SAMPLING AND ANALYSIS PLAN
FOR THE
ABANDONED MINING WASTES
TORCH LAKE NON-SUPERFUND SITE
TAMARACK CITY OPERATIONS AREA
HOUGHTON COUNTY, MICHIGAN
SITE IDENTIFICATION NO. 31000098

Prepared for:

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
Remediation and Redevelopment Division
55195 US Highway 41
Calumet, Michigan 49913

Prepared by:

WESTON SOLUTIONS OF MICHIGAN, INC.
P.O. Box 577
Houghton, MI 49931

April 2015

Work Order No. 20177.001.001.0010

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LIST OF ABBREVIATIONS AND ACRONYMS

°C	Degrees Celsius
µm	Micron
ACM	Asbestos Containing Materials
AUV	Autonomous Underwater Vehicle
bgs	Below Ground Surface
BUI	Beneficial Use Impairments
C&H	Calumet and Hecla
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHTC	C&H Tamarack City Operations Area
CLP	Contract Laboratory Program
COC	Chain of Custody
CSV	Comma-Separated-Value
DCC	Direct Contact Criteria
DO	Dissolved Oxygen
DQO	Data Quality Objective
DWC	Drinking Water Criteria
DWPC	Drinking Water Protection Criteria
ERB	Equipment Rinsate Blank
EPA	U.S. Environmental Protection Agency
ESL	Ecological Screening Levels
GPS	Global Positioning System
GSIC	Groundwater/Surface Water Interface Criteria
GSIPC	Groundwater/Surface Water Interface Protection Criteria
GSU	Geological Services Unit
HASP	Health and Safety Plan
HDPE	High-Density Polyethylene
ID	Identification
IDW	Investigative derived Waste
ISID	Indefinite Scope Indefinite Delivery
KW	Kilowatt

LCS	Laboratory Control Sample
MDEQ	Michigan Department of Environmental Quality
MeOH	Methanol
mg/kg	Milligram per kilogram
Michigan Tech	Michigan Technological University
mL	Milliliter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NREPA	Natural Resources Environmental Protection Act
NS	Non-Superfund
ORP	Oxidation-Reduction Potential
PA	Public Act
PCB	Polychlorinated Biphenyls
PCI	Peninsula Copper Industries
PEC	Probable Effect Concentration
PID	Photoionization Detector
PNA	Polynuclear Aromatic Hydrocarbon
PPE	Personal Protective Equipment
ppm	Parts Per Million
PSIC	Particulate Soil Inhalation Criteria
QA/QC	Quality Assurance/Quality Control
ROV	Remotely Operated Vehicle
RRD	Remediation and Redevelopment Division
RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
SI	Site Inspection
SOO	Statement of Objectives
SOP	Standard Operating Procedure
SOW	Statement of Work
SPM	State Project Manager
SVOC	Semi-volatile Organic Compound
TAL	Target Analyte List
TBD	To Be Determined
TCLP	Toxicity Characteristic Leaching Procedures
TDD	Technical Direction Document
TDL	Target Distance Limit
TEC	Threshold Effect Concentration
USCS	Unified Soil Classification System

UST	Underground Storage Tank
VOC	Volatile Organic Compound
WESTON	Weston Solutions, Inc.
yd^3	Cubic Yards

1. INTRODUCTION

Weston Solutions of Michigan, Inc. (WESTON®) has prepared this Sampling and Analysis Plan (SAP) to identify data collection activities and associated quality assurance/quality control (QA/QC) measures specific to the Abandoned Mining Wastes – Torch Lake non-Superfund Site (Project), Calumet and Hecla (C&H) Tamarack City Operations Area (CHTC) in Houghton County, Michigan.

The SAP has been prepared in accordance with the *Scope of Work, Schedule, and Budget Estimate - Abandoned Mining Wastes – Torch Lake non-Superfund Site, C&H Lake Linden Operations Area, Houghton County Michigan, December 16, 2013* and the subsequent *Scope of Work, Schedule, and Budget Estimate for Modification 1 (July 2014)* prepared by WESTON in response to a request from the Michigan Department of Environmental Quality (MDEQ), Remediation Division, under the Indefinite Scope, Indefinite Delivery (ISID) Professional Services contract between WESTON and the MDEQ (Contract No. 00477).

The SAP has been developed to detail the project's organization and operational responsibilities of key MDEQ and WESTON personnel working on the Project. The SAP also describes the design and implementation of measurement systems that will be used during the collection of environmental samples at the Site. The document describes the sampling procedures, analytical methods/procedures, data quality objectives (DQOs), data handling, and documentation procedures.

Section 1 of the SAP defines the objectives of the investigation and the organizational structure of the project team. **Section 2** provides the Project background including a description and a brief account of the previous investigative activities implemented in the CHTC. **Section 3** provides an outline of the proposed implementation schedule. **Section 4** provides a summary of the sampling rationale and environmental media to be sampled during the field activities. **Section 5** provides a summary of field procedures, sampling protocols, and laboratory analyses necessary to complete the field activities, and **Section 6** includes a list of the proposed analytical laboratories, and **Section 7** outlines the QA/QC protocols that will be implemented to assess the overall reproducibility of the laboratory analytical results.

1.1 PROBLEM DEFINITION

The Project is characterized by the risks posed by chemical containers and residues historically discarded in or near Torch Lake. These concerns are distinct and separate from the risks historically addressed under the U.S. Environmental Protection Agency's (EPA's) Superfund program. The EPA defines the Torch Lake Superfund Site as the upper six inches of stamp sand and slag in certain areas of Houghton County and any soil cap and vegetative cover applied to such areas.

The remaining concerns at Torch Lake and the surrounding areas identified by the MDEQ include known or suspected impacts to groundwater, surface water, sediments, and upland media that were not addressed under the Superfund program. Environmental impacts that will be evaluated under this SAP include, but are not limited to the assessment of the following:

- Unidentified, significant in-lake and/or terrestrial sources of contamination including polychlorinated biphenyls (PCBs);
- Uncharacterized waste deposits, including more than 750 uncharacterized drums, reportedly, on the lake bottom;
- Bulk disposal areas, including stamp sand deposits, slag dumps, and landfills; and,
- Industrial ruins including coal storage areas, underground storage tanks (USTs), asbestos containing materials (ACM), and any other waste materials identified in future investigations.

The risks posed to environmental media, sediment in particular, by these waste deposits and continuing sources of contamination contribute to the limited recovery of the Torch Lake ecosystem. As such, the investigation will be largely driven by documented observations of drum and/or other debris locations in the lake as well as consideration related to historic operations and detected PCB concentrations.

The objectives of the Project are to support a comprehensive management approach that will guide MDEQ's decision making process in addressing risks present in the CHTC. The primary focus of the project is to ascertain the source, nature, and extent of contaminants (including PCBs) in all affected environmental media (soil, groundwater, surface water, and sediments) within Torch Lake, including former industrial areas along the shoreline, summarized as follows:

- Ahmeek Stamp Mill Complex;
- Osceola Township Park;
- Tamarack Reclamation Plant Complex;
- Tamarack Stamp Mill Complex;
- Osceola Stamp Mill; and,
- Historic Municipal Dump.

The activities, operations, and wastes related to the former industrial areas will be researched and documented. Terrestrial and underwater surveys will be conducted to identify drum and waste deposits. Representative sediment, surface water, groundwater, soil, and waste samples in the vicinity of these previously uncharacterized debris and waste deposits will be collected and analyzed. Further, the sample intervals will be spaced horizontally and vertically to accurately characterize the extent of any identified contamination in the vicinity of the identified wastes.

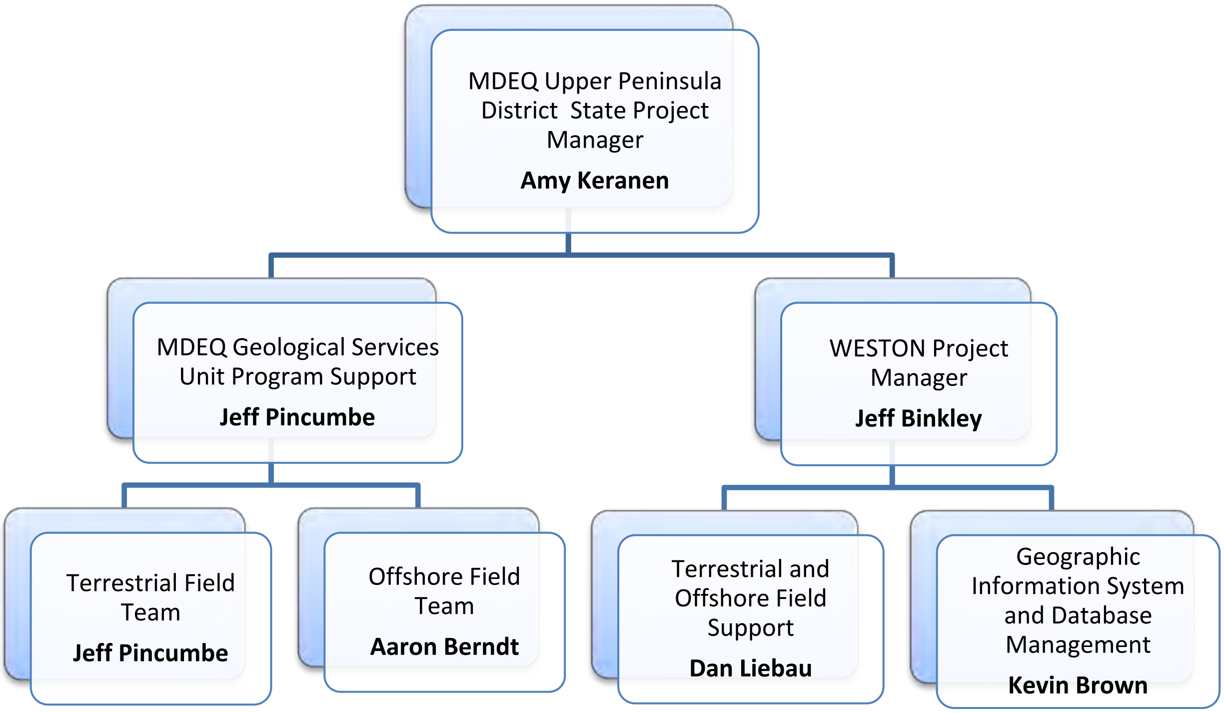
1.2 PROJECT MANAGEMENT

The Project is built upon partnerships and stakeholder engagement. Engagement among team members requires regular communication and is often driven by updated and additional information as well as shifting project priorities. The MDEQ SPM developed a collaborative management approach for the Project that is facilitated through a partnership with the WESTON Project Manager to achieve the Project goals. Additionally, investigative activities will be supported by the MDEQ Geological Services Unit (GSU), which will provide the tools, equipment, and resources to facilitate the investigative work within the CHTC.

Coordination of multiple team members will facilitated by establishing the project goals, building consensus, exchanging and integrating ideas, and setting a path forward with all team members. This approach will allow for team members to discuss the scope and objectives, clarify issues, and learn individual goals, success factors, and ideas. The kick off meeting will establish the foundation for the development and execution of the remainder of the project.

