tamarack City and Mason Tailings in OU I, Calumet Lake, Boston Pond, Michigan Smelter, Dollar Bay and Grosse-Point Tailings in OU III, and the slag pile/beach in Hubbell in OU I. The Isle-Royale Tailings are included in parts.

(1992). U. S. EPA, **Record of Decision: Decision Summary Torch Lake Site Operable Units I and III Houghton County, Michigan**. Torch Lake, U.S. EPA, Superfund, Operable Unit I, Operable Unit III.

There are two parts of this document: the Declaration of the Record of Decision for Operable Units I and III, and the Record of Decision itself. The Declaration states the chosen remediation options for OUs I and III. As stated in the Declaration, the major components of the selected remedy include the following: 1. Deed restriction to control the use of tailing piles, 2. Removal of debris from the tailing piles, 3. Soil cover with vegetation on tailing piles in OUs I and III, 4. Slag pile in Quincy Smelter area will either be developed as a national park or otherwise prevented from development as residences, 5. North Entry, Redridge and Freda mine tailings will not be covered. The sections included in the ROD are the following: I. Site Name, Location and Description, II. Site History and Enforcement Activities, III. Community Relations History, IV. Scope and Role of Remedial Actions, V. Site Characteristics, VI. Summary of Site Risks, VII. Description of Remedial Alternatives, VIII. Summary of the Comparative Analysis of Alternatives, IX. The Selected Remedy, X. Statutory Determinations Summary, XI. Documentation of Significant Changes.

(1992). U. S. EPA, **Extension of the Public Comment Period on the Feasibility Study and Proposed Plan for Operable Units 1 and 3 for the Torch Lake Superfund Site Houghton County, Michigan**. Torch Lake, Superfund, public outreach.

States that public comment period on the feasibility study and the proposed plan for OUs I and III will be extended until July 1, 1992.

(1992). U. S. EPA, **Extension of the Public Comment Period on the Feasibility Study and Proposed Plan for Operable Units 1**

and 3 for the Torch Lake Superfund Site. Torch Lake, Superfund, public outreach.

Notice that public comment period on feasibility study and proposed plan for Operable Units I and III is extended a second time to July 13, 1992.

(1992). U. S. EPA, **THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY announces a PUBLIC COMMENT PERIOD and PUBLIC MEETING on the Feasibility Study and Proposed Plan for Operable Units 1 and 3 for the Torch Lake Superfund Site, Houghton County, Michigan**. Torch Lake, Superfund, Operable Units I and III, public outreach.

Notice to public about public meeting and opportunity to comment on the proposed plan for Operable Units I and III. States the remediation alternatives and what the EPA's preferred alternatives are.

(1992). R. Erkkila, Village of Calumet. Personal Communication. P. Schutte, U.S. EPA. Torch Lake, Superfund, public outreach.

Letter from Village of Calumet to EPA stating that the village approves of the No Action alternative.

(1992). The Daily Mining Gazette, **EPA, go home**. Torch Lake, Superfund, public reaction.

Editorial by the Gazette expressing concern that cost to taxpayers to vegetate the stamp sands is more than the public health or environmental benefit of doing so.

(1992). Geraghty & Miller, Inc., et al.. **Final Drum Removal Report - Torch Lake Drum Removal Houghton County, Michigan**.

The parties responsible for the removal of drums found onshore and underwater in Torch Lake near Lake Linden "Respondents" conducted terrestrial and underwater searches for drums. 103 drums were removed (83 terrestrial drums and 20 underwater drums). 4 out of the 103 drums that were removed contained hazardous waste, but all drums that were removed "were disposed of in a licensed hazardous waste storage facility." (page 36)

(1992). Geraghty & Miller, Inc., Paul, Weiss, Rifkind, Wharton & Garrison. **Alternatives Evaluation Report for Operable Units I and III - Torch Lake Superfund Site Houghton County, Michigan**. Superfund, Operable Units I and III, Proposed Alternative.

(paraphrased from the document) The purpose of this evaluation report is to find information that the US EPA did not consider in its Proposed Alternative for OUs I and III and to compare the Proposed Alternative to the No Action Alternative (Section 1.1: Purpose of Report). The authors conclude that the No Action Alternative is the best solution for remediation. They claim the following: "...the USEPA Proposed Alternative is inferior to the No Action Alternative for the primary balancing and modifying criteria of short term effectiveness, implementability, cost and public acceptance, and provides no significant additional protection of human health or the environment." (Section 6.0: Conclusions and Recommendations, page 48)

(1992). G. Gwathmey, Paul, Weiss, Rifkind, Wharton & Garrison. **Re: Torch Lake NPL Site**. Personal Communication. F. H. Habicht, U.S. EPA. Torch Lake, Superfund, public outreach.

The lawyers of UOP claim that Torch Lake is not degraded and that the EPA is demonstrating bias in making UOP and two other large businesses the Potentially Responsible Parties for the site. They are urging the EPA to adopt the "No Action" remediation alternative.

(1992). G. Gwathmey, Paul, Weiss, Rifkind, Wharton & Garrison. **Comments Submitted on Behalf of Universal Oil Products, Inc. ("UOP") Relating to the Torch Lake Superfund Site**. Personal Communication. Superfund, UOP.

UOP's lawyers present UOP's comments on the proposed plan, which consist of the following:
1. EPA's proposed plan violates CERCLA (page 10): a. There are no unacceptable health risks presented by Torch Lake; accordingly, the proposed plan is unjustifiable (page 10). b. Torch Lake is a healthy and productive environment; accordingly the proposed plan is unjustifiable (page 14).
2. The inappropriateness of the proposed plan is demonstrated by other RODs where the No Action remedy was selected (page 18).
3. EPA unlawfully biased the community during the public comment period (page 21).

(1992). R. J. Harding, MDNR. Personal Communication. V. V. Adamkus, Regional Administrator, U.S. EPA, Region V. Torch Lake, Superfund, Record of Decision.

Letter to the EPA from the MDNR stating that they accept the ROD with conditions. The MDNR concurs with the remedy proposed in the ROD for OU I and OU III to the extent that it can be shown that the risk level exceeds one in 1,000,000.

(1992). T. Hartsig, R. M. Gau, M. L. Crosser and I. Donohue and Associates, U.S. EPA. **Addendum No. 3: Final Field Sampling Plan Revision 2: Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**. Torch Lake, Superfund, Remedial Investigation.

The addendum includes a description of extended sediment sampling in OUII. The purpose of this additional sampling is "...to determine the extent of contamination to provide data necessary to assess the feasibility and cost-effectiveness of remedial action alternatives." (page 2-1)

(1992). T. Hartsig and P. Markelz, U.S.EPA. **Addendum No. 1: Final Health And Safety Plan Revision 2: Torch Lake Remedial Investigation/Feasibility Study Houghton County, Michigan**. Torch Lake, Superfund, Remedial Investigation.

From page 1-1: "This addendum addresses continued sampling of Torch Lake sediments in Operable Unit II (OU II) for the Torch Lake, Houghton County, Michigan RI/FS."

(1992). C. Jacobson, U.S. EPA. **Remedy Delegation for Torch Lake, MI Site RODs**. Personal Communication. D.A. Ullrich, U.S. EPA. Torch Lake, Superfund.

Memo within the EPA stating that the Torch Lake Superfund site is listed in CERCLIS as a planned completion. Enclosure contains supporting documentation.

(1992). V. Jolly, Village of Lake Linden. **Torch Lake Site EPA Proposed Plan**. Personal Communication. J. B. Lee, U.S. EPA. Torch Lake, Superfund, public outreach.

Village of Lake Linden concisely states that they approve of the EPA plan but they do not believe that their residents should be held liable.

(1992). R. C. Krestner, City of Houghton. **Re: Torch Lake Superfund Site, Houghton County, Michigan**. Personal Communication. P. Schutte, U.S. EPA. Torch Lake, Superfund, public outreach.

Letter from the City of Houghton urging the U.S. EPA to adopt the No Action alternative and delist the Torch Lake Superfund Site from the NPL as soon as possible.

(1992). Life Systems, Inc., U.S. EPA (Inferred). **Final Ecological Assessment for the Torch Lake Superfund Site: Torch Lake Risk Assessment Report**. Torch Lake, Superfund, Donohue, ecological assessment.

From the Executive Summary:
"Objectives of the Ecological Assessment
The objectives of this Report are as follows:
1. Provide a summary of existing ecological studies that have been performed at the site or included samples of contaminated environmental media from the site.
2. Perform an evaluation based on existing studies and additional site information to estimate the magnitude and extent of actual impacts and potential risks at the site....

Severe degradation of benthic communities and absence of wetlands in shallow areas are the most obvious ecological impacts associated with tailings deposits and contaminated sediments in Torch Lake and other surface waters in the study area.

Very few locations where sediment was sampled in Torch Lake have sediment copper concentrations that are below laboratory estimates of the LC50 (AOO to 630 mg/kg) for Hyalella exposed to copper in contaminated sediments. These include three areas farthest removed from tailings deposits: in the mouth of the Trap Rock River; near the mouth of the Trap Rock River; and in the south-central area of the lake near the entrance to drainage into Portage Lake.... Extremely high concentrations of lead and arsenic in submerged tailings near Hubbell are likely to enhance copper toxicity, so this area presents the greatest risk to aquatic life in Torch Lake. All other areas of the lake where tailings have been deposited are likely to be too toxic for development of pollution intolerant benthic organisms....