The general project organization is presented on **Figure 1-1**.

FIGURE 1-1
PROJECT ORGANIZATION



The following key project personnel will be involved in planning and/or technical activities performed during the various phases of data collection on the project. Each will receive a copy of the approved SAP. A copy of the SAP will also be retained in the Site file.

TABLE 1-1
KEY PROJECT PERSONNEL

Personnel				
Amy Keranen	State Project Manager	MDEQ-RRD	(906)-337-0389	KERANENA@michigan.gov
Jeff Binkley	Project Manager	WESTON	(906) 523-5457	J.Binkley@WestonSolutions.com
Jeff Pincumbe	Field Team Leader	MDEQ-GSU	(517) 335-6418	pincumbej@michigan.gov
Aaron Berndt	Field Team Leader	MDEQ-GSU	(517) 335-6419	berndta@michigan.gov
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Kevin Brown	Geographic Information System/Database Manager	WESTON	(517) 381-8945	Kevin.Brown@westonsolutions.com

2. PROJECT DESCRIPTION

Hard rock mining operations were prevalent throughout Houghton and Keweenaw Counties for nearly a century, primarily spanning an era between the mid-1800's and the mid-1900's. As mining activities declined in the region, a majority of the mine holdings, including surface and underground operations were abandoned, scrapped, and remnants otherwise left in-place.

The Project includes properties remote from Torch Lake proper, such as the 270+ acre Centennial Mine just north of Calumet, the Michigan Smelter, Freda/Redridge, the Tamarack City industrial ruins, Mason-Quincy Mill & leach plant, and other areas congruent with the Torch Lake Superfund site where the response action has been limited to the application of the vegetative cover or eliminating the area from further consideration.

The vast distribution of these former mining operations throughout the region (spanning several townships, villages and cities in Houghton County along the Portage Canal, Lake Superior, Slaughterhouse Creek, and Torch Lake) required that operational areas of the mining companies be divided into geographic subsets, allowing for prioritization of the geographic subsets and establishing a phased approach for assessing and addressing environmental concerns regionally.

The CHTC encompasses the former C&H Mining Company copper mining and processing operations in the vicinity of Tamarack City and Osceola Township, Michigan. Industrialization of the CHTC was initiated with the construction of several facilities between 1887 and 1908. These facilities included the construction and operation of the Osceola Stamp Mill, the Tamarack Stamp Mill, the Lake Stamp Mill No.2, and the Ahmeek Stamp Mill which were owned and operated by separate mining companies. Beginning in a timeframe around 1910, C&H gradually gained controlling interests in these operations. By the 1920s and 1930s milling operations ceased at several of the facilities while others, such as the Ahmeek Stamp Mill, were renovated or improved to meet the demands of the mining operations in the region. In a similar timeframe the Tamarack Reclamation Plant Complex was constructed for the processing of stamp sands recovered from Torch Lake (initially deposited in the lake as waste material by the aforementioned Osceola, Tamarack, Lake, and Ahmeek stamp mills). Wastes generated by the operation of the reclamation plant, including re-grinded stamp sands, were discharged to Torch Lake for disposal.

2.1 SITE BACKGROUND

The Project is located adjacent to the Torch Lake Superfund Site; however, the properties identified for assessment under the Project are generally not included in the Torch Lake Superfund Site, nor are remedies in place to mitigate environmental conditions on the properties. The only property included in this investigation that underwent previous remedial activities is the capped portion of the Tamarack Sands Area where historical dumping was reported.

In addition to the remedial activities implemented as part of the Torch Lake Superfund Site, the EPA also performed a site assessment and subsequent removal action to mitigate potential public health risks related to identified ACM at the Ahmeek Stamp Mill Complex. In August 2014, the EPA removal action resulted in the collection and disposal of 4 cubic yards (yd^3) of friable asbestos material. At the completion of the removal action, backfill was placed in the areas of former debris piles and around the concrete pillars on the Ahmeek Stamp Mill property.

Historically, numerous environmental investigations have been completed within the geographic subset by state, federal, and private parties. Key data and information derived from these investigations were assimilated and compiled by the MDEQ and considered in the development of this SAP.

Investigations at these properties have indicated elevated levels of metals in surficial soils, and in some cases, asbestos; lead and arsenic in sludges; polynuclear aromatic hydrocarbons (PNAs) and PCBs in waste materials; volatile organic compounds (VOCs) venting into Torch Lake from contaminated groundwater; and metals in groundwater. Further, the findings of the MDEQ SI and other investigations confirm that significant quantities of waste are present at terrestrial and offshore locations in and around Torch Lake. Further, analytical results indicate that shallow and subsurface soils, groundwater, and sediments have become contaminated with heavy metals, especially arsenic, chromium, copper, and lead.

2.2 SITE LOCATION AND DESCRIPTION

The CHTC is located along the west shore of Torch Lake in Tamarack City and Osceola Township, in Houghton County, Michigan. The CHTC is depicted on **Figure 2-1**.

The CHTC consists of approximately 110 acres of land extending approximately three miles along the shoreline of Torch Lake. The geographic area also incorporates up to 187 different parcels with multiple property owners. Building on the organization of the Preliminary Assessment completed by the MDEQ in November 2012, the CHTC was divided into three smaller study areas based on the historical industrial operations in each area. For consistency, WESTON has expanded upon the Subarea identification established by the MDEQ, while focusing on the identified industrial sites defined in the Statement of Objectives (SOO) prepared by the MDEQ. The investigative areas and their respective former industrial sites are summarized as follows:

- Ahmeek Mill Processing Area;
  - Ahmeek Stamp Mill Complex;
    - Ahmeek Stamp Mill;
    - Ahmeek Pump House;
    - Ahmeek Power House; and,
    - Ahmeek Boiler Houses.
- Tamarack Processing Area;
  - Tamarack Reclamation Plant Complex;
    - Tamarack Regrinding Plant;
    - Tamarack Electric Substation;
    - Tamarack Floatation Plant;
    - Tamarack Leaching Plant; and,
    - Tamarack Classifying Plant.
  - Tamarack Stamp Mill Complex;
    - Tamarack Mill No.1; and,
    - Lake Stamp Mill No.2 (Tamarack Mill No.2).
  - Osceola Stamp Mill.

- Tamarack Sands Area
  - Stamp Sand Deposit; and,
  - Historic Municipal Dump.

The following subsections provide additional detail related to the organizational areas identified above.

2.2.1 Ahmeek Mill Processing Area

The Ahmeek Mill Processing Area is northern-most study area in the CHTC, located adjacent to and directly south of the Hubbell Beach and Slag Dump study area located in the C&H Lake Linden Operations Area. The Ahmeek Mill Processing Area essentially includes the Ahmeek Stamp Mill Complex and lands adjacent to the former industrial facility that were potentially negatively impacted by former the former industrial operations. The Ahmeek Stamp Mill Complex was comprised of the following primary facilities that supported the processing of ore from the Ahmeek Mine located in Keweenaw County:

- Ahmeek Stamp Mill;
- Ahmeek Pump House;
- Ahmeek Power House; and,
- Ahmeek Boiler Houses.

The general locations of these former structures are depicted on **Figure 2-2**.

As documented by Michigan Technological University (Michigan Tech), the Ahmeek Stamp Mill was constructed in 1909 by the Ahmeek Mining Company. The mill processed ore from the Ahmeek Mining Company's mines as well as other smaller mines that did not have their own stamping facilities. The mill was supported by a power house and boiler house. A mixed pressure 2,000 kilowatt (KW) turbine was installed at the mill in 1916 to capture and utilized excess steam generated by the mill.

In 1923 the Ahmeek Mining Company's holdings, as well as other smaller mining companies, were consolidated with C&H forming the C&H Consolidated Mining Company. In 1930 the existing boiler house and power house at the Ahmeek Stamp Mill Complex were demolished and new facilities were constructed and brought on line in 1931. By 1938 the Ahmeek Stamp Mill housed eight stamps that could process 900 tons of material per day. By 1941 the Ahmeek Boiler House was providing steam to the Tamarack Reclamation Complex and by 1947 the Ahmeek Power House had become a central component in C&H's power generation in the region.

The Ahmeek Stamp Mill Complex continued to operate and between 1958 and 1968, and was reportedly recovering copper from slag, tailings, and brick in addition to processing ore from the mines. The Ahmeek Stamp Mill Complex discontinued operation in 1969 when C&H's holdings were sold to Universal Oil Products.

The areas of interest are generally bound to the north by 6^{th} Street and to the west by Highway M-26. The study area then extends west toward Torch Lake to include stamp sand deposits along the lake shore and Gull Island, which is also comprised of stamp sands. Properties within the Ahmeek Mill Processing Area are both municipally and privately owned. The Osceola Township Park is located within the footprint of the former Ahmeek Stamp Mill Complex.

As summarized in **Section 2.1**, the EPA performed a site assessment and subsequent removal action at the Ahmeek Stamp Mill Complex in 2014. Since the completion of those activities, the MDEQ documented a suspect panel-like material labeled "Asbestos" in the brush across the street from the basketball court and the Tamarack City Park/Playground. The observation of the panel-like suspect asbestos containing material (SACM) confirms that disposal practices at the end of mining era operations created the potential for waste distribution along the shoreline of Torch Lake, and in particular, the vicinity of the former stamp mill.

The Ahmeek Mill Processing Area is generally characterized as being a former industrial area. The industrial footprint of the stamp mill complex, including the locations of former buildings is depicted on **Figure 2-2**. Refer to **Appendix A** for a historical account of the Ahmeek Mill Processing Area, specifically the Ahmeek Stamp Mill Complex prepared by Michigan Tech.

2.2.2 Tamarack Processing Area

The Tamarack Processing Area is located on the west side of Highway M-26, southwest of the Ahmeek Mill Processing Area. Similar to the Ahmeek Mill Processing Area, the Tamarack

Processing Area was initially developed as the location for several stamp mills for smaller mining companies in the region. The Tamarack Mill was located centrally in the study area and was the northern-most stamp mill within the study area. The Tamarack Mill was constructed in 1887 by the Tamarack Mining Company. The Tamarack Mining Company constructed a second stamp mill, the Tamarack No.2, directly to the south of the existing mill in 1898. After 1917, the Tamarack No.2 mill was renamed the Lake Milling, Smelting, and Refining Company No.2 Mill. Approximately 300 feet south of the Tamarack No.2, was the Osceola Stamp Mill that was constructed by the Osceola Mining Company in 1899. Between 1906 and 1910, C&H had purchased controlling interests in the Tamarack and Osceola Mining Companies and over time consolidated their operations and transitioned to a focus on reclamation. The Tamarack Stamp Mill was closed in 1919 and demolished and scrapped in 1920. The Tamarack No.2 continued operation until 1930 and was demolished and scrapped in 1947. The Osceola Stamp Mill was closed in 1921 and the mill and associated boiler house were scrapped in 1941.

As C&H's operational focus shifted towards reclamation, the Tamarack Reclamation Complex was built in 1920 with the majority of the facilities becoming operational by 1925. The Tamarack Reclamation Complex was constructed to the north of the Tamarack Mill and was comprised of the following primary facilities:

- Tamarack Regrinding Plant;
- Tamarack Electric Substation;
- Tamarack Floatation Plant;
- Tamarack Leaching Plant; and,
- Tamarack Classifying Plant.

The Tamarack Reclamation Complex reprocessed stamp sands originally deposited in Torch Lake by the Ahmeek Stamp Mill and the older mills described in the preceding paragraphs. The recovered stamp sands were reground, classified/sorted, and leached via chemical processes to recover residual copper that remained in the previously discarded stamp sands. In 1945 C&H expanded operations at the Tamarack Reclamation Complex by establishing Lake Chemical Company which would focus on the development of copper chemicals, such as agricultural amendments and insecticides. In 1947 the Tamarack No.2 mill was renovated to establish a warehouse to increase storage capacity for copper chemicals produced at Lake Chemical Company as well surplus machinery and electrical equipment. Lake Chemical Company's operations continued into the 1960's and reportedly closed in 1968 when Tamarack Reclamation Complex closed.

The areas of interest are generally bound to the west by North Amygdaloid Street and to the east by Highway M-26. The study area is generally characterized by residential properties in the north with the focus of the SAP being placed on the former industrialized areas south of Tamarack Hill Road. Properties within the Tamarack Processing Area are generally privately owned.

The Tamarack Processing Area is generally characterized as being a former industrial area. The industrial footprint of the stamp mills and the reclamation complex, including the locations of former buildings is depicted on **Figure 2-3**. Refer to **Appendix A** for a historical account of the Tamarack Processing Area prepared by Michigan Tech.

2.2.3 Tamarack Sands Area

The Tamarack Sands Area is located south of the Ahmeek Mill Processing Area and east of the Tamarack Processing Area along the shoreline of Torch Lake. The area is generally accessible to vehicular and pedestrian traffic. The area was capped as part of the EPA's Torch Lake Superfund remedial action; however, reports related to the existence of a historic municipal dump have resulted in the areas inclusion in the planned investigation under this SAP. Further, the cap stamp sands are wastes associated with the industrial operations in the Ahmeek Mill and Tamarack Processing Areas. Since salvage and disposal operations during the decommissioning of the industrial facilities are not well documented there is also reason to investigate the potential for contaminant sources to be deposited with the stamp sands.

The Tamarack Sands Area is bound to the west by Highway M-26 and to the east by Torch Lake. The Tamarack Sands Area is both municipally and privately owned and is generally characterized as in lake waste deposits. The location of the Tamarack Sands Area is depicted on **Figure 2-4**. Refer to **Appendix A** for a historical account of the Tamarack Sands Area prepared by Michigan Tech.

2.2.4 Torch Lake

The study areas described in the preceding subsections are located or conducted operations along the shoreline of Torch Lake. Each of these former industrial operations relied on the waters of Torch Lake for shipping, process water, and waste discharge. In addition, the communities established around these industrial facilities also used the lake for similar purposes, historically discharging sewage and other wastes into the lake.

Historically, containers, drums, and building materials have been identified in Torch Lake. Some of these items were characterized and recovered as part of previous removal actions; however, many areas of similar waste deposits remain submerged or partially submerged along the shoreline of the lake. In addition, the abandoned or vacant state of some of the properties makes Torch Lake susceptible to the erosion or discharge of contaminated environmental media emanating from properties along the shoreline.

Numerous investigations have been completed in Torch Lake to evaluate sediment and water quality within the lake. PCBs have been detected in sediment and surface water in the lake and have resulted in the placement of the following beneficial use impairments (BUIs):

- **Restrictions on fish and wildlife consumption** - When contaminant levels in fish or wildlife populations exceed current standards, objectives or guidelines, or public health advisories are in effect for human consumption of fish and wildlife.
- **Degradation of benthos** - When the benthic macroinvertebrate community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when toxicity (as defined by relevant, field-validated bioassays with appropriate quality assurance/quality controls) of sediment associated contaminants at a site is significantly higher than controls.

Despite the effectiveness of these prior investigations in identifying sediment contamination; the investigations were not focused on identifying and characterizing the sources of contamination. As such, the goals of this investigation are to verify the presence of these abandoned containers and wastes on the bottom of the lake and to more fully characterize the nature and extent of these likely contaminant sources. The evaluation of potential PCB sources and PCB "hot spots" in and around

Torch Lake are an integral component of this SAP that will support the long-term protection and rehabilitation of the lake.

2.3 CONTAMINANTS OF CONCERN AND TARGET ANALYTES

Contaminants attributable to the Site include VOCs, PNAs, PCBs, inorganic contaminants, and asbestos. The properties in the CHTC feature vacant land, historical and recreational parks, in mixed residential/non-residential areas within the village of Tamarack City and Osceola Township.

The analytical results from historical investigative and response activities were used to assist in the characterization of the study areas. Further, the sample locations from these events were also evaluated to assist in locating the horizontal and vertical locations of proposed sampling locations included in this SAP. The locations and respective analytical results used to develop this SAP are summarized in the WESTON prepared document entitled, *Compilation and Interpretation of Key Historic Studies, Abandoned Mining Wastes Torch Lake non-Superfund Site, Tamarack City Operations Area, Technical Memorandum* dated March 2015.

2.3.1 Ahmeek Mill Processing Area

Between 2001, 2007, and 2008 samples were collected for field screening and laboratory analysis from the following environmental media in the Ahmeek Mill Processing Area.

- Surface soil;
- Subsurface Soil;
- Sediment; and,
- Groundwater.

The analytical and screening results indicate that inorganic contaminants and PNAs are present in surface and subsurface soils in excess of Part 201 Residential and Non-Residential Cleanup Criteria for Response Activity of Michigan’s Natural Resources and Environmental Protection Act (NREPA), being Public Act (PA) 451 of 1994, as amended.

Six temporary monitoring wells were installed in the Ahmeek Mill Processing Area during the 2002 Brownfield Redevelopment Assessment conducted by the MDEQ. Analytical results from monitoring well sampling activities that elevated detections of inorganic contaminants were present in groundwater. PCBs were not detected in the groundwater samples.

Analytical results for inorganic contaminants exceeding applicable criteria during previous investigations in the Tamarack City Operations Area include the following:

- Aluminum;
- Antimony;
- Arsenic;
- Barium;
- Beryllium;
- Cadmium;
- Chromium;
- Cobalt;
- Copper;
- Cyanide;
- Iron;
- Lead;
- Lithium;
- Magnesium;
- Manganese;
- Mercury;
- Nickel;
- Selenium;
- Silver;
- Thallium; and,
- Zinc.

As a result surface soil, subsurface soil, groundwater, sediment, and surface water collected during implementation of the SAP in the Ahmeek Mill Processing Area will be analyzed for the aforementioned metals.

Based on the results of the previous investigations, the prevailing contaminants of concern in environmental media are generally inorganic contaminants in surface and subsurface soils and groundwater. The analytical results exceeded multiple Residential and Non-Residential Cleanup Criteria for Response Activities including the following:

- Statewide Default Background Levels;
- Groundwater Surface Water Interface Protection Criteria (GSIPC);
- Residential Drinking Water Protection Criteria (DWPC);
- Non-residential DWPC;
- Residential Direct Contact Criteria (DCC);
- Non-Residential DCC
- Residential Particulate Soil Inhalation Criteria (PSIC);
- Non-residential PSIC;
- Residential Drinking Water Criteria (DWC);
- Non-Residential DWC ; and,
- Groundwater Surface Water Interface Criteria (GSIC).

Based on the findings summarized above it is anticipated that up to 24 sampling locations, including soil, groundwater, surface water, and sediment will be established in the Ahmeek Mill Processing Area including the following target analytes:

Surface Soils (0 to 6 inches below ground surface [bgs])

- Total Metals by SW-846 including 3000 Series Analysis 7000 Series and 6010;
- PCBs by SW-846 Method 8082A; and,
- Asbestos by Polarizing Light Microscopy (PLM) – California Air Resource Board (CARB) 435 – 1,000 point count – analytical sensitivity 0.1 percent (%).

Subsurface Soils (Greater than (>) 6 inches bgs)

- PNAs by SW-846 Method 8310;
- Total Metals by SW-846 including 3000 Series Analysis 7000 Series and 6010; and,
- PCBs by SW-846 Method 8082A.

Groundwater

- VOCs by SW-846 Method 8260;
- PCBs by SW-846 Method 8082A; and,
- PNAs by SW-846 Method 8310.

Sediment

- Total Metals by SW-846 including 3000 Series Analysis 7000 Series and 6010;
- PCBs by SW-846 Method 8082A; and,
- PNAs by SW-846 Method 8310.

Drums, Containers, Building Materials, Bulk Asbestos, and Waste Deposits – Not Associated with Sediment/Depositional Wastes

- VOCs by SW-846 Method 5035A;
- PCBs by SW-846 Method 8082A;
- PNAs by SW-846 Method 8310;
- Bulk Asbestos by PLM Method 600/R-93/116; and,
- Toxicity Characteristic Leaching Procedure (TCLP) by SW846 EPA 1311.

2.3.2 Tamarack Processing Area

During 2007 and 2012 samples were field screened and collected for laboratory analysis from the following environmental media in the Tamarack Processing Area.

- Surface soil;
- Subsurface Soil;
- Groundwater; and,
- Surface Water.

The analytical and screening results indicated that inorganic contaminants, PNAs, and PCBs are present in surface and subsurface soils in excess of Part 201 Residential and Non-Residential Cleanup Criteria for Response Activity of Michigan's NREPA, being PA 451 of 1994, as amended.

Four temporary monitoring wells were installed in the Tamarack Processing Area during the 2012 Site Inspection (SI) conducted by the MDEQ. Analytical results from monitoring well sampling activities indicated elevated detections of inorganic contaminants were present in groundwater. PCBs were not detected in the groundwater samples.

Based on the results of the previous investigations, the prevailing contaminants of concern in environmental media are generally inorganic contaminants, PNAs, and PCBs in surface and subsurface soils and groundwater. The analytical results exceeded multiple Residential and Non-Residential Cleanup Criteria for Response Activities including the following:

- Statewide Default Background Levels;
- GSIPC;
- Residential DWPC;
- Non-residential DWPC;
- Residential DCC;
- Non-Residential DCC
- Residential PSIC;
- Non-residential PSIC;
- Residential DWC;
- Non-Residential DWC; and,
- GSIC.

Analytical results for inorganic contaminants exceeding applicable criteria during previous investigations in the Tamarack City Operations Area include the following:

- Aluminum;
- Antimony;
- Arsenic;
- Barium;
- Beryllium;
- Cadmium;
- Chromium;
- Cobalt;
- Copper;
- Cyanide;
- Iron;
- Lead;
- Lithium;
- Magnesium;
- Manganese;
- Mercury;
- Nickel;
- Selenium;
- Silver;
- Thallium; and,
- Zinc.

As a result surface soil, subsurface soil, groundwater, sediment, and surface water collected during implementation of the SAP in the Tamarack Processing Area will be analyzed for the aforementioned metals.