Reduction in nutrient cycling, mineralization and productivity in fish populations that feed on bottom dwelling organisms are possible secondary results of degraded benthic communities.

The primary ecological impact of tailings deposits on land is significant habitat loss due to a variety of chemical and nonchemical stresses....

The extent of adverse impacts to terrestrial organisms living in areas surrounding tailings is expected to be minimal. Bald eagles and other birds are not likely to be affected by the primary metals of concern at this site since the metals do not biomagnify in their food webs. Plant species of special concern to the State of Michigan may be exposed to site related stresses in the study area, but information on populations potentially exposed to tailings is not available for evaluation....

Greatest risks to aquatic life in Torch Lake are posed by the area of elevated levels of arsenic and lead in tailings near Hubbell...."

(1992). Life Systems, Inc., U.S. EPA. **Appendix D: Final Baseline Risk Assessment Draft Remedial Investigation Report Operable Unit II**. Torch Lake, Superfund, Operable Unit II, U.S. EPA.
Evaluates potential risks from Operable Unit II to humans in Torch Lake. Carcinogenic risks are typically 1-3 orders of magnitude higher than the risk value considered small enough to be of no practical concern. Hypothetical future residents using groundwater for drinking water may have some risk of the effects associated with exposure to these chemicals. Lead is not a source of concern at this site.

(1992). M. D. Lydon. Personal Communication. P. Schutte, U.S. EPA. Torch Lake, Superfund, public outreach.
Letter from Torch Lake Township to U.S. EPA stating that they do not believe that they should have to pay for the remediation of the stamp sands.

(1992). J. B. Manderfield, County Road Commissioners, Houghton County. **Public comments Torch Lake Superfund Site, Houghton County, Michigan**. Personal Communication. P. Schutte, U.S. EPA. stamp sands, roads, Superfund, public outreach.
The Houghton County Board of Road Commissioners strongly opposes the proposed plan to cover up the stamp sands. They are used as road abrasives and also as subbase in construction.

(1992). J. B. Manderfield, County Road Commissioners, Houghton County. Personal Communication. P. Schutte, U.S. EPA. Torch Lake, Superfund, public outreach.
Letter to EPA from Houghton County Board of Road Commissioners stating their opposition to cover and vegetate the Grosse Pointe No. 10 stamp sands.

(1992). MDNR. **A Biological Survey of the Trap Rock River and its Tributaries, July 29-30, 1991 Houghton County, Michigan**.
Objective of study was to qualitatively evaluate whether historical copper mining operations have adversely impacted the biological integrity and physical habitat conditions of Slaughterhouse Creek, Scales Creek, Kearsarge Creek, and/or the Trap Rock River. Results among the eight sampling stations are mixed.

(1992). F. J. Musich, Village of Laurium. Personal Communication. P. Schutte, U.S. EPA. Torch Lake, Superfund, public outreach.
Letter from the Village of Laurium to the EPA stating that the village approves of the No Action alternative.

(1992). J. A. Niemi, Houghton County Board of Commissioners. Personal Communication. P. Schutte, U.S. EPA. Torch Lake, Superfund, public outreach.
Letter from Houghton County Board of Commissioners to U.S. EPA expressing its support of a letter dated June 24, 1992 sent to the EPA by Commissioner Gerard Perreault and urging the EPA to choose the No Action alternative.

(1992). G. Perreault, Houghton County Board of Public Works. Personal Communication. P. Schutte, U.S. EPA. Torch Lake, Superfund, public outreach.
Letter from the Houghton County Board of Public Works to the EPA stating that they approve of the No Action alternative.

(1992). L. Smith, Donohue and Associates, Inc., U.S. EPA. **Addendum to Final Quality Assurance Project Plan for Operable Unit II Remedial Investigation Activities Torch Lake Remedial Investigation/Feasibility Study, Houghton County, Michigan**.
This addendum accounts for sediment sampling activities in OUII.

(1992). M. Tuisku, Mayor of Hancock. Personal Communication. U.S. EPA (assumed). Torch Lake, Superfund, public outreach.
Letter to the EPA (assumed) stating that Hancock residents cannot afford to pay for the remediation of the Isle Royale Stamp Sands.

(1992). K. B. Vettori, Court Reporter, CER-2517, **Public Meeting Torch Lake Superfund Site**. Torch Lake, Superfund, public outreach.
Transcript from the public meeting concerning the cleanup plan for OUs I and III. This meeting took place on May 12, 1992 in Hancock, MI.

(1992 (inferred)). Geraghty & Miller, Inc., **Public Comment Document Operable Units I and III**. Superfund, OUI, OUIII, public comments, potentially responsible parties.
Extensive comments developed by a contractor for Universal Oil Products on the following documents: 1) Remedial Investigations for OUs I and III; 2) Risk Assessments for OUs I and III; 3) Ecological Assessment; 4) Feasibility Study; 5)

Proposed Plan; in addition to other summary comments.

(1992 (inferred)). USDA Soil Conservation Service, U.S. EPA. **Report of the Phase I Literature Search**. Mine tailing vegetation.
Findings of literature search conducted by Soil Conservation Service for EPA on the subject of vegetating mine tailings.

G. T. Ankley, V. R. Mattson, E. N. Leonard, C. W. West and J. L. Bennett, PREDICTING THE ACUTE TOXICITY OF COPPER IN FRESH-WATER SEDIMENTS - EVALUATION OF THE ROLE OF ACID-VOLATILE SULFIDE. *Environmental toxicology and chemistry* **1993,** *12* (2), 315-320.
Research evaluated role of acid-volatile sulfide in determining copper toxicity in sediments. Results indicated that AVS alone is not an appropriate partitioning phase for predicting copper bioavailability in freshwater sediments (from article abstract).

(1993). R. Campbell, MDNR. **Re: Institutional Controls on the Public Use of Groundwater Torch Lake Superfund Site**. Personal Communication. G. Shebuski, Houghton County Department of Public Health and M. Webber, Michigan Department of Public Health.
This letter discusses the results of a meeting between the EPA, the MDPH and the Houghton County Department of Public Health to strengthen Institutional Controls on groundwater to ensure that drinking water wells do not draw from contaminated sources in the stamp sands. In addition to screening drinking water wells in the sandstone aquifer and rigorous testing by the State and the County, and heightened awareness by the affected communities in permitting construction on the stamp sands, the following enhancements to the institutional controls will be made (from the document):

"1) The County Health Department and the Michigan Department of Public Health (MDPH) could stipulate the use of municipal water supplies, where available, for any residential developments on stampsands. A likely first candidate for this would be the development currently underway on the Isle Royale sands.
2) The County Health Department could formalize the practice of prohibiting the installation of drinking water wells that would be screened so as to draw groundwater from stampsands. Wells installed on stampsands would be required to extend down through the sands and to be screened in the underlying sandstone.
3) The County could adopt the practice of making the granting of building permits for work to be undertaken on the stampsands contingent upon County Health Department approval. County Health Department approval would depend upon the provision of satisfactory drinking water supply plans."

The above constitute the institutional controls to which the Record of Decision for Operable Unit II refers.

(1994). D. Banette (inferred), UPPCO. **Re; Torch Lake Superfund Site**. Personal Communication. D. Novak, U.S. EPA. Torch Lake, Superfund, Operable Unit II, public outreach.
Author expresses his support of the no action alternative for Operable Unit II.

(1994). A. J. Birnbaum, Paul. Weiss. Rifkind, Wharton & Garrison, **UOP's Public Comments on EPA's Proposed Plan for OU II at the Torch Lake Superfund Site**. Torch Lake, Superfund, Operable Unit II, public outreach.
Comments from UOP about Operable Unit II. The conclusion, from the document, states:
"The extensive scientific data in the Administrative Record clearly demonstrates that OU II poses no meaningful risk to people or the environment. EPA's Proposed Plan selecting the No Action Alternative therefore is in complete accordance with the Administrative Record. In fact, for the reasons identified herein and by EPA, the No Action Alternative — overwhelmingly supported by the public and by local and state government officials — is the only response that is consistent with the NCP and valid under CERCLA."

(1994). B. Darling, Friends of the Land of Keweenaw. Personal Communication. J. Kuhns, U.S. EPA. Torch Lake, Superfund, Operable Unit II, public outreach.
Letter from FOLK to the U.S. EPA commenting on the "No Action" alternative to remediate OUII.

(1994). Environmental Consultations, Inc., Michigan Technological University. **Public Comments Relative To The US EPA Proposed Cleanup Remedy for Torch Lake Operable Unit II Torch Lake Superfund Site Houghton County, Michigan**. Torch Lake, Superfund, public outreach.
The Michigan Tech administration fully supported the "no-action" alternative for OU II.

(1994). U. S. EPA, **Record of Decision: Decision Summary: Torch Lake Superfund Site Operable Unit II, Houghton County,**

Michigan. Torch Lake, Superfund, Operable Unit II, Record of Decision.

From the document:

"This decision document presents the selected remedial action for the Torch Lake Superfund Site, Operable Unit (OU) II (OU II consists of groundwater, surface water, and sediments associated with the site), in Houghton County, Michigan, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and is consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) to the extent practicable. This decision is based upon the contents of the Administrative Record for the site. The attached index identifies the items that comprise the Administrative Record upon which the selection of the remedial action is based. The State of Michigan concurs with the selected remedy.