Based on the findings summarized above it is anticipated that up to 18 sampling locations, including soil and groundwater will be established in the Tamarack City Processing Area including the following target analytes:

Surface Soils (0 to 6 inches bgs)

- Total Metals by SW-846 including 3000 Series Analysis 7000 Series and 6010;
- VOCs by SW-846 Method 8260;
- PCBs by SW-846 Method 8082A;
- PNAs by SW-846 Method 8310;
- Oil and Grease by SW-846 Method 1664A; and,
- Asbestos by PLM –CARB 435 – 1,000 point count – analytical sensitivity 0.1 %.

Subsurface Soils (>6 inches bgs)

- Total Metals by SW-846 including 3000 Series Analysis 7000 Series and 6010;
- VOCs by SW-846 Method 5035A;
- PCBs by SW-846 Method 8082A;
- PNAs by SW-846 Method 8310; and,
- Oil and Grease by SW-846 Method 1664A.

Groundwater

- Total Metals by SW-846 including 3000 Series Analysis 7000 Series and 6010;
- VOCs by SW-846 Method 8260;
- PCBs by SW-846 Method 8082A;
- PNAs by SW-846 Method 8310;
- Chloride by SW-846 Method 300.1; and,
- Sulfate by SW-846 Method 325.

Drums, Containers, Building Materials, Bulk Asbestos, and Waste Deposits – Not Associated with Sediment/Depositional Wastes

- VOCs by SW-846 Method 5035A;
- PCBs by SW-846 Method 8082A;
- PNAs by SW-846 Method 8310;
- Bulk Asbestos by PLM Method 600/R-93/116; and,
- TCLP by SW846 EPA 1311.

2.3.3 Tamarack Sands Area

During 2007 and 2008 samples were field screened and collected for laboratory analysis from the following environmental media in the Tamarack Sands Area.

- Surface soil; and,
- Sediment.

The analytical and screening results indicate that inorganic contaminants are present in surface soils in excess of Part 201 Residential and Non-Residential Cleanup Criteria for Response Activity of Michigan's NREPA, being PA 451 of 1994, as amended, including the following:

- Statewide Default Background Levels;
- GSIPC;
- Residential DWPC;
- Non-residential DWPC; and,
- Residential DCC.

Analytical results for inorganic contaminants exceeding applicable criteria during previous investigations in the Tamarack City Operations Area include the following:

- Aluminum;
- Antimony;
- Arsenic;
- Barium;
- Beryllium;
- Cadmium;
- Chromium;
- Cobalt;
- Copper;
- Cyanide;
- Iron;
- Lead;
- Lithium;
- Magnesium;
- Manganese;
- Mercury;
- Nickel;
- Selenium;
- Silver;
- Thallium; and,
- Zinc.

As a result surface soil, subsurface soil, groundwater, sediment, and surface water collected during implementation of the SAP in the Tamarack Sands Processing Area will be analyzed for the aforementioned metals.

Based on the findings summarized above it is anticipated that up to 39 sampling locations, including soil, groundwater, surface water, and sediment will be established in the Tamarack Sands Area including the following target analytes:

Surface Soils (0 to 6 inches bgs)

- Total Metals by SW-846 including 3000 Series Analysis 7000 Series and 6010;

- VOCs by SW-846 Method 8260;
- PCBs by SW-846 Method 8082A;
- PNAs by SW-846 Method 8310; and,
- Asbestos by PLM –CARB 435 – 1,000 point count – analytical sensitivity 0.1 %.

Subsurface Soils (>6 inches bgs)

- VOCs by SW-846 Method 5035A;
- PCBs by SW-846 Method 8082A; and,
- PNAs by SW-846 Method 8310.

Sediment

- PNAs by SW-846 Method 8310;
- Total Metals by SW-846 including 3000 Series Analysis 7000 Series and 6010; and,
- PCBs by SW-846 Method 8082A.

Groundwater

- VOCs by SW-846 Method 8260;
- PCBs by SW-846 Method 8082A;
- PNAs by SW-846 Method 8310;
- Total Metals by SW-846 including 3000 Series Analysis 7000 Series and 6010.

Drums, Containers, Building Materials, Bulk Asbestos, and Waste Deposits – Not Associated with Sediment/Depositional Wastes

- VOCs by SW-846 Method 5035A;
- PCBs by SW-846 Method 8082A;
- PNAs by SW-846 Method 8310;
- Bulk Asbestos by PLM Method 600/R-93/116; and,
- TCLP by SW846 EPA 1311.

2.3.4 Torch Lake

During 2007, 2008, and 2011 the analytical results from surface water and sediment samples indicated that contaminants emanating from documented contamination on land may be impacting the nearshore aquatic environment of Torch Lake. In addition, historical investigations in the lake have documented the presence of submerged drums, containers, and waste deposits on the bottom of Torch Lake.

To address these concerns, the MDEQ has developed a collaborative approach to this SAP that incorporates advanced technological methods and common sampling approaches for use in characterizing Torch Lake. Michigan Tech assisted in these characterization activities by conducting historical research of industrial operations in the CHTC. The historical archive research and mapping phase of the work assisted in the identification of historic shoreline and landward industrial operations responsible for the generation and/or disposal of wastes in and along Torch Lake. Michigan Tech utilized the university archives, Sanborn Fire Insurance Maps, blueprints, C&H operational records, aerial photos, and interviews with former employees to reconstruct potential waste and disposal areas in and around Torch Lake.

In addition to historical research the MDEQ GSU conducted underwater mapping of the lake bottom and debris fields in the Tamarack City Operations Area during 2014. The MDEQ GSU offshore sampling team also conducted a visual assessment of the near shore environment in the CHTC using a Remotely Operated Vehicle (ROV) equipped with video logging equipment. Prior to video surveillance of the lake bottom, the offshore areas were surveyed with side-scan sonar. The side-scan sonar imagery was used to identify anomalies on the lake bottom that may be targeted for video surveillance. The overall intent of the assessment was to collect qualitative data that could be used to develop a plan for investigation, sampling, and assessment of potential offshore contaminant sources.

The results and data derived from the underwater survey were compiled and evaluated; however, no significant underwater features were identified during the underwater reconnaissance and mapping effort. Offshore sampling will be completed using the MDEQ GSU's sampling vessel and necessary equipment to complete the scope of work. Sediment samples will be collected from each of the study areas and analyzed for contaminants as described in the preceding subsections.

3. PROPOSED SCHEDULE

WESTON has prepared this SAP to detail the planned approaches for investigative sampling, field screening, and laboratory analyses to be used at the CHTC. The proposed investigative and sampling methods are described in more detail in **Section 4** and **Section 5** of this SAP.

Field activities are scheduled to begin in May 2015. Sampling and screening activities will be implemented in a phased approach and are anticipated to be initiated in May 2015. Laboratory analytical are anticipated to become available approximately 30 to 45 days after receipt of the samples by the analytical laboratory. The anticipated schedule is outlined in the table below.

TABLE 3-1
SCHEDULE

Activities	Dates (Month Day, Year)		Deliverables	Deliverable Due Date
	Anticipated Date(s) of Initiation	Anticipated Date of Completion		
• HASP Preparation • SAP Preparation • Planning Meetings • ROV Testing	March 30, 2015	April 24, 2015	HASP, SAP	May 12, 2015
Field Sample Collection – GSU Terrestrial Investigation	May 12, 2015	May 19, 2015	Log Books, Sampling and Screening Logs	2 weeks after completing field activities
Laboratory Analysis – MDEQ Environmental Laboratory or Selected Contract Laboratory	May 20, 2015	June 10, 2015	Laboratory Analytical Report	3 weeks after submitting the last sample(s)
Potential Physical and Health Hazard Inventory	May 25, 2015	May 29, 2015	Log Books, Reconnaissance Logs, Targeted Inspection Logs	2 weeks after completing field activities
Field Sample Collection – GSU Offshore Investigation	May 27, 2015	June 2, 2015	Log Books, Sampling and Screening Logs	2 weeks after completing field activities
Laboratory Analysis – MDEQ Environmental Laboratory or Selected Contract Laboratory	June 3, 2015	June 24, 2015	Laboratory Analytical Report	3 weeks after submitting the last sample(s)

Activities	Dates (Month Day, Year)		Deliverables	Deliverable Due Date
	Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Field Sample Collection – GSU Terrestrial Investigation	August 17, 2015	August 26, 2015	Log Books, Sampling and Screening Logs	2 weeks after completing field activities
Laboratory Analysis – MDEQ Environmental Laboratory or Selected Contract Laboratory	August 27, 2015	September 17, 2015	Laboratory Analytical Report	3 weeks after submitting the last sample(s)
Field Sample Collection – GSU Offshore Investigation	July 7, 2015	July 14, 2015	Log Books, Sampling and Screening Logs	2 weeks after completing field activities
Laboratory Analysis – MDEQ Environmental Laboratory or Selected Contract Laboratory	July 15, 2015	August 6, 2015	Laboratory Analytical Report	3 weeks after submitting the last sample(s)
Public Outreach and Technical Meeting Support	December 30, 2013	December 30, 2015	Website updates, newsletters, fact sheets, and public relations support	Attendance at up to Eight Meetings – TBD

4. FIELD PROCEDURES AND SAMPLE COLLECTION

The field procedures and sample collection activities that will be implemented in the CHTC to evaluate the presence of contaminated environmental media in the study areas defined in the preceding sections of the SAP. This Section describes the sampling methodology and procedures that will be implemented to collect samples from various environmental media.

As the primary contaminant of concern at the Site, PCB analytical results will be evaluated to determine if additional analyses is needed. Analytical results will initially be reported PCB Aroclors, including Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268. Future analysis may include a more detailed analysis that includes the identification of the 209 PCB congeners, which may provide relevant data for comparison to analytical results from other sample media such as fish tissue. The selection of samples for PCB analyses will be based on the concentrations of PCB Aroclors. Only soil and sediment samples will potentially be analyzed for PCB congeners. The laboratory will retain any excess sample volume from all soil and sediment samples collected during the investigation for later analyses. The chain of custody that accompanies the submitted samples will be labeled with “Hold for Congener Analysis” and any remaining sample volume will be retained and stored in the laboratory cold room until congener analysis is requested.

The proposed sampling rationale for each of the study areas within the CHTC are described in **Section 2**. The proposed terrestrial and offshore sampling and screening locations within each study area are depicted as follows:

- Ahmeek Mill Processing Area – **Figure 4-1**
- Tamarack Processing Area – **Figure 4-2**
- Tamarack Sands Area – **Figure 4-3**

Proposed sampling locations, proposed laboratory analyses, and sampling rationale are summarized on **Table 4-1**.

4.1 POTENTIAL PHYSICAL AND HEALTH HAZARD INVENTORY

The investigation and of each study area included in the CHTC will include a physical inspection of the area. The inspection will include the inventory and locating of historical structures and artifacts associated with the former industrial operations within each area.

Each area will also be inspected for potential physical and health hazards. Such hazards may include potentially abandoned drums and containers, suspect asbestos containing materials, stained or oily soils, and similar observed environmental conditions. Potential physical hazards, including waste deposits, metal debris, and similar conditions in areas without restricted access will also be recorded.