DESCRIPTION OF THE SELECTED REMEDY:

U.S. EPA has selected a "No Action" remedy for OU II. The remedy selected for OU n takes into consideration and relies upon:

• The reduction of stampsand loading to surface water bodies expected as a result of the remedial action which will be taken at OUs I & III.

• Ongoing natural sedimentation and detoxification such as that which is occurring in other surface water bodies in the area.

• Institutional programs and practices controlling potential future exposure to site affected groundwater which are administered at the county and state level.

The long-term monitoring and the five year review process monitoring requirements of the remedy selected for OUs I & III under a previous Record of Decision for this site."

(1994). U. S. EPA. **Torch Lake Superfund Site Operable Unit II Final Remedy Position Paper**. Superfund, Operable Unit II, ROD.

Paper summarizes remediation decision for Operable Unit II. It was decided that no action would be taken to remediate the lake sediment, with the assumption that a natural sediment layer would cap the contaminated sediment over time as what was occurring in Portage Lake. It was also decided that existing institutional controls would suffice to protect human health, but that these controls should be monitored for effectiveness over time.

(1994). R. J. Harding, MDNR. Personal Communication. V. V. Adamkus, U.S. EPA, Region V. Torch Lake, Superfund, Operable Unit II, Record of Decision, public outreach.

Letter states that the MDNR supports the No Action alternative for OU II provided that certain other criteria are met.

(1994). J. H. Hartig and N. L. Law, Wayne State University. **Progress in Great Lakes Remedial Action Plans: Implementing the Ecosystem Approach in Great Lakes Area of Concern**. Area of Concern, Torch Lake.

Provides an overview of progress in all Great Lakes Areas of Concern as of 1992.

W. C. Kerfoot, G. Lauster and J. A. Robbins, Paleolimnological Study of Copper Mining Around Lake Superior: Artificial Varves from Portage Lake Provide a High Resolution Record. *Limnology and Oceanography* **1994,** *39* (3), 649-669.

(1994). H. D. Paikala, Notary Public Houghton County, **Declaration of Restrictive Covenant**. Torch Lake, Superfund, stamp sands, Lake Linden.

Lake Linden owns the stamp sands, but if, in the process of construction, the stamp sands are uncovered, they must be recovered after construction.

(1994). J. A. Spence. Personal Communication. D. Novak, U.S. EPA. Torch Lake, Superfund, Operable Unit II, public outreach.

A resident (specifically James Spence) provides comments on the EPA's selection of the no-action remediation alternative. The comments are extensive. The conclusion from his comments are found below:

"In conclusion, the Final Remedy Position Paper argues that "...the nature and extent of the TL sediment would render attempts to actively remediate impracticable." In the case of the hot spot I would argue Just the opposite. When compared to the remainder of TL, the nature and extent of the sediments in the hot spot offer an opportunity to remediate. Many of the hot spot contaminants are significantly more toxic than copper; In combination, they may create an even greater risk. If not remediated, the composition of the hot spot will significantly delay any natural remediation process. Consequently, the contaminants would be available for uptake over a longer period of time. If, however, analysis of the geomembrane cap proves it to be technically feasible, it would appear to offer a very cost-effective remediation alternative that would expedite rather than delay the lake's eventual recovery."

(1994). M. C. Stearns, CER-3917, **Public Meeting & Public Comments Regarding Operable Unit #2 Torch Lake Superfund Site Houghton, Michigan**. Torch Lake, Superfund, Operable Unit II, public outreach.

Transcript of Public Meeting about Operable Unit II that took place at Michigan Tech on March 3, 1994.

(1994). United Salvage & Reclamation Co.; et al. **<u>Re: EPA's P(r)oposed Plan For Torch Lake Remedy Of All Operating Units ('OU's 1-3) ,"' A Non-Action Plan "</u>**. Personal Communication. Superfund, community relations.

This comment seems like it may have been received or sent well after the decisions on OUs I and III were made, but in response to the selection of the no-action alternative for OU II. The commenters disagree with the selection of this alternative.

(1994). U.S. EPA. **<u>EPA Proposes Cleanup Remedy at Torch Lake Superfund Site Operable Unit II</u>**. U.S. EPA. Torch Lake, Superfund, Operable Unit II, public outreach.

This Fact Sheet describes the plan recommended by the U.S. Environmental Protection Agency (EPA) as the most appropriate remedy option for dealing with the contamination associated with Operable Unit (OU) II at the Torch Lake site. It also summarizes the reasoning behind this recommendation.

(1994 (inferred)). USDA Soil Conservation Service. **<u>Treatability Study to Determine the Effectiveness of Vegetation on Stabilizing Mine Tailings at the Torch Lake Site</u>**.

(1995). N. Boersma, Michigan Technological University. **<u>An Analysis of Copper in Torch Lake</u>**. Torch Lake, Copper, sediment.

Report analyzes the "natural attenuation" of Torch Lake sediments. Conclusion states that while improving the vegetation and stabilization of Torch Lake shores is the most logical remediation at the time, it may not be adequate to accelerate the remediation of the sediments.

(1995). C. C. Cusack. **<u>Sediment toxicity from copper in the Torch Lake (MI) Area of Concern</u>**. Thesis. Michigan Technological University, Master of Science in Civil Engineering. Torch Lake, copper, sediment.

Thesis by C.C. Cusack studying the sediment toxicity from in Torch Lake. Reduction of copper toxicity in the sediments is occurring. Torch Lake's low productivity level and 1-year residence time may account for the slow recovery by natural attenuation compared to Portage Lake.

(1995). Houghton-Keweenaw Soil and Water Conservation District, **<u>August 9, 1995 Torch Lake Remediation Tour Itinerary Guide</u>**. Torch Lake, Superfund, Area of Concern, stamp sands, Houghton-Keweenaw Soil and Water Conservation District.

Tour included: Portage Cove (Isle Royale Stamp Sands), Mason Sands, Tamarack Sands, Tamarack City M-26 Bypass, Hubbell Slag Pile and Slag Sands, Lake Linden private properties, and Lake Linden Stamp Sands.

(1995). Houghton-Keweenaw Soil and Water Conservation District, **<u>Houghton/Keweenaw Soil and Water Conservation District Public Meeting Agenda for the purpose of discussing the Torch Lake Superfund Site Remediation Plan</u>**. Torch Lake, Superfund, Houghton-Keweenaw Soil and Water Conservation District.

Agenda for the meeting and a summary of the planned remediation activities for the Superfund site stamp sands including debris removal, stamp sand pile shaping for future use, soil treatment, tree planting and operation and maintenance.

(1996). **<u>History of Boston Pond and Area</u>**. Copper, mining history, Boston Pond.

Describes brief history of land ownership and mill construction, milling processes, mineralogy of area, site accessibility and briefly addresses lack of remediation by revegetation of stamp sands.

(1996). U. S. EPA. **<u>Soil Screening Guidance: User's Guide</u>**. Superfund, soil.

From Page 1 of document:
"The Soil Screening Guidance is a tool that the U.S. Environmental Protection Agency (EPA) developed to help standardize and accelerate the evaluation and cleanup of contaminated soils at sites on the National Priorities List (NPL) with future residential land use.1 This guidance provides a methodology for environmental science/engineering professionals to calculate risk-based, site-specific, soil screening levels (SSLs) for contaminants in soil that may be used to identify areas needing further investigation at NPL sites."

(1999). M. Lyons, **<u>Design Report: Lake Linden Sands, Torch Lake EPA Superfund Site</u>**. Torch Lake, Superfund, stamp sands, Lake Linden.

Describes plan to vegetate stamp sands in Lake Linden and possibly use the sands as a park.

(1999). M. Lyons, USDA NRCS. **<u>Construction Completion Report: Lake Linden Stamp Sands, Torch Lake EPA Superfund Site, Houghton County, Michigan</u>**. Torch Lake, Superfund, stamp sands, Lake Linden.

As-built documents and drawings for restoration work completed at the Lake Linden stamp sands.

(1999). D. J. Quirk. **Copper from Sand: A History of Copper Reclamation on Torch Lake, Houghton County, Michigan**. Thesis. Michigan Technological University, Master of Science in Industrial Archaeology. Torch Lake, copper, copper reclamation.

Explains the industrial processes, stamping and milling, how they were conducted by C&H and Quincy, economic importance and the impacts on the population, economy and the environment.

(2000). USDA NRCS, **Design Report: Tamarack City, Torch Lake EPA Superfund Site**. Torch Lake, Superfund, stamp sands, Tamarack.

Construction plan for stream stabilization, vegetation and debris removal at Tamarack stamp sands.

(2000). USDA. NRCS. **Operation and Maintenance Plan: Torch Lake Superfund Site, Tamarack City**. Torch Lake, Superfund, stamp sands, Tamarack.

This document describes the monitoring and maintenance activities to be performed at the Tamarack stamp sands site. The establishment period activities, establishment period inspections, and post- establishment period inspections are described. The vegetation is also described in case repairs to it are necessary.

(2000). USDA. **Operation and Maintenance Plan: Torch Lake Superfund Site, Lake Linden Stamp Sands**. Torch Lake, Superfund, stamp sands, Lake Linden.

This document describes the monitoring and maintenance activities to be performed at the Lake Linden stamp sands. The establishment period, establishment period inspections, and post-establishment period inspections activities are stated.

(2001). J. A. Blair, Michigan Technological University. **The Quincy Mining Company Torch Lake Smelter & Reclamation Plant At Mason Sands Torch Lake EPA Superfund Site**. OUI.

Archaeological survey report on the Quincy Smelter and Reclamation Plant at the Mason Stamp Sands.

(2001). U. S. EPA. **Baseline Study Report: Torch Lake Superfund Site, Houghton County, MI**. Torch Lake, Superfund.

The purpose of the Baseline Study is to establish the conditions of Torch Lake and the nearby groundwater before remedial actions were taken, and to establish methods and baseline data for future sampling efforts. Baseline Study work included assessing the benthic community populations, measuring sediment toxicity to benthic invertebrates, measuring concentrations of metals and semi-volatile organic compounds in sediment, surface water and groundwater, and studying the sedimentation process in lake sediments. Several results are discussed in the document. Analysis of results of sediment sampling show that metals (particularly copper) are high in concentration and persistent both in the surface and at depth. It was determined that the sediments are toxic to benthic organisms, and that the abundance and diversity of benthic species are low. Surface water samples indicate a relatively uniform distribution of metals, none of the metals detected in groundwater samples exceeded federal drinking water levels (at that time), and SOCs were not detected in the sediments. Semi-volatile organic compounds detected in surface water and groundwater samples were not significant (few detects and at low concentrations).

(2001). A. J. Howard, MDEQ. **Plan for Deletion of the Torch Lake Site from the National Priorities List**. Personal Communication. J. Mayka, U.S. EPA, Region 5. Torch Lake, Superfund, delisting.

This letter to the EPA from the MDEQ outlines the schedule for Torch Lake Superfund site parcels to be delisted as and when they are remediated.

(2002). U. S. EPA. **Torch Lake Superfund Site Remediation Monitoring: Fall, 2002 Sampling Overview and Results**. Microsoft PowerPoint. Torch Lake, Superfund, U.S. EPA.

Slideshow by B. Jones providing an overview of fall 2002 sampling efforts and a summary of the results from this sampling. Surveys of small mammals, plants and birds were conducted, as well as a GPS survey of the entire site and all sampling locations. The survey results show that the number of species and number of individuals [plants and animals] increased from the time that the protruding stamp sands were capped and vegetated. It was also shown that soil fertility increased after remedy.

(2002). G. V. Gulezian, U.S. EPA Region V. **ENVIRONMENTAL PROTECTION AGENCY 40 CFR Part 300 [FRL ——-] National Oil and Hazardous Substance Pollution Contingency Plan; National Priorities List**. Torch Lake, Superfund, delisting.

Direct final notice of deletion of the Lake Linden parcel and Operable Unit 2 of Torch Lake Superfund Site from the National Priorities List. Gives detail of deletion procedures, the basis for site deletion, and deletion action.

(2002). G. V. Gulezian, U.S. EPA Region V, **ENVIRONMENTAL PROTECTION AGENCY 40 CFR Part 300 [FRL-7136-7] National Oil**

and Hazardous Substance Pollution Contingency Plan; National Priorities List. Torch Lake, Superfund, delisting.

Notice of intent to delete the Lake Linden parcel and Operable Unit 2 of the Torch Lake Superfund Site from the National Priorities List published in the Federal Register.

(2002). G. V. Gulezian, U.S. EPA Region V, **ENVIRONMENTAL PROTECTION AGENCY 40 CFR Part 300 [FRL-7136-6] National Oil and Hazardous Substance Pollution Contingency Plan; National Priorities List**. Torch Lake, Superfund, delisting.

Direct final notice of deletion of the Lake Linden parcel and Operable Unit 2 of Torch Lake Superfund Site from the National Priorities List with details about deletion procedures, basis for site deletion, and deletion action published in the Federal Register.

(2002). B. R. Jones. **Torch Lake Superfund Site Remediation Monitoring: Fall, 2002 Sampling Overview and Results**. Microsoft PowerPoint. Torch Lake, Superfund, USEPA, natural attenuation.

Presentation summarizing ecological monitoring of vegetation on Gay, Lake Linden, Hubbell/Tamarack, Mason and Point Mills stamp sands piles. Presentation states that biodiversity at each site has improved.

(2002). Michigan Technological University. **The Quincy Mining Company Smelting Works, 1898 Historical Land Use Survey Project**. MTU, OUIII.

The report discusses the historical land use of the Quincy Smelting Works site to assist Franklin Township with the redevelopment of the site.

(2002). S. Padovani, U.S. EPA. **RE: Response to February 17, 2002 letter Concerning the Torch Lake Superfund Site, Houghton County, Michigan**. Personal Communication. V. Troesch and K. Troesch. Torch Lake, stamp sands, vegetation, public outreach.

EPA response to resident letter opposing vegetation of stamp sand on resident property.

(2002). S. Padovani, U.S. EPA. **Discussion of Shoreline Protection and Gravel Driveways at the Point Mills Portion of the Torch Lake Superfund Site, Houghton County, Michigan**. Personal Communication. File. Point Mills stamp sands.

This memo is intended to provide a summary and explanation of additional remedial action (RA) costs as a result of the extensive use of shoreline protection, two types of shoreline protection used, and the installation of gravel driveways for some landowners at the Point Mills portion of the Torch Lake Superfund Site, Houghton County, Michigan.

(2002). S. Padovani, U.S. EPA. **No Action at the Coal Dock Property Located at the Hubbell/Tamarak Portion of the Torch Lake Superfund Site, Houghton County, Michigan.** Personal Communication. File. Torch Lake, Superfund, Operable Unit I.

This memo provides an explanation for taking no action at the coal dock property. The debris (including the coal) is of a relatively large size and would likely not be subject to wind erosion. In addition, the NRCS conducted soil borings through the debris and observed native soil within 6 to 10 inches of the surface. surface water runoff from the property did not enter Torch Lake. The agencies confirmed the presence of only a thin layer of surface debris (mainly coal pieces) which contains only minor amounts of stampsand. Based on this observation, the agencies concluded that the volume of waste material is not significant enough to be a significant contaminant source to Torch Lake. Also, no significant contamination was detected in the two soil samples collected by the MDEQ. The MDEQ analytical results, along with field observations, support the conclusion that the coal dock property is not likely a significant potential source of contamination to Torch Lake. (Text from document)

(2002). S. Padovani, U.S. EPA. **Vegetation Planting at Gull Island, Torch Lake Superfund Site, Houghton County, Michigan**. Personal Communication. File. stamp sands, Gull Island.

From the first page of the memorandum:
"This memo provides an explanation for the planting of vegetation as a way to stabilize stampsands at Gull Island (see attached figure), Torch Lake Superfund Site (the Site), Houghton County, Michigan."

There are two main reasons that it was decided that only a vegetation cover (as opposed to a vegetation and soil cover) was necessary: 1) The water table was high enough to reside in the rooting zone for vegetation and 2) the species of plants being installed are known for their ability to fix their own nitrogen from the atmosphere.

(2002). T. V. Skinner, U.S. EPA. **Responsiveness Summary Torch Lake Superfund Site Deletion of Lake Linden Parcel and Operable Unit 2 Houghton County, Michigan**. Torch Lake, Superfund, Operable Unit II, delisting.

The EPA responds to two comments regarding the delisting of OUII from the NPL. The first comment expresses concern about contaminants spreading from uncapped areas of surface stampsands. The resident was confused about the definition of OUII. The second comment is extremely extensive:

"A resident raises three general concerns: 1) Unclear Site definitions presented in the 2/5/02 issue of the Federal Register, 2) the inappropriateness of delisting OU2 because of the lack of measurable [natural recovery] progress and 3) inappropriateness of delisting OU2 because of the need for institutional controls in OU2. The resident strongly recommends U.S. EPA consider placing institutional controls on "Torch Lake's OU2" and supports the need with detailed technical information."

The EPA response is extensive and generally defends the EPA's decision to delist OUII.

(2002). V. Troesch and K. Troesch. **TORCH LAKE EPA SUPERFUND SITE ENGINEERING DESIGN LANDOWNER REVIEW**. Personal Communication. G. Aho, USDA and S. Padovani, U.S. EPA. Torch Lake, stamp sands, vegetation, public outreach.

Resident letter opposing the vegetation of stamp sands on their property, citing the degradation of the wildlife habitat that currently exists on the stamp sands on their property.

(2002 (inferred)). G. V. Gulezian, U.S. EPA Region V. **ENVIRONMENTAL PROTECTION AGENCY 40 CFR Part 300: National Oil and Hazardous Substance Pollution Contingency Plan National Priorities List**. Torch Lake, Superfund, delisting.

Notice of intent to delete the Lake Linden parcel and Operable Unit 2 of the Torch Lake Superfund Site from the National Priorities List

(2003). D. W. Charters, U.S. EPA, et al.. **Final Report Torch Lake Stamp Sand Evaluation Torch Lake Site Keweenaw, Michigan**.