Inventoried locations will be located with a GPS unit with sub-meter accuracy. Field decisions may be made to collect samples from abandoned containers, however suspect asbestos containing materials (SACM) will not be sampled unless an asbestos inspector licensed in the State of Michigan is present to complete the sampling.

4.2 SURFACE SOIL SAMPLING

Grab soil sample will be collected from proposed surface soil (0-6 inches) sampling locations. In sampling areas where waste deposits or historical surface soils have been capped or covered, the surface soil sample will be collected from directly beneath the cover media. These conditions are anticipated to be encountered in capped areas, but also in areas that have been redeveloped or improved such as the public parks and private property. Proposed surface soil sampling locations are illustrated on **Figure 4-1** through **Figure 4-3**.

Specific procedures selected for this project are summarized as follows:

- The location of each sampling point will be sketched on field documentation, and the coordinates of the sample location will be recorded using a GPS receiver with sub-meter accuracy.
- Rocks and organic matter (including grasses, shallow vegetation roots, and leaves) will be scraped from the surface of each location before surface soil is collected.

- Direct push boring techniques will be used to collect soil samples from each location. The surface samples will be collected from the 0 to 6 inch interval of the extracted soil core. Down hole sampling equipment will be decontaminated prior to sampling at another location. Decontamination fluids will be discharged to the ground surface by the MDEQ.
- Soil samples will be transferred directly into laboratory-provided sample jars.
- Sample jars will be labeled using the nomenclature outlined in **Section 5.1**, and placed in a cooler on ice for shipment to the identified analytical laboratory under chain of custody.
- Investigative-derived wastes (IDW), including potentially contaminated soil will be returned to the boring location from which it was generated by the MDEQ. Personal protective equipment (PPE) and waste generated by sample preparation will be bagged and staged for disposal as municipal solid waste by the MDEQ.

Field team members will don a new pair of disposable nitrile gloves prior to collection of each sample. The stainless steel coring device will be decontaminated after collection of each sample by washing in an alconox-and-water solution, rinsing with distilled water, and drying with disposable paper towels.

Laboratory information related to the chemical analyses of surface soil samples is summarized in **Section 6**.

Field Screening

Soil cores will be field-screened with the following equipment:

- PID.

Sample Collection Equipment

- Laboratory-provided sample containers; and,
- Stainless steel trowels/coring tool.

Container and Analytical Requirements List

Matrix	Containers (Numbers, Size, and Type)	Analytical Parameter(s)	Analytical Method	Preservation Requirements	Holding Time
Surface Soil	One 250 mL wide mouth glass jar	Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Cyanide, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Nickel, Selenium, Silver, Thallium, and, Zinc	SW846-EPA 6020A /7470A	Cool to 4°C	6 months; 28 Days
	One 250 mL wide mouth glass jar	PCBs	EPA 8082	Cool to 4°C	12 months
		PNAs	SW846-EPA 8270C	Cool to 4°C	14 Days
	One 250 mL wide mouth glass jar	Asbestos	PLM	Cool to 4°C	12 months
	Two 250 mL wide mouth glass jar	Oil and Grease	SW846-EPA 1664A	Cool to 4°C	28 days
	1 MeOH Kit, 40 mL glass vial	VOCs	SW846-EPA 8260	Cool to 4°C	14 Days

Notes:
°C – degrees Celsius
µm - Micron
mL – Milliliter
MeOH – Methanol
PCBs – Polychlorinated Biphenyls
PLM - Polarized Light Microscopy
PNAs – Polynuclear Aromatic Hydrocarbons
VOCs – Volatile Organic Compounds

4.3 SUBSURFACE SOIL SAMPLING

Soil borings will be advanced in each sub area to evaluate subsurface conditions. It is anticipated that a track-mounted hydraulic push-probe drill rig will be used to retrieve continuous soil cores from the subsurface. Actual boring depths will be determined in the field and will be based on field observations and field screening results. Proposed soil boring locations are illustrated on **Figure 4-1** through **Figure 4-3**. Subsurface soil samples collected for laboratory analysis will be selected based on field screening results and visual or olfactory indication that contamination may be present. The soil borings will be logged and screened with a PID.

Select borings will be chosen for the collection of groundwater samples based on field observations. It is anticipated that a stainless steel slotted screen will be installed in select boring locations to allow for the collection of groundwater analytical samples.

- It is anticipated that soil borings will be advanced by the MDEQ GSU. MDEQ GSU will be responsible for coordinating utility locates using Michigan's one-call system and in accordance with *Public Act 174, Miss Dig Underground Facility Damage Prevention and Safety Act.*
- The location of each sampling point will be sketched on field documentation, and the coordinates of the sample location will be recorded using a GPS receiver with sub-meter accuracy.
- The lithology for each boring will be classified by the field geologist in accordance with the Unified Soil Classification System (USCS).
- Before advancing reusable downhole equipment, the driller will decontaminate all equipment including the working end of the Geoprobe. Care will be taken to avoid placing equipment, tools, and materials on the ground during the boring activities.
- It is anticipated that borings will be advanced using a 5-foot long, 1.5-inch diameter Macro-Core sampler to collect continuous soil samples at all borings using a motor-driven hydraulic hammer to the desired depth.
- Soil samples will be transferred directly into laboratory-provided sample jars.
- Sample jars will be labeled using the nomenclature outlined in **Section 5.1**, and placed in a cooler on ice for shipment to the identified analytical laboratory under chain of custody.
- IDW, including potentially contaminated soil cuttings, groundwater, and decontamination water will be discharged to the ground surface in the vicinity of the boring. PPE and waste generated by sample preparation will be bagged and staged for disposal as municipal solid waste.

Laboratory information related to the chemical analyses of subsurface soil samples is summarized in **Section 6**.

<u>Field Screening</u>

Soil cores will be field-screened with the following equipment:

- PID.

Sample Collection Equipment

- Laboratory-provided sample containers;
- Stainless steel bowls; and,
- Stainless steel trowels.

Container and Analytical Requirements List

Matrix	Containers (Numbers, Size, and Type)	Analytical Parameter(s)	Analytical Method	Preservation Requirements	Holding Time
Subsurface Soil	One 250 mL wide mouth glass jar	Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Cyanide, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Nickel, Selenium, Silver, Thallium, and Zinc	SW846-EPA 6020A /7470A	Cool to 4°C	6 months; 28 Days
	One 250 mL wide mouth glass jar	PCBs	EPA 8082	Cool to 4°C	12 months
		PNAs	SW846-EPA 8270C	Cool to 4°C	14 Days
	Two 250 mL wide mouth glass jar	Oil and Grease	SW846-EPA 1664A	Cool to 4°C	28 days
	1 MeOH Kit, 40 mL glass vial	VOCs	SW846-EPA 8260	Cool to 4°C	14 Days

Notes:
°C – Degrees Celsius
µm - Micron
mL – Milliliter
MeOH – Methanol
PCBs – Polychlorinated Biphenyls
PNAs – Polynuclear Aromatic Hydrocarbons
VOCs – Volatile Organic Compounds

4.4 GROUNDWATER SAMPLING

Groundwater samples will be collected utilizing a Screen-Point-16 stainless steel screen, or similar reusable sampling rod from select soil borings advanced in each study area. The actual locations and depths of the groundwater samples will be determined in the field and will be based on field observations and field screening results. The proposed soil boring and groundwater sampling locations are illustrated on **Figure 4-1** through **Figure 4-3**.

The down hole sampling tools will be advanced into the water-bearing zone in each boring. The outer rod will be withdrawn to expose the internal stainless steel screen. Following the installation of the Screen-Point-16 sampling rod, a low-flow peristaltic pump with disposable Teflon tubing will be used to collect a groundwater grab sample from the screened sample interval. Field parameters for dissolved oxygen (DO), pH, oxidation reduction potential (ORP), conductivity, temperature, and turbidity will be measured with a water-quality monitoring instrument equipped with a flow-through cell at the time of groundwater sample collection. In the event of minimal groundwater presence and/or slow recharge, the available groundwater will be sampled regardless of the purge volume or field parameter stability. Groundwater will be pumped directly into laboratory-provided sample containers. Sample containers will be labeled using the nomenclature outlined in **Section 5.1**, and placed in a cooler on ice for delivery to the designated laboratory under COC.

Laboratory information related to the chemical analyses of groundwater samples are summarized in **Section 6**.

Sample Collection Equipment

Groundwater will be will be collected using the following equipment:

- Laboratory-provided sample containers;
- Peristaltic pump;
- Teflon tubing or similar compatible material;
- Water quality meter with flow through cell such as a YSI Model 6820; and,
- Turbidity-meter.

Container and Analytical Requirements List

Matrix	Containers (Numbers, Size, and Type)	Analytical Parameter(s)	Analytical Method	Preservation Requirements	Holding Time
Groundwater	1 500-mL plastic	Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Cyanide, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Nickel, Selenium, Silver, Thallium, and, Zinc	EPA 6020A /7471A	HNO^3 to PH<2; Cool to 4^oC	6 months; 28 Days
	1 500-mL plastic	Chloride, Sulfate	EPA 325, EPA 300.1	Cool to 4^oC	28 Days
	2 1-L Amber glass	PCBs	EPA 8082	Cool to 4°C	12 months
		PNAs	EPA 8270C	Cool to 4^oC	14 Days
	3 40-mL glass vials	VOCs	EPA 8260B	HCl to pH < 2; Cool to 4^oC	14 Days

Notes:
°C – Degrees Celsius
< - Less than
HCl – hydrochloric acid
HNO_3 – nitric acid
L – Liter
mL – Milliliter
PCBs – Polychlorinated Biphenyls
PNAs – Polynuclear Aromatic Hydrocarbons
VOCs – Volatile Organic Compounds

4.5 SURFACE WATER SAMPLING

The collection of surface water samples will be at the discretion of field sampling personnel. In locations where drums or other wastes are observed, suggesting unusual conditions, a surface water sample may be collected. If a surface water sample is collected, it will be prior to the collection of any sediment samples at that location. At this time no surface water samples are proposed for collection and analysis. It is anticipated that sample locations will be located in the vicinity of landward sampling locations or submerged containers to assess the potential for contamination related to the migration of contaminants from potentially identified sources. It is anticipated that surface water samples will be collected from the water column within 1 foot of the lake bottom. Prior to sample collection, the depth to the bottom of the lake will be measured and recorded in the field log book.

Surface water may be collected directly into sample containers if the depth of the water is sufficient or a dip sampler may be used. Alternatively, a low-flow peristaltic pump and Teflon tubing may be used to pump water from the lake into laboratory-provided sample containers. Sample containers will be labeled using the nomenclature outlined in **Section 5.1**, and properly preserved for delivery to the designated laboratory COC. At the time of sample collection field measurements of temperature, conductivity, pH, ORP, turbidity, and DO will also be made at all locations.

Laboratory information related to the chemical analyses of surface water samples is summarized in **Section 6**.

Sample Collection Equipment

Surface water will be collected using the following equipment:

- Laboratory-provided sample containers;
- Dip sampler (if needed);
- Peristaltic pump (if needed);
- Teflon tubing (if needed);
- Water quality meter such as a YSI Model 6820; and,
- Turbidity-meter.