Text from the Executive Summary of the document is found below:

In 1998, the U.S. EPA selected a remedy which included the installation of a soil cap over shoreline deposits of stamp sand and the establishment of a vegetative cover to stabilize the soil. This project evaluated the success of this portion of the remedy by monitoring the development of habitat, as well as plant, bird and mammal communities over time in remediated and un-remediated areas. During August 2002, a field investigation was conducted to characterize the ecological setting and resources of the site. The field activities include a small mammal, bird and plant survey, and an evaluation of soil fertility, plant biomass, plant root penetration, and percent soil coverage by vegetation….

In summary, the establishment of a soil and vegetative cover over the shoreline deposits of stamp sand areas has resulted in the development of a soil-stabilizing plant community and habitat which has attracted birds and small mammals.

(2003). U. S. EPA. **First Five-Year Review Report for the Torch Lake Superfund Site, Houghton County, Michigan**. Superfund, U.S. EPA.

Document discusses whether or not chosen remedy (in this case "natural attenuation") is protective of human health and the environment. It was determined that the chosen remedy will be effective once it is complete. Document also gives progress of remediation activities. The document states the following as of 2003:

"Issues:
1) Need to complete all remedy requirements in accordance with the 1992 ROD and memoranda to Site file.
2) Need to ensure deed restrictions are in place in accordance with the 1992 ROD and 1994 AOC (see Section III - Initial Response). To date, only a small number of these restrictions have been verified to be in place.
3) Need to conduct a periodic review of groundwater uses at the Site and the effectiveness of the county well permitting process in preventing drinking water well installation in tailings at the Site. Currently, EPA is not aware of any drinking water wells at the Site that use tailings as a potable water source.
4) Need to make repairs to cover material and shoreline protection, as necessary, to ensure long-term integrity of remedy.
5) Need to investigate MDEQ observation that tailings have been applied around recently installed culverts and on the surface of trails and campground pads at the Lake Linden parcel.
6) Need to complete restoration of Mason borrow-soil source.
7) Need to complete evaluation of North Entry and Scales Creek for possible elimination from remediation plans.
8) Need to resolve access issues at Point Mills (summary in attachment 6).
9) Need to evaluate long-term access for conducting monitoring and O&M activities.
10) Need to evaluate Houghton County Road Commission's road traction tailing excavation practices at Point Mills relative to 1992 ROD requirements.
11) Evaluate the need for deed restrictions to prevent the development of residences in the slag area of Quincy Smelter...
Recommendations and Follow-up Actions:

1) Maintain current IAG contract with USDA-NRCS and work cooperatively with USDA-NRCS to ensure the work is adequately completed.
2) Continue to seek documentation from landowners at the Site to verify proper deed restrictions have been put in place, and if they are not, work with the landowners and/or county to ensure deed restrictions are put in place.
3) Conduct periodic on-Site inspections of groundwater use and work with county officials to evaluate the effectiveness of the county well permitting process in preventing the installation of drinking water wells in tailings.
4) Conduct routine inspections and coordinate repair work with USDA-NRCS and/or State.
5) Conduct Site inspection and if tailings are confirmed, evaluate the potential for the tailings to enter Torch Lake.
6) Ensure USDA-NRCS addresses and adequately completes this work in 2003.
7) Review State response to EPA's 12/27/02 letter and establish a final position in a letter to the State.
8) Continue to work with the Office of Region Counsel, Department of Justice, and the Federal court system to enforce two Administrative Orders for Access dated April 2002.
9) Review 1994 AOC and other access agreements for applicability to long-term access. Seek additional/updated access agreements where necessary.
10) Work with the Houghton County Road Commission to ensure practices are consistent with the 1992 ROD and/or evaluate the need for possible modification of the specific 1992 ROD requirements on this issue to better reflect current engineering and protectiveness needs.
11) Work with landowner and stakeholders to determine Historical Park redevelopment schedule. If a redevelopment schedule cannot be committed to by the end of 2003, work with the landowner and/or county to have deed restrictions immediately in place to prevent residential development of the slag area."

(2003). Exponent, MDEQ. **Fish Contaminant Monitoring Program: Review and Recommendations**.
The purpose of this document is for the MDEQ's consultant, Exponent, to present the results of its review of the trends monitoring elements of the Fish Consumption Monitoring Program (FCMP). They provide recommendations to make trends analyses more robust.

(2004). C. Flaga and S. Hession. **Quincy Smelter Evaluation**. Personal Communication. A. Keranen. Superfund, OUIII, Soil DCC.
Discusses soil sampling completed at the Quincy Smelter in OUIII in 1990, 1991, 1997 and 2002, and compares concentrations to soil direct contact criteria (SDCC). The memo also discusses the estimated cancer risk for visitors to and workers at the property should the smelter site be developed into a national historical park. It was concluded that arsenic levels were unacceptable for residential use, but were acceptable for high soil intensive grounds keeping activities and visitors. Additional sampling is recommended. Asbestos abatement activities should be started. Substances that exceed the groundwater surface water interface criteria were listed.

(2005). L. Anderson et al., Michigan Technological University. **Accelerating the Natural Remediation of Torch Lake**. Torch Lake, Copper, sediment cap.
Senior design project exploring remediation options for copper contamination in Torch Lake. A sediment cap consisting of sand with a thickness of 40cm was is predicted to be the best solution.

(2005). P. Blanchard et al., Environment Canada, U.S. EPA. **Atmospheric Deposition of Toxic Substances to the Great Lakes: IADN Results through 2005**. Great Lakes, IADN.
Reports contaminant air deposition data collected by the IADN from 2001-2005. PCB deposition measured at Eagle Harbor, MI is included in this report.

(2005). Great Lakes Environmental Center, MDEQ. **Quality assurance project plan (QAPP) for project number 05-25: PCB study using semi-permeable membrane devices in Torch Lake, Houghton County**.
Torch Lake, Semi-Permeable Membrane Devices

(2006). **Standard Operating Procedure for the Measurement of WHO/NIST/NOAA List Polychlorinated Biphenyl Congeners and Polybrominated Diphenyl Ethers in Water, Soils and Sludge Extracts by Gas Chromatography Using Both Ion Trap Tandem Mass Spectrometry and Quadrupole Negative Chemical Ionization Mass Spectrometry.** U.S. EPA Region 5 Chicago Regional Laboratory. Operating procedure, WHO, NIST, NOAA, polychlorinated biphenyl congeners, polybrominated diphenyl ethers, gas chromatography, mass spectrometry.

(2006). Great Lakes Environmental Center and MACTEC Engineering and Consulting, Inc. MDEQ. **Torch Lake Sediment Flux and Metals Analysis Study Houghton Co., MI**. Torch Lake, metals, natural attenuation.
This is a study of the concentrations of metals found in the "natural" sediment cap in 2006. The conclusions and recommendations are stated in the "Recommendations for future work" section of the document:

"Several metals appear to be at sufficient concentrations in the suspended sediment to cause adverse effects on aquatic life. However, there is anecdotal evidence that suggests a relatively health fishery, plankton populations and forage fish base exist in Torch Lake despite the relatively high metal concentration. Additional work is necessary to completely understand the bioavailability and subsequent effect of the metals on aquatic life in Torch Lake."

(2006). S. DeLong, NPS. Personal Communication. F. Fiala, NPS. Superfund, OUIII.

Summary from the document:

"Following recent heavy rainfalls I visited areas in the park associated with stormwater drainage projects to examine how they performed. An area that I remain concerned about is the culvert on the Quincy Smelter site installed as part of an EPA project in 2004. While placement of the culverts has effectively rerouted drainage, erosion continues in this location and has led to sediment basins filling after less than one season. Seeking answers for why this occurred, I explored the drainage area south of the culvert that passes below highway M-26. The photos I have included below are useful to examine change in the landscape and to identify issues to be resolved."

(2006). Great Lakes Environmental Center, MDEQ. **PCB study using semipermeable membrane devices in Torch Lake, Houghton County (MDEQ project number 05-25)**. Torch Lake, MDEQ, PCB, SPMD, water.

This report describes the study the MDEQ conducted using Semi-Permeable Membrane Devices to determine congener concentrations in the Torch Lake water column compared to control sites on the Portage Canal and in Huron Bay. The concentrations of PCBs were generally higher, and high concentrations found in tetra- and penta- chlorinated congeners were generally higher than others. The results of the study suggest that there is a source of PCBs at the northern side of Torch Lake. GLEC is the contractor that carried out the work and their report provides additional detail to what is provided in the MDEQ report on the same study.

(2006). Great Lakes Environmental Center, MDEQ. **Development of a Copper Criteria Adjustment Procedure for Michigan's Upper Peninsula Waters**. copper, MDEQ.

From the Executive Summary from the document:

"Results of laboratory tests and water quality monitoring revealed that elevated copper concentrations in several Upper Peninsula (U.P.), Michigan....suggest that Michigan's current copper standard may be overprotective for streams and rivers in the U.P., and perhaps in other State waters as well. This research program was designed to develop a copper criteria adjustment procedure for U.P. waters using a scientifically defensible approach that accounts for site-specific conditions.... The data indicate that i) a single standard for copper in the U.P. is not appropriate; ii) copper toxicity in U.P. waters is highly dependent on DOC concentration; iii) copper toxicity in U.P. waters is poorly correlated with water hardness (also alkalinity and pH); and iv) the copper BLM consistently overestimates observed LC50 values and WERs in U.P. waters. Modification of Michigan's copper standard at any given U.P. site appears to be best achieved by linear graphic interpolation of the WER from measured DOC concentrations."