Container and Analytical Requirements List

Matrix	Containers (Numbers, Size, and Type)	Analytical Parameter(s)	Analytical Method	Preservation Requirements	Holding Time
Surface Water	1 500-mL plastic	Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Cyanide, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Nickel, Selenium, Silver, Thallium, and, Zinc	EPA 6020A /7471A	HNO^3 to PH<2; Cool to $4^{o}C$	6 months; 28 Days
	2 1-L Amber glass	PCBs	EPA 8082	Cool to 4°C	12 Months
		PNAs	EPA 8270C	Cool to $4^{o}C$	14 Days

Matrix	Containers (Numbers, Size, and Type)	Analytical Parameter(s)	Analytical Method	Preservation Requirements	Holding Time
	3 40-mL glass vials	VOCs	EPA 8260B	HCl to pH < 2; Cool to 4°C	14 Days

Notes:
°C – Degrees Celsius
< - Less than
HCl – hydrochloric acid
HNO3 – nitric acid
L – Liter
mL – Milliliter
PCBs – Polychlorinated Biphenyls
PNAs – Polynuclear Aromatic Hydrocarbons
VOCs – Volatile Organic Compounds

4.6 SEDIMENT SAMPLING

Following the collection of surface water samples, sediment samples will be collected from the bottom of Torch Lake from the same location as the surface water samples. The tentatively proposed sediment sampling locations are depicted on **Figure 4-1** through **Figure 4-3**. Final sampling locations may be modified based on the underwater reconnaissance completed by the MDEQ GSU. It is anticipated that sample locations will be located in the vicinity of terrestrial sampling locations or previous sediment sampling locations where PCBs were detected, or submerged containers to assess the potential for contamination related to the migration of contaminants from potentially identified sources.

It is anticipated that sediment will be collected from multiple intervals within the sediment to evaluate the vertical extent of contamination. Sediment samples will be collected utilizing the MDEQ GSU's vibracore sampler. Lexane tubing, or similar will be advanced in the sediment using the vibracore. The extracted sample core will be opened and the sediment column logged, screened and sampled, based on screening results and observations within the sample core.

Following collection, the sediment will be placed into a container constructed of inert material, homogenized, and transferred to the appropriate sample containers. The depth of water at the sample location will be recorded prior to sampling. Visual observations, including physical characteristics, staining, or olfactory evidence of contamination within the sediment will be recorded. Sample containers will be labeled using the nomenclature outlined in **Section 5.1**, and placed in a cooler on ice for delivery to the designated laboratory under chain of custody.

Laboratory information related to the chemical analyses of sediment samples is summarized in **Section 6**.

Sample Collection Equipment

- Laboratory-provided sample containers;
- Stainless steel bowls;
- Stainless steel trowels; and,
- Sample coring devices.

Container and Analytical Requirements List

Matrix	Containers (Numbers, Size, and Type)	Analytical Parameter(s)	Analytical Method	Preservation Requirements	Holding Time
Sediment	One 250 mL W.M. glass jar	Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Cyanide, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Nickel, Selenium, Silver, Thallium, and, Zinc	SW846-EPA 6020A /7470A	Cool to 4°C	6 months; 28 Days
	One 250 mL W.M. glass jar	PCBs	EPA 8082	Cool to 4°C	12 months
		PNAs	SW846-EPA 8270C	Cool to 4°C	14 Days
	1 MeOH Kit, 40 mL glass vial	VOCs	SW846-EPA 8260	Cool to 4°C	14 Days

Notes:
°C – Degrees Celsius
< - Less than
HCl – hydrochloric acid
HNO3 – nitric acid
L – Liter
mL – Milliliter
PCBs – Polychlorinated Biphenyls
PNAs – Polynuclear Aromatic Hydrocarbons
VOCs – Volatile Organic Compounds

4.7 DRUMS, CONTAINERS, BUILDING MATERIALS, BULK ASBESTOS, AND WASTE DEPOSIT SAMPLING

Grab or composite samples may be collected from identified waste deposits. The contents of open or dilapidated drums or containers will be sampled. Field personnel will not open sealed drums or containers, but may elect to sample in the vicinity of such containers to determine if the contents of the containers are discharging to the surrounding environmental media. The collection of container or waste samples will be consistent with surface soil sampling methodologies described in **Section 4.2**.

Field decisions may be made to collect samples from abandoned containers; however, SACM will not be sampled unless an asbestos inspector licensed in the State of Michigan is present to complete the sampling. If an inspector is present, SACM will be organized into homogenous groups and a minimum of three representative samples will be collected from each homogenous group. Samples will be placed in sealable plastic bags/containers and submitted to the laboratory for analysis.

Laboratory information related to the chemical analyses of container contents, waste samples, and asbestos is summarized in **Section 6**.

Field team members will don a new pair of disposable nitrile gloves prior to collection of each sample. The stainless steel coring device will be decontaminated after collection of each sample by washing in an alconox-and-water solution, rinsing with distilled water, and drying with disposable paper towels.

Field Screening

Open containers and waste deposits will be field-screened with the following equipment:

- PID.

Sample Collection Equipment

- Laboratory-provided sample containers;

- Sealable plastic bags/containers; and,
- Stainless steel trowels/coring tool.

Container and Analytical Requirements List

Matrix	Containers (Numbers, Size, and Type)	Analytical Parameter(s)	Analytical Method	Preservation Requirements	Holding Time
Drums, Containers, Waste Deposits	One 250 mL wide mouth glass jar	Aluminum, Antimony, Arsenic, Barium, Cadmium, Cobalt, Copper, Cyanide, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Nickel, Selenium, Silver, Thallium, and, Zinc	SW846-EPA 6020A /7470A	Cool to 4°C	6 months; 28 Days
	One 250 mL wide mouth glass jar	PCBs	EPA 8082	Cool to 4°C	12 months
		PNAs	SW846-EPA 8270C	Cool to 4°C	14 Days
	One 250 mL wide mouth glass jar	Asbestos	PLM	Cool to 4°C	12 months
	Two 250 mL wide mouth glass jar	Oil and Grease	SW846-EPA 1664A	Cool to 4°C	28 days
	1 MeOH Kit, 40 mL glass vial	VOCs	SW846-EPA 8260	Cool to 4°C	14 Days
Bulk Asbestos	Sealable Plastic Bag/Container	Asbestos	PLM	None	Indefinite

Notes:
°C – degrees Celsius
µm - Micron
mL – Milliliter
MeOH – Methanol
PCBs – Polychlorinated Biphenyls
PLM - Polarized Light Microscopy
PNAs – Polynuclear Aromatic Hydrocarbons
VOCs – Volatile Organic Compounds

5. SAMPLING PROCEDURES

This Section describes the project-specific sample nomenclature, management of IDW, decontamination, custody procedures, and other standard operating procedures intended for use on this project.

5.1 SAMPLE NOMENCLATURE

All samples for analysis, including QC samples, will be given a unique sample number. The sample numbers will be recorded in the field logbook and/or established sample tracking forms, on the sample jars, and on the COC paperwork. The sample identification (ID) number will be used to track field-screening data and laboratory analytical results from each parcel in the project database.

WESTON and the field sampling team will assign each sample its unique ID based on the nomenclature outlined below. The sample identification will be used for documentation purposes in field logbooks, as well as for presentation of the analytical data in memoranda and reports. The project samples will be identified using the following format:

<u>Project Identification Code</u>

CHTC = C&H Tamarack City Operations

<u>Sample Media Code</u>

This shall consist of the following:

- ASBBLK = Bulk Asbestos
- DM = Drum or container sample
- GW = Groundwater sample
- SB= Subsurface soil sample
- SD = Sediment sample
- SS = Surface soil sample
- SW = Surface water sample

Sample Number Code

The two digit sample number code will correspond to the consecutive sample count for a given sample media. For example, soil borings are tentatively numbered 01 through 44 and sediment samples are tentatively numbered 01 through 38. Field decisions will ultimately determine the total number of sampling locations for each media type.

Sample Interval or Sample Depth Code

The sample depth or interval code will utilize the top and bottom of the sample interval consisting of the following:

- X-Y = Where X represents the top of the sample interval and Y represents the bottom of the sample interval. For groundwater samples, the screen interval of the monitoring well shall represent the top and bottom of the sample interval.

QA/QC Identification Code

DUP = Field duplicate

Date Code

MMDDYY = The two-digit month (MM), followed by the two-digit day (DD), followed by the two-digit year (YY).

Surface soil sample ID's will be constructed with the project identification code, followed by the sample media code, followed by the sample interval code, followed by the QA/QC identification, if applicable.

An example sample identification for a surface soil sample follows:

- **CHTC-SS01-0-6" =** the first surface soil sample collected from the CHTC from the 0-6 inch sample interval.

Subsurface soil sample ID's will be constructed with the project identification code, followed by the sample media code, followed by the sample interval code, followed by the QA/QC identification, if applicable.

An example sample identification for a subsurface soil sample follows:

- **CHTC-SB14-1-3' =** subsurface soil sample collected from the fourteenth soil boring advanced in the CHTC from the 1-3 foot sample interval.

Groundwater sample ID's will be constructed with the project identification code, followed by the sample media code, followed by the sample/screen interval code, followed by the QA/QC identification, if applicable.

An example sample identification for a field duplicate groundwater sample follows:

- **CHTC-GW03-8-13'-FD =** field duplicate of the third groundwater sample collected from the CHTC from a monitoring well screened from 8 to 13 feet.

Surface water sample ID's will be constructed with the project identification code, followed by the sample media code, followed by the sample interval code, followed by the QA/QC identification, if applicable.

An example sample identification for a surface water sample follows:

- **CHTC-SW01-39-40'=** the first surface water sample collected from the CHTC from a depth of 39 to 40 feet.

Sediment sample ID's will be constructed with the project identification code, followed by the sample media code, followed by the sample interval code, followed by the QA/QC identification, if applicable.

An example sample identification for a sediment sample collected from Torch Lake follows:

- **CHTC-SD45-0-6" =** the forty-fifth sediment sample collected from the CHTC from the 0-6 inch sample interval.

Drum or Container sample ID's will be constructed with the project identification code, followed by the sample media code, followed by the sample interval code, followed by the QA/QC identification, if applicable.

An example sample identification for a drum/container sample follows:

- **CHTC-DM03-0-6" =** the third drum/container sample collected from the CHTC from the 0-6 inch sample interval.

Bulk Asbestos sample ID's will be constructed with the project identification code, followed by the sample media code, followed by the date code.

An example sample identification for a bulk asbestos (material) sample follows:

- **CHTC-ASBBLK05-061815 =** the fifth bulk asbestos (material) sample collected from the CHTC on 18 June 2015.

5.2 DECONTAMINATION PROCEDURES AND MANAGEMENT OF INVESTIGATIVE-DERIVED WASTES

For purposes of this SAP, IDWs are defined as any byproduct of the field activities that is suspected or known to be contaminated with hazardous substances. The performance of field activities will produce waste products, such as spent sampling supplies (*e.g.*, sample tubing, disposable sample devices, paper towels, etc.), and expendable PPE. Disposable sampling supplies and PPE will be containerized in trash bags, in the vicinity of the work, which may include terrestrial locations and offshore locations, and disposed of as non-hazardous municipal solid waste at the end of the project phase by the MDEQ.

5.2.1 Terrestrial Investigation

Soil boring advancement and monitoring well installation will result in the generation of soil cuttings, purge water, and decontamination water. It is anticipated that soil cuttings, following logging, screening, and sampling will be temporarily contained in a five-gallon bucket. Following completion of the boring installation the staged soil cuttings will be returned to the boring by the MDEQ. For locations where groundwater samples are collected, the soil cuttings will be staged until all samples have been collected and the sampling equipment extracted from the boring. Purge water generated as a result of groundwater sampling activities will be temporarily containerized in five-gallon bucket. Following groundwater sampling collection the collected purge water will be returned to the boring and the boring will be backfilled with the soil cuttings by the MDEQ. Expendable groundwater sampling materials will be containerized in a trash bag for disposal as non-hazardous municipal solid waste at the end of the project phase.

Commercially-available topsoil may be added to soil sampling locations to restore original grade as necessary by the MDEQ.

It is anticipated that reusable equipment, including the stainless steel sampling screen, will be decontaminated between boring locations using steam-cleaning methods which will minimize decontamination water. In addition, some parts or equipment may be decontaminated using an alconox wash and rinse. Decontamination water generated through washing and rinsing will be discharged in the vicinity of the sample locations. Spray bottles of wash and rinse water may be used to minimize the volume of decontamination fluids generated but the soil boring and well installation activities.

5.2.2 Offshore Investigation

Offshore sampling locations will result in the generation of similar waste streams. Spent Lexane tubing used in the collection of vibracore sediment samples will be collected and staged for disposal as non-hazardous municipal solid waste by the MDEQ. Sample tubing and similar reusable sampling equipment will collected in a trash bag for disposal as non-hazardous municipal solid waste by the MDEQ. Spent sampling supplies and PPE will be staged on the sampling vessel until the vessel returns to the dock at which time bagged and containerized waste will be transferred to a dumpster for disposal by the MDEQ.

Excess sediment, debris, and surface water generated as a result of the sampling activities will be temporarily containerized on the vessel in a five-gallon bucket until sampling at the location is complete. Following completion of the sampling activities the excess sediment and surface water will be returned to the lake in the vicinity of the sample location by the MDEQ.

It is anticipated that reusable equipment will be decontaminated on board the sampling vessel using an alconox wash and rinse. Spray bottles of wash and rinse water may be used to minimize the volume of decontamination fluids generated during the surface water and sediment sampling activities. Decontamination water generated through washing and rinsing will be discharged to the lake in the vicinity of the sample location by the MDEQ.

In the event that free phase oils or liquids or grossly contaminated media are encountered during the terrestrial or offshore sampling activities, contingency containment will be available in the area of the work. Contingencies for containment will include two, clean, five-gallon buckets with lids that will be used to contain any free phase product or residues. The contingency containment will also be used to containerize decontamination fluids resulting from encountering the grossly contaminated material. The containerized waste will be sampled and characterized for proper disposal. It is assumed that any grossly contaminated media collected as a contingency will be temporarily secured and staged at the property where it was generated or at facility secure location until it can be properly characterized and disposed.

5.3 SAMPLE HANDLING, TRACKING, AND CUSTODY PROCEDURES

All samples will be identified, handled, shipped, tracked, and maintained under COC. This section discusses sample labels, custody seals, sample documentation, sample chain-of-custody, the field logbook, and sample shipment.

5.3.1 Sample Identification

As described in **Section 5.1**, each sample collected will be given a unique sample ID number that is project- and location-specific. A record of sample ID numbers will be kept with the field records and recorded on chain-of-custody forms.

5.3.2 Sample Labels

Sample labels will be affixed to sample containers. The label will be completed with the following information written in indelible ink:

- Project name and location
- Sample ID number
- Date and time of sample collection
- Preservative used
- Sample collector's initials
- Analyses required

After labeling, each sample will be placed in a cooler that contains ice to maintain the sample temperature at 4 ± 2 degrees Celsius (ºC). A temperature blank will be provided in each cooler for the laboratory to confirm storage temperature upon sample receipt.

5.3.3 Custody Seals

A self-adhesive custody seal will be placed across the lid of each sample cooler so that the cooler cannot be opened without breaking the seal. The shipping containers in which samples will be stored will be sealed with self-adhesive custody seals any time they are not in someone's possession or view before shipping. Custody seals will be signed and dated.

Custody seals also will be used in combination with strapping tape on the shipping containers to ensure that samples have not been disturbed during transport. Openings will be taped shut to prevent potential leakage during transport.

5.3.4 Sample Documentation

Documentation during sampling is essential to ensure proper sample identification. Sampling personnel will adhere to the general guidelines summarized below for maintaining field documentation:

- Documentation will be completed in permanent black ink;
- Entries will be legible;
- Errors will be corrected by crossing out with a single line and then dating and initialing the lineout in a manner that allows the initial entry to be read;
- Any serialized documents including the sampling forms will be maintained in a site file folder by MDEQ and WESTON field personnel and referenced in the site logbook; and,
- Unused portions of pages will be crossed out, and each page will be signed and dated.

MDEQ and WESTON field personnel will be responsible for ensuring that sampling activities are properly documented.

5.3.5 Sample Chain of Custody

The field team will use standard sample custody procedures to maintain and document sample integrity during sample collection, transportation, storage, and analysis. A sample will be considered to be in custody if one of the statements below applies:

- It is in a person's physical possession or view;
- It is in a secure area with restricted access;
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal; and,
- Special instructions regarding short holding/extraction times will be noted.

Chain-of-custody procedures provide an accurate written record that traces the possession of individual samples from the time of collection in the field to the time of acceptance at the laboratory. The chain-of-custody form will be used to document samples collected and the analyses requested. The field personnel will record the following information on the chain-of-custody record:

- Project name and number;
- Sampling location;
- Name and signature of sampler;
- Destination of samples (laboratory name);
- Sample ID number;
- Date and time of collection;
- Number and type of containers filled;
- Analyses requested;
- Preservatives used (if applicable);
- Filtering (if applicable);
- Sample designation (grab or composite);
- Signatures of individuals involved in custody transfer;
- Air bill number (if applicable); and,
- Project contact and telephone number.

Unused lines on the chain-of-custody record will be crossed out. Field personnel will sign chain-of-custody records that are initiated in the field, and the air bill number will be recorded. The record will be placed in a waterproof plastic bag and taped to the inside of the shipping container used to transport the samples. Signed air bills will serve as evidence of custody transfer between field personnel and the courier and between the courier and the laboratory. Copies of the chain-of-custody records and the air bills will be retained and filed by field personnel before the containers are shipped.

Laboratory chain-of-custody begins with sample receipt and continues until samples are discarded. Laboratories analyzing samples must follow custody procedures at least as stringent as those required by the EPA Contract Laboratory Program (CLP) Statement of Work (SOW) (U.S. EPA 2007). The laboratory should designate a specific individual as the sample custodian. The custodian will receive incoming samples, sign the accompanying custody forms, and retain copies of the forms as permanent records. The laboratory sample custodian will record pertinent information concerning the samples, including the person(s) delivering the samples, the date and time received, and sample condition at the time of receipt (sealed, unsealed, or broken container; temperature; and other relevant remarks).

The sample ID numbers, along with unique laboratory ID numbers, will be recorded on the sample receipt form. After the sample transfer process is complete, the custodian is responsible for maintaining internal logbooks, tracking reports, and other records necessary to maintain custody throughout sample preparation and analysis.

The laboratory will provide a secure storage area for samples. Access to this area will be restricted to authorized personnel. The custodian will ensure that samples requiring special handling, including samples that are heat- or light-sensitive or have other unusual physical characteristics, will be properly stored and maintained prior to analysis.

5.3.6 Sample Shipment

The procedures summarized below will be implemented to ship samples collected during this project.

- The cooler will be filled with bubble wrap, sample bottles, and packing material. Sufficient packing material will be used to prevent sample containers from breaking during shipment. Enough ice will be added to maintain the sample temperature at 4 ± 2 °C. A temperature blank will be provided in each cooler for the laboratory to confirm storage temperature upon sample receipt. In addition, in order to avoid interference with the laboratory analysis, the packing material will be handled and used in such a manner that it will not contact the sample media at the Site.

- The chain-of-custody records will be placed inside a waterproof plastic bag. The bag will be sealed and taped to the inside of the cooler lid. The air bill, if required, will be filled out before the samples are handed over to the carrier. The laboratory will be notified if the sampler suspects that the sample contains any substance that would require laboratory personnel to take safety precautions.
- The cooler will be closed and taped shut with strapping tape around both ends. If the cooler has a drain, the drain will be taped shut both inside and outside the cooler.
- Signed and dated custody seals will be placed on the front and side of each cooler. Wide clear tape will be placed over the seals to prevent accidental breakage.
- The chain-of-custody record will be transported in the taped sealed cooler. When the cooler is received at the analytical laboratory, laboratory personnel will open the cooler and sign the chain-of-custody record to document the transfer of samples.

Multiple coolers may be sent in one shipment to the laboratory. The outsides of the coolers will be marked to indicate the number of coolers in the shipment.

Alternatively, samples may be transported by |MDEQ personnel directly to the environmental laboratory. Standard chain of custody procedures will be followed during transfer of the samples to the laboratory.

5.4 FIELD LOG BOOK

Complete and accurate documentation is essential to demonstrate that field measurement and sampling procedures are carried out as described in this. Field personnel will use permanently bound field logbooks with sequentially numbered pages to record and document field activities. The logbook will list the contract name and number, the project name and number; the Site name and location; and the names of subcontractors.

At a minimum, the following information will be recorded in the field logbook:

- Names and affiliations of on-site personnel and visitors;
- Weather conditions during the field activity;

- Summary of daily activities and significant events;
- Information regarding sample collection, including collection date and time, sample ID number, sampling location, sample matrix (such as water or soil), sample type (such as regular, duplicate, blank, grab, or composite), and sampling depth;
- Notes of conversations with coordinating officials;
- References to other field logbooks or forms that contain specific information;
- Discussions of problems encountered and their resolution;
- Discussions of deviations from the SAP or other governing documents; and,
- Description of photographs taken.

Changes or corrections will be made by crossing out the item with a single line initialed and dated by the person performing the correction. The original item, although erroneous, will remain legible beneath the cross-out. The new information will be written above the crossed-out item. Corrections will be written clearly and legibly with indelible ink.

6. LABORATORY INFORMATION

Investigative samples will be delivered by a courier or shipped under chain of custody to the designated laboratory listed in the table below.