(2006). R. M. Hobrla, MDEQ. Quality. Personal Communication. D. Lorenzetti.

(2006). D. S. Ireland. **Torch Lake PCB/SPMD results**. Personal Communication. M. Elster. PCB, PCBs in SPMDs.

Interpretation of results from study 2005 MDEQ study of PCBs in semi-permeable membrane devices.

(2006). MDEQ. **Guidance for Delisting Michigan's Great Lakes Areas of Concern**. Torch Lake, Great Lakes, Area of Concern.

From the Purpose section of the document:

"The purpose of this document is 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."

(2006). MDEQ. **Torch Lake SPMD study cover letter_3-29-06**. Personal Communication. D. Lorenzetti. PCB, PCBs in SPMDs.

Letter from MDEQ Water Bureau to D. Lorenzetti, a member of the Torch Lake PAC. Letter updates the PAC about the status of the assessment of the Beneficial Use Impairment covering Restrictions on Fish and Wildlife Consumption in the Torch Lake Area of Concern (AOC).

(2006). MDEQ, **PCB concentrations in Torch Lake using semi-permeable membrane devices**.

This report describes the study the MDEQ conducted using Semi-Permeable Membrane Devices to determine congener concentrations in the Torch Lake water column compared to control sites on the Portage Canal and in Huron Bay. The *concentrations of PCBs were generally higher, and high concentrations found in tetra- and penta- chlorinated congeners were generally higher than others. The results of the study suggest that there is a source of PCBs at the northern side of Torch Lake.*

(2006). M. B. Schafer. **Subject: Sediment Core Studies of Biotic Recovery Following Mining Perturbations in Torch Lake Superfund Site**. Personal Communication. W. C. Kerfoot. Torch Lake, sediment, natural attenuation.

Comments on MTU report on sediment core studies in Torch Lake from MDEQ Water Bureau and Superfund staff. Among other items, they seemed to be unclear on the type of model used to understand copper dynamics in Torch Lake and what is the CRS model.

(2006). U.S. EPA, **Exception to CRL QA Procedure**. PCB, fish.

Explanation for a performed exception to the CRL QA procedure related to the PCB sampling in fish.

(2006). W. J. Whipple, CRL. **Case Narrative**. PCB, PCBs in passive samples.

Includes Case Description, Quality Controls, and Sample Results for soil sample analysis. Soil samples were taken from same locations as SPMD samples during the 2005 SPMD study in Torch Lake.

(2007). M. A. Gade. Personal Communication. S. E. Chester. Torch Lake, Area of Concern, Beneficial Use Impairment, Fish Tumors.

Letter from U.S. EPA stating that they approve the MDEQ's request for the delisting of the Fish Tumors and Other Deformities Beneficial Use Impairment in Torch Lake

(2007). MDEQ. **The Michigan Department of Environmental Quality Biennial Remedial Action Plan Update for the Torch Lake Area of Concern**.

The purpose of the document is to determine if Torch Lake can be delisted as an AOC. When Torch Lake was established as an AOC, three BUIs were identified: Fish Tumor or Other Deformities, Restrictions on Fish and Wildlife Consumption and Degraded Benthos. The Fish Tumor or Other Deformities BUI was delisted in 2007. The other two BUIs still remain. This document explains in detail the status of the three BUIs. It also gives a summary of the Superfund remedial actions.

The document states that the Fish Tumor BUI can be delisted. Degradation of Benthos is addressed by the natural attenuation of Torch Lake sediment and will only be improved once the sediment is no longer toxic to benthos. To address the Restriction on Fish and Wildlife Consumption BUI, the local source of PCBs to the lake must be identified and removed.

(2007). M. Schafer and B. Vetort, **Torch Lake**. Torch Lake, Superfund, sediment, metals, PCB.

2007 sediment sampling in Lake Linden Park for metals and PCBs. Several metals and Aroclors 1248 and 1254 were found.

(2007). Weston Solutions, Inc., U.S. EPA. **Summary Report for the Torch Lake Area Assessment Torch Lake NPL Site and Surrounding Areas Keweenaw Peninsula, Michigan**. Torch Lake, Superfund, metals, PCB, Weston.

This is the Weston report from 2007 that measured metals and PCB concentrations in 17 different Areas of Investigation within the Torch Lake Superfund site.

(2008). U. S. EPA. **Second Five-Year Review Report for the Torch Lake Superfund Site, Houghton County, Michigan**. Torch Lake, Superfund, Five-Year Report.

The second five-year report describes progress on the Superfund-required remediation activities. The issues and recommendations to addresses these issues are as follows (from the document):

"Issues:
1. Based upon the IC evaluation activities thus far, follow-up actions are required to assure that Deed Restrictions on the remaining private properties are implemented. Further review of the institutional controls is needed to assure that the remedy is functioning as intended with regard to the ICs and to ensure effective procedures are in place for long term stewardship at the Site.
2. Possible exposures for groundwater and the effectiveness of the county well permitting process in preventing drinking water well installation in tailings at the Site requires evaluation. EPA has recently been informed that there may be drinking water wells at the Site that use tailings as a potable water source. Specifically evaluate residential areas within the Site. (Isle-Royale, Dollar Bay, Mason Sands, Point Mills)

3. Possible groundwater exposures/complete GSI pathway, GSI needs to be evaluated
4. Mining related wastes have been left in place and unaddressed in the Lake Linden Recreational Area.
5. Lack of cover and sedimentation basin issues at Quincy Smelter to prevent further erosion of stampsands into surface water.
6. Continued Deterioration of Buildings and structural safety concerns. Friable asbestos exists in some buildings at the Quincy Smelter facility.
7. Possible additional contaminant sources at Mason Sands. The need for additional work will be determined.
8. Need to determine if additional areas from the Torch Lake Area Assessment Report (TLAA Report) need assessing or remediation (Attachment 6- "Attachment A" from MDEQ – MDEQ's list of concerns).
9. Long-term access for conducting monitoring and O&M activities has not been formally established.
10. Houghton County Road Commission's road traction tailing excavation practices at Point Mills relative to 1992 ROD requirements are a possible concern.
11. Deed restrictions to prevent the development of residences in the slag area of Quincy Smelter were not implemented.
12. Slow-sedimentation and lack of detoxification of sediments in Torch Lake as assumed in OU2 ROD, leading to a current estimate of natural recovery in excess of several hundred years.
13. A next round of monitoring and data collection for Torch Lake is required by 2009.
14. Lack of acceptable vegetative cover establishment in certain areas of Point Mills....

Recommendations and Follow-up Actions:
1. Continue to seek documentation from landowners at the Site to verify proper deed restrictions have been put in place, and if they are not, work with the landowners and/or county to ensure deed restrictions are put in place.
2. Evaluate groundwater data and uses at the Site, as well as develop a plan for periodic on-Site inspections of groundwater use and work with county officials to evaluate the effectiveness of the county well permitting process in preventing the installation of drinking water wells in tailings.
3. Groundwater exposures/complete GSI pathway, needs to be evaluated.
4. Further assessment, evaluation and remediation as necessary in the Lake Linden Area.
5. Prepare and Finalize a Decision Document (ROD Amendment) to implement appropriate remedy at Quincy Smelter.
6. Building and structural stability along with asbestos removal will be assessed.
7. Further assessment, evaluation and remediation as necessary in the Mason Sands parcel.
8. Determine if any areas from the TLAA Report need additional evaluation.
9. Review 1994 AOC and other access agreements for applicability to long-term access. Seek appropriate long term solution for access agreements where necessary. Evaluate the need for additional ICs.
10. Work with the Houghton County Road Commission to ensure practices are consistent with the 1992 ROD.
11. Work with Franklin Township to ensure they record appropriate deed restrictions at Quincy Smelter.
12. Determine and develop alternative studies or measures for OU#2, Torch Lake, as appropriate.
13. Develop Data collection plan/Monitoring for Torch Lake.
14. Evaluate vegetative cover establishment in certain areas of Point Mills and determine possible solution."

(2008). U. S. EPA. **Proposed Plan for Record of Decision Amendment for Operable Unit 3 at Torch Lake Superfund Site**. Superfund, OUIII, Record of Decision.

This amendment describes a revised plan for the Quincy Smelter site in OUIII. The reason a revision was necessary is that the site was supposed to become a national park, but it did not. The revised plan consists of soil and vegetative cover at the smelter and improved erosion control along the shoreline.

(2008). U.S. EPA. **Planning for the Future: Reuse Assessment for the Quincy Smelter Site Torch Lake Superfund Site, Houghton County, Michigan**. Superfund, OUIII.

This document is a concept plan for the reuse of the Quincy Smelter site (OUIII) as a more functional park space.

(2008). B. Kelly, U.S. EPA. **Initial/Final - Asbestos Removal Complete Quincy Smelter 48991 Maple Street, Ripley, Franklin TWP, MI Latitude: 47.12 Longitude: -88.54**. Personal Communication. Various. Superfund, OUIII, Emergency Removal.

Report discussing actions taken in removing and abating asbestos from the Quincy Smelter (OUIII) site.

(2008). MACTEC Engineering and Consulting of Michigan, Inc., MDEQ. **MONITORING REPORT TORCH LAKE SUPERFUND SITE**. Torch Lake, Superfund.

Conclusions include the following:
1. Natural recovery of sediments is not occurring at an appreciable rate. Based on a study by Dr. Kerfoot, the

estimated time for natural sediment recovery to occur is 800 years.
2. There has been some improvement in pelagic fish species.
3. Sources of copper, mercury and other contamination remain uncontrolled. A persistent source of copper is present.
4. No conclusions were drawn from any evaluation of bioavailability.
5. Copper concentrations in surficial sediment layer have increased; specifically they have increased to concentrations above those found in the deeper sediments.
6. The benthic organism community remains low in abundance and richness, and is not improved by natural recovery of sediments.

Recommendations include the following:
1. Rates of copper concentration and deposition over time should be determined.
2. Biotic recovery should be evaluated.
3. Nature and extents of the contaminants should be characterized.
4. Conduct modeling on copper and metals to determine their transport and transformation.
5. Conduct an investigation on PCBs at the site.
6. Generally implement monitoring and modeling of transport and fate of contaminants so that all possible sources of contamination are accounted for. Once this has been accomplished, do the remediation.

(2008). MDEQ. **A sediment chemistry survey of Torch Lake**. Torch Lake, AOC, MDEQ, PCB, sediment.

The purpose of this study is to follow up to the one completed in 2005 using Semi-Permeable Membrane Devices to determine PCB concentrations in the water. The results of that study indicated that a source of PCBs exists within the lake, therefore the purpose of this study was to determine where in the sediment elevated concentrations of PCBs are found.

Conclusions from this study include the following (from the summary of the document):
"2. The metals analysis demonstrated elevated concentrations of copper and lead consistent with the historical sampling activities.
3. PCBs were detected in 16 of the 71 discrete samples, with quantified concentrations ranging from 130 micrograms/kilogram (ug/kg) to 8,900 ug/kg. PCBs were also detected at 11 of the 36 surficial sampling locations.
4. Surficial sediments in the Hubbell area in Torch Lake appear to have low levels (1,000 ug/kg or less) of PCB concentrations. PCB concentrations in the deeper sediments, except at the very northern end of the sample area (Figure 2), were predominantly below reporting limits.
5. Based on the data collected, the PCB sediment concentrations in the north/northwest basin of Torch Lake are below levels requiring remedial action. However, given that low levels of PCBs are detected in the surficial sediment in the Hubbell sampling area an ongoing upland source of PCBs to Torch Lake can not be ruled out."

(2008). MDEQ. **PCB concentrations in Walleye collected from Torch Lake (Houghton County) and Lake Superior**. Torch Lake, AOC, MDEQ, BUI, fish consumption advisory, PCB.

This study was conducted as a follow up to the Semi-Permeable Membrane Device study completed by the MDEQ in 2005 and the Sediment Chemistry Survey completed by the MDEQ in 2007. The objective of this study was to determine if PCB concentrations found in fish caught from Torch Lake were greater than PCB concentrations found in fish caught from Lake Superior.

Conclusions of the study include the following (from the document summary):
"3. Total PCB and lipid-normalized total PCB concentrations in Torch Lake walleye collected in 2007 were equivalent to the concentrations in walleye collected in 2000.
4. Total PCB and lipid-normalized total PCB concentrations in walleye collected from Torch Lake were higher than concentrations in walleye collected from Huron Bay, and the data suggest that walleye from the two areas represent distinct groups.
5. Total PCB concentrations in Portage Lake walleye appear similar to the concentrations in walleye collected from Huron Bay, but the comparisons are weak due to a small Portage Lake sample.
6. The MDCH fish consumption advisories for Torch Lake and Portage Lake walleye are unlikely to be relaxed based on the total PCB concentrations measured in the 2007 samples."

(2008). Weston Solutions, Inc. U.S. EPA. **FINAL LETTER REPORT FOR THE QUINCY SMELTER SITE RIPLEY, FRANKLIN TWP., HOUGHTON COUNTY, MICHIGAN**.

WESTON START conducted a time-critical removal of asbestos at the Quincy Smelter Site in April 2008. This report discusses the specific activities performed. (From page 3 of the document) Activities include the following:

- *reducing the height of the Reverberatory Furnace Building smoke stack*
- *asbestos removal*
- *air monitoring*
- *health and safety removal oversight*

(2008 (inferred)). B. Kelly, U.S. EPA. **ACTION MEMORANDUM - Request for a Time Critical Removal Action at the Quincy Smelter Area of the Torch Lake Superfund Site, Franklin Township, Houghton County, Michigan (Site ID B57M)**. Personal Communication. R. C. Karl, U.S. EPA. Superfund, OUIII, Emergency Removal.

The purpose of this memo was to request approval from the EPA for an emergency removal of asbestos from the Quincy Smelter site.

(2009). U.S. EPA. **Aroclor sediment investigation Torch Lake area of concern**. Torch Lake, sediment, PCB, MDEQ, EPA.

From the Project Goals and Objectives Section (page 3):
"The objective of this study was to evaluate surficial sediments throughout the Lake to determine if there are areas of higher PCB concentrations that might indicate a terrestrial and/or aquatic source of PCBs to the lake. This report presents the results of the 2008 sediment sampling event and provides some context for those results."

From the Results and Discussion:
"Of the eighty nine samples collected and analyzed, only two had detectable concentrations of PCBs, sample TL08-75 (90 micrograms per kilogram [µg/kg] J) and TL08-76 (26 µg/kg J). The J flag, in both cases indicates that the values are estimated because they are below the contract required detection limits, as required by the EPA CLP program."

(2009). B. Vetort. **Residential Wells Evaluation, Torch Lake Superfund Site Houghton County, Michigan**. Personal Communication. S. Cornelius. Torch Lake, Superfund, groundwater.

Summary of residential and municipal groundwater well monitoring on Torch Lake Superfund site locations.

(2009). B. Vetort-Tiffany, MDEQ. **Groundwater Sampling Investigation Report for Village of Lake Linden Torch Lake Superfund Site Lake Linden, Michigan**. Torch Lake, Lake Linden, Superfund, metals, groundwater.

Purpose of this document (from the General Summary on page 1):
"This work was conducted to further evaluate exposure pathways identified during the United States Environmental Protection Agency (U.S. EPA) August 2007 emergency removal action, and to investigate agency and citizen reports of "blue water" discharging onto the Lake Linden beach and into the creek adjacent to the beach. This sampling effort is designed to screen for likely groundwater discharge locations along the Lake Linden stampsands, and to collect samples of groundwater prior to its discharging into the Torch Lake surface water body."

From the results and discussion section (page 8):
"The MDEQ identified several areas of preferential flow. The most significant of these groundwater discharge locations are where the field screening data coincide with upward hydraulic gradients. Sample locations were biased to these locations. Field screening data, especially specific conductance and temperature measurements, were used to identify where to collect samples."

Recommendations for next steps are given in the document.

(2009). B. Vetort-Tiffany, MDEQ. **Groundwater Sampling Investigation Report for Michigan Smelter, Torch Lake Superfund Site, Houghton County, Michigan**. Superfund, groundwater, Michigan Smelter.

Sampling was conducted to find potential discharge sources of groundwater from the smelter site and to collect samples prior to their discharge into the Portage Canal. According to the document, "The MDEQ identified several areas of preferential flow. The most significant of these groundwater discharge locations are where the field screening data coincide with upward hydraulic gradients. Sample locations were biased to these locations. Field screening data, especially specific conductance and temperature measurements, were used to identify where to collect samples." Recommendations for next steps are given in the document.

(2010). MDEQ. **Michigan Department of Environmental Quality Fish Contaminant Monitoring Program 2010 Annual Edible Portion Report Recommendations for Changes to the 2011 Michigan Department of Community Health Fish Consumption Advisory**.

(2011). B. R. Jones, U.S. EPA. **Torch Lake Area of Concern: Current Status**. Torch Lake, Area of Concern.
Slideshow introduces the Torch Lake Area of Concern and describes ecological monitoring that took place at the site.

(2011). N. R. Urban et al., **Integrated Assessment of Torch Lake Area of Concern**. Torch Lake, Michigan Sea Grant.
Michigan Sea Grant Integrated Assessment project proposal.

(2011). USACE. **Keweenaw Stamp Sands Ecosystem Restoration, Keweenaw and Houghton Counties, MI**. stamp sands, Gay, USACE
USACE study to determine effects of Gay stamp sands on ecosystem and benthics.

(2011 (Accessed)). U.S. EPA. **MID980901946, NPL Fact Sheet | Region 5 Superfund | US EPA**. November 2, 2011. Torch Lake, Superfund.
EPA online summary description of the Torch Lake Superfund Site.

(2012). T. Lipsey. **Development of Site-Specific Aquatic Values for Total Copper for Water Bodies in the Upper Peninsula of Michigan**. Personal Communication. Stakeholders. Keweenaw Peninsula, copper.
This letter explains what the copper criteria document is, tells the stakeholder where online they can find the document, and asks for comments.

(2012). T. Lipsey. **"Two Total Maximum Daily Loads (TMDLs) for Total Copper for the Owl Creek Watershed, Keweenaw County, Michigan" and "Three TMDLs for Total Copper for portions of the Trap Rock River Watershed, Houghton County, Michigan"**. Personal Communication. Stakeholders. copper, TMDL, MDEQ.
Letter informing stakeholders of development of TMDLs

(2012). MDCH. **Health Consultation: Technical Support Document for a Polychlorinated Biphenyl Reference Dose (RfD) as a Basis for Fish Consumption Screening Values (FCSVs)**. MDCH, U.S. Department of Health and Human Services, PCB, fish, MDCH.
From the document:
"The purpose of this document is to review the recent literature on PCBs and recommend changes in the MFCAP, if necessary, to ensure that the consumption advice remains protective of public health and the basis of the screening levels can be evaluated and updated as needed." (page 10) Conclusions: "MDCH concludes that eating unlimited amounts of certain fish from lakes in Michigan throughout the year could harm people's health. This is a public health hazard." (page 9) Next steps: "Use the proposed reference dose (RfD), protective of immunological effects and other non-carcinogenic effects, to develop updated PCB fish contaminant screening values (FCSVs) and utilize these values to provide fish consumption advice in Michigan.... Continue monitoring of fish in Michigan for PCBs.... Provide the Fish and Wildlife Contaminant Advisory Committee (FAWCAC) and other relevant groups (Great Lakes Sport Fish Advisory Task Force and Great Lakes Human Health Network) with a copy of this document." (page 9)

(2012). N. R. Urban, **ENVE4505 Fall 2012 Modeling Project 2**. copper.
Description of term-project assignment consisting of calculating the mass balance of copper in Torch Lake.

(2012 (Inferred)). MDCH, U.S. Department of Health and Human Services. **Public Health Assessment Initial/Public Comment Release: Evaluation of Municipal and Residential Drinking Water around Torch Lake**. Torch Lake, groundwater.
In 1989, 1995 and 1998, the MDCH produced several documents discussing public health issues at the Torch Lake Superfund site. In 2007, the MDEQ requested updated information. According to the document, "This document addresses potential contaminant exposure from municipal or residential wells in the Torch Lake area. This document does not include any ecological assessments, such as discussion of impacts to wildlife or benthic communities." (page 7) According to the summary of the document, the following conclusions concerning drinking water wells at the Torch Lake site were made: 1) "MDCH concludes that drinking municipal drinking water is not expected to harm people's health." (page 7) and 2) "MDCH is unable to determine if contaminants present in private residential wells installed or screened in stampsand may harm people's health." (page 7)

(2012 (Inferred)). MDCH, U.S. Department of Health and Human Services. **Public Health Assessment Initial/Public Comment Release: Physical hazards in the Torch Lake Superfund site and surrounding area, Houghton and Keweenaw Counties, Michigan**. Torch Lake, Superfund, MDCH, U.S. Department of Health and Human Services, physical hazards.
This document evaluates the physical hazards present throughout the entire Torch Lake Superfund Site. The study concludes that many physical hazards are present throughout the site and that the degree of human protection varies throughout the site. Physical hazards need to be removed, corrected or better restricted.

(2012 (Inferred)). MDCH. **Torch Lake Superfund Site and Surrounding Areas Drinking Water**. M. D. o. C. Health. Torch Lake, groundwater.

Fact Sheet summarizing results of 2010 municipal and residential groundwater monitoring. Tells residents they should only consume water from well-constructed wells.

(2012 (Inferred)). MDCH, MDEQ. **Two Total Maximum Daily Loads for Total Copper for the Owl Creek Watershed, Keweenaw County, Michigan**. TMDL, Owl Creek.

(2012 (Inferred)). MDCH, MDEQ. **Three Total Maximum Daily Loads for Total Copper for Portions of the Trap Rock River Watershed, Houghton County, Michigan**. Trap Rock River, TMDL.

(2013). U.S. EPA. **Five-Year Review Report for the Torch Lake Superfund Site, Houghton County, Michigan**. Torch Lake, Superfund, Five-Year Report.

The third five-year report describes progress on the Superfund-required remediation activities. The issues and recommendations to addresses these issues are as follows (from the document):

"Issues:
1) Lack of vegetative cover establishment at certain properties at the Point Mills. Also, minor areas need repair and additional reseeding and fertilization at Point Mills.
2) A determination needs to be made that the required restrictive covenants on residential properties and permitting restrictions on wells screened in the stamp sands are in place and effective to ensure long-term protectiveness of human health and the environment for the groundwater.
3) Houghton County Road Commission is currently using tailing material at Point Mills to spread on roads during winter to provide traction for motor vehicles.
4) Site-wide O&M Plan have not been finalized. Existing residential wells are screened in the stamp sands. While these wells are not contaminated above drinking water standards, monitoring is necessary to ensure remedy continued protectiveness....

Follow-up Recommendations:
1) U.S. EPA and MDEQ will work with property owners to find a cost-effective solution to the vegetation problem at Point Mills.
2) U.S. EPA and MDEQ will review the required restrictive covenants on residential properties and the permitting restrictions on wells screened in the stamp sands and confirm that they are necessary, in place and effective. U.S. EPA and will prepare an IC plan for the Site which will include a plan for long-term stewardship.
3) U.S. EPA and MDEQ will work with the Houghton County Road Commission to ensure that road traction tailing excavation practices are consistent with the 1992 ROD.
4) MDEQ will finalize the Site-wide O&M Plan. MDEQ will revise the O&M Plan to include monitoring of residential wells screened in the stamp sands."

(2013). LimnoTech, MDEQ, U.S. EPA. **Statewide Michigan PCB TMDL**. TMDL, PCB, Michigan.

From Page 1 of the document:

"The 2010 Sections 303(d), 305(b), and 314 Integrated Report (Michigan Department of Environmental Quality2 [MDEQ], 2010a) identified 21,923 miles of rivers and streams and 144,693 acres of inland lakes and reservoirs as not supporting their designated use due to high concentrations of polychlorinated biphenyls (PCBs) in fish tissue. In addition, 49,551 miles of rivers and streams and 125 acres of lakes are not supporting their designated use due to PCBs in the water column (MDEQ, 2010a).

The scope of this PCB TMDL covers inland water bodies in the state of Michigan, primarily impacted by atmospheric deposition of PCBs. These water bodies are described further in Section 2 and Appendix A. This document describes the statewide approach that Michigan has taken to develop a TMDL for PCBs."

(2013 (Inferred)). MDCH, U.S. Department of Health and Human Services. **Public Health Assessment Public Comment Release: Evaluation of recreational uses at beach areas at Lake Linden and along Torch Lake, Houghton County, Michigan**. Torch Lake, Lake Linden, MDCH, U.S. Department of Health and Human Services, beaches.

The purpose of this document is to identify potentially harmful exposures and actions that would minimize those exposures. The MDCH was unable to determine if the chemicals found at the Lake Linden, Hubbell beach areas and

Boston Pond and Calumet Lake were harmful to human health. They determined that the chemicals found in the Mason stamp sand area are not harmful to human health, and that unlimited consumption of fish from Torch Lake is harmful to human health.

Part 3. Major sources used in historical and community engagement chapters

Benedict, C.H. ***Lake Superior Milling Practice. A Technical History of a Century of Copper Milling***. Houghton, MI: Michigan School of Mines. 1955.

The standard work on milling technology in the Lake Superior Copper district, written by a Calument & Hecla mining engineer and major figure in the development of reclamation methods of tailings (stamp sands) in Torch Lake. Covers milling and reclamation processes from the earliest years to the 1950s.

Calumet and Hecla Mining Companies Finding Aid. MS-002. Michigan Technological University Archives. 2/22/2010

MTU Archives houses a large collection of the business and production archives for Calumet and Hecla Mining Company, covering the 1860s through the 1960s. Correspondence, photos, drawings, maps, financial information, and production records are available for most of C&H's divisions (milling, smelting, secondary copper, etc.). The finding aid provides a comprehensive guide for locating company information.

Michigan Department of Environmental Quality (MDEQ). **Torch Lake Area of Concern**. Website. http://www.michigan.gov/deq/0,4561,7-135-3313_3677_15430_57448---,00.html

Michigan Department of Environmental Quality (MDEQ. **Abandoned Mining Waste Project – Torch Lake non-Superfund Site**. Website. http://www.michigan.gov/deq/0,4561,7-135-3311_4109_9846_76560---,00.html

Mining Congress Journal. October, 1931.

This issue of a major journal for mining engineers is devoted to several articles on operations at Calumet and Hecla Mining Company. It provides a detailed snapshot on the technology and status of major operations of the company, including facilities along Torch Lake such as mills, power plant, reclamation plants, and the smelter.

Quincy Mining Company Collection. MS-001. Michigan Technological University Archives. 2014.

Finding Aid for MTU's collection of Quincy Mining Company's large collection of business and production records. Similar in organization and scope to that of C&H Mining Company.

Torch Lake. Vertical File. Michigan Technological University Archives

Clipping file containing articles on Torch Lake from 1980s through 2000s. Excellent source of Daily Mining Gazette articles on EPA Superfund and the Area of Concern at Torch Lake documenting local meetings and work by federal and state agencies at the site. Not all articles are included, and some years lack more than a very few clippings (especially after the early 2000s).

US Environmental Protection Agency. **Torch Lake Superfund Site**. Website. https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0503034

US Environmental Protection Agency. **Torch Lake AOC Site**. Website. https://www.epa.gov/torch-lake-aoc