Matrix	Laboratory Name	Laboratory Address	Laboratory Contact Name	Laboratory Phone Number	Accept Saturday Deliveries?
Surface Soil Subsurface Soil Groundwater Surface Water Sediment	MDEQ Environmental Laboratory	3350 N. Martin Luther King Blvd. Lansing, MI 48906-2933	MDEQ Laboratory Services Section – Kirby Shane	(517) 335-9800	No
Bulk Asbestos and Asbestos in Soil Waste Characterization	TestAmerica, Inc.	4101 Shuffel Street Northwest North Canton, OH 44720	MDEQ Laboratory Services Section – Kris Brooks	(330) 497-9396	Yes

Although the MDEQ Environmental Laboratory does not perform asbestos analyses, the contract laboratory program requires that the samples be shipped and managed by the MDEQ Environmental Laboratory. The laboratory will deliver the samples under chain of custody to the appropriate laboratory in the Contract Laboratory Program. Field personnel will follow these procedures unless directed otherwise by MDEQ or laboratory personnel.

6.1 MEASUREMENT AND PERFORMANCE CRITERIA

Generic measurement and performance criteria will be used. These criteria will ensure that data are sufficiently sensitive, precise, accurate, and representative to support Site decisions. The criteria are summarized below.

- Sensitivity **–** Sensitivity is the ability of the method or instrument to detect the contaminant of concern and other target analytes at the level of interest. For this project, the laboratory quantitation limits are below the site action levels for lead as required (see **Section 6.2**).
- Accuracy **–** Accuracy is a measure of the agreement between an observed value and an accepted reference value. It is a combination of the random error (precision) and systematic error (bias), which are due to sampling and analytical operations. Accuracy is determined by percent recovery calculations of laboratory QC samples.

- Precision **–** Precision is a measure of the closeness of agreement among individual measurements. Precision is determined by relative percent difference (RPD) and/or standard deviation calculations for laboratory duplicate samples.

- Completeness **–** Completeness is a measure of the amount of valid data obtained compared to the amount of data that was planned to be collected. Completeness is project specific but is generally around 90 percent.

- Representativeness **–** Representativeness is a measure of the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Simply, this is the degree to which samples represent the conditions for which they were taken.

- Comparability **–** Comparability is a measure of the degree to which one data set can be compared with another. Some conditions of comparability of data sets are as follows: standardized sampling and analysis, consistency of reporting units, and standardized data format.

The MDEQ Environmental Laboratory will validate analytical results, ensuring that the data is acceptable for use in supporting Site decisions.

6.2 DATA QUALITY OBJECTIVES

DQOs address requirements that include when, where, and how to collect samples; the number of samples; and the limits on tolerable error rates. Sufficient data will be obtained from a representative number of samples to support defensible decisions by MDEQ and to determine whether further actions at the Site are necessary. These steps should periodically be revisited as new information about a problem is learned.

The following is a list of DQOs that apply to the CHTC. Analytical data must meet all requirements for comparison to the following regulations:

Surface Soil

- MDEQ Cleanup Criteria Requirements for Response Activity.
    - Rule 299.46 Generic soil cleanup criteria for residential category; and,
    - Rule 299.48 Generic soil cleanup criteria for nonresidential category.

Subsurface Soil

- MDEQ Cleanup Criteria Requirements for Response Activity.
  - Rule 299.46 Generic soil cleanup criteria for residential category; and,
  - Rule 299.48 Generic soil cleanup criteria for nonresidential category.

Groundwater

- MDEQ Cleanup Criteria Requirements for Response Activity
  - Rule 299.44 Generic groundwater cleanup criteria.

Surface Water

- MDEQ – Rule 57 Water Quality Values, Surface Water Assessment Section
- EPA Ecological Screening Levels (ESLs)

Sediment

- MDEQ Cleanup Criteria Requirements for Response Activity;
  - Rule 299.46 Generic soil cleanup criteria for residential category; and,
  - Rule 299.48 Generic soil cleanup criteria for nonresidential category.
- EPA ESLs; and,
- Sediment Quality Guidelines, Threshold Effect Concentrations (TECs) and Probable Effect Concentrations (PECs), MacDonald, et al, 2000.

Bulk Asbestos

- EPA, National Emission Standards for Hazardous Air Pollutants (NESHAP).
  - 40 Code of Federal Regulations (CFR), Part 61, Subpart M.

7. QUALITY CONTROL ACTIVITIES

The following sections describe the field and laboratory quality control procedures.

7.1 FIELD QUALITY CONTROL

QC samples will be collected to evaluate the field sampling and decontamination methods, and the overall reproducibility of the laboratory analytical results. Specifically, QC samples will be collected at the following frequencies:

- Field duplicate samples
    - 1 per 10 investigative samples

Field duplicate samples will be collected using the same sampling techniques as its associated investigative sample. Field duplicate samples will be processed, stored, packaged, and analyzed by the same methods as the investigative samples. Sample nomenclature specific to QC samples is listed in **Section 5.1**. For field duplicates, the RPD between the duplicate and investigative sample will be calculated by the WESTON QA reviewer and those RPDs greater than 50 percent (where detections are greater than the quantitation limit) will be summarized in a data validation report. Corrective actions may include resampling, reassessment of the laboratory's methods, or the addition of data qualifiers to laboratory results by WESTON.

Matrix spike/matrix spike duplicate (MS/MSD) samples will not be collected during the implementation of field activities. Alternatively, MS/MSD will be selected by the laboratory or "batched". As such, MS/MSD samples may not be derived from investigative samples from the Site, but may come from another sample set at the laboratory. The MDEQ Environmental Laboratory will flag data based on the MS/MSD results if appropriate, but the MS/MSD results will not be reported with investigative sample results. The collection of samples for MS/MSD analyses will not be conducted as part of this investigation.

7.2 ANALYTICAL QUALITY CONTROL

QC for analytical procedures will be performed at the frequency described in the laboratory Standard Operating Procedures (SOPs). In addition, method-specific QC requirements will be used to ensure data quality.

7.3 PERFORMANCE EVALUATION SAMPLES

Performance evaluation samples will not be used in this site assessment.

7.4 QUALITY ASSURANCE ASSESSMENT / CORRECTIVE ACTIONS

Field activities are anticipated to require four 2 week mobilizations for completion; no long-term project field audit will be completed at this time.

7.5 DOCUMENTATION, RECORDS, AND DATA MANAGEMENT

The MDEQ Environmental Laboratory and Contract Laboratories, as applicable will be expected to provide analytical results in electronic data deliverable (EDD) and report formats, with QA/QC and investigative data results. The EDDs will be specifically requested from the MDEQ Environmental Laboratory and will include analyte comments. Sample comments will be added to the database by WESTON. Laboratory-generated data will be imported to a project database for mapping, reporting, and archival activities. Laboratory reports will be archived electronically in the WESTON project file and by the MDEQ Environmental Laboratory.

8. REFERENCES

1. Alexander, M., *A Sediment Chemistry Survey of Torch Lake, Houghton County, Michigan, August 7, 8, and 9, 2007*, Editor 2008: Lansing, Michigan.Michigan

2. Donahue & Associates. *Final Remedial Investigation Report OU II, Volume 1*. January 1992.

3. Donahue & Associates. *Final Investigation Report OU II, Addendum 1*. March 1992.

4. Great Lakes Environmental Center. *PCB Study Using Semipermeable Membrane Devices in Torch Lake, Houghton County, MDEQ Project Number 05-25*. March 2006.

5. MacDonald, D.D., Ingersoll, C.G., and Berger, T.A. *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems*. January 2000.

6. Michigan Department of Environmental Quality (MDEQ), Remediation and Redevelopment Division (RRD) Superfund Section, Pre-remedial Group, Site Evaluation Unit (Pre-remedial Group), *Draft Site Inspection Report for C&H Tamarack Operations, Hubbell, Michigan 49934*. March 2013.

7. MDEQ-RRD, Superfund Section, Pre-remedial Group. *Brownfield Redevelopment Assessment Report for Tamarack City Stamp Mill, M-26 Highway, Hubbell, Michigan*. December 2002.

8. MDEQ, Water Bureau. *PCB Concentrations in Walleye Collected from Torch Lake (Houghton County) and Lake Superior*. June 2008.

9. Michigan Technological University. *Tamarack Area Facilities, Task 3 – Phase 2 Report, Historical Archive Research and Mapping from Hubbell Beach through Tamarack City, C&H Historic Properties of Torch Lake*. October 2014.

10. Oneida Total Integrated Enterprises, Inc. *Removal Action Letter Report, Tamarack Stamp Mill, Osceola Township, Houghton County, Michigan*. October 2014.

11. United States Environmental Protection Agency (EPA) Great Lakes National Program Office (GLNPO). *Aroclor Sediment Investigation, Torch Lake Area of Concern, Houghton County, Michigan*. June 2009.

12. U.P. Engineers and Architects, Inc. *Baseline Environmental Assessment of Tamarack Stamp Mill in Osceola Township, Portions of Section 13, T55N, R33W, Osceola Township, Houghton County, Michigan*. November 2001**.**

13. Weston Solutions of Michigan, Inc. (WESTON). *Draft Technical Memorandum for Tamarack City Stamp Mill Site Analytical Data Review and Evaluation*. March 2005.

14. WESTON. *Summary Report for the Torch Lake Area Assessment, Torch Lake NPL Site and Surrounding Areas, Keweenaw Peninsula, Michigan*. December 2007.

15. WESTON. *Draft Compilation and Interpretation of Key Historic Studies Technical Memorandum.* March 2015.

TABLES

Table 4-1
Sampling and Analysis Summary
C&H Tamarack City Operations Area
Ahmeek Mill Processing Area
Houghton County, Michigan

Proposed Sampling Location	Sampling Rationale	Sample Interval	Anticipated Sampling Method	Sample Type/Matrix						Sample Analyses					Duplicate Analyses				
				Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Drums, Containers, and Building Materials/SACM	VOCs	PNAs	Metals	PCBs	Asbestos	VOCs	PNAs	Metals	PCBs	Asbestos
CHTC-SB01-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB01-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X						
CHTC-SB02-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB02-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X					X	X		X						
CHTC-SB03-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X	X					
CHTC-SB03-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X						
CHTC-SB04-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB04-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X					X	X		X						
CHTC-SB05-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X	X					
CHTC-SB05-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X					X	
CHTC-SB06-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB06-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X						
CHTC-SB07-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X	X					
CHTC-SB07-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X						
CHTC-SB08-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X	X					
CHTC-SB08-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X						
CHTC-SB09-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X	X					
CHTC-SB09-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X						
CHTC-SB10-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X	X					
CHTC-SB10-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X					X	
CHTC-SB11-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X	X					
CHTC-SB11-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X					X	X		X						
CHTC-SB12-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB12-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X					X	X		X						
CHTC-SB13-0-6"	Proximity to a historical power house.	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB13-X-Y'	Proximity to a historical power house.	Composite sample from above water table	Direct Push Boring		X					X	X		X						
CHTC-SB14-0-6"	Proximity to observed suspect asbestos panel	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X					X				X	X					
CHTC-SB14-X-Y'	Proximity to observed suspect asbestos panel	Composite sample from above water table	Direct Push Boring		X								X						
CHTC-GW01-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						
CHTC-GW02-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						
CHTC-GW03-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						
CHTC-GW04-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						
CHTC-GW05-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						
CHTC-GW06-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						
CHTC-GW07-X-Y'	Proximity to a historical power house.	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						
CHTC-GW08-X-Y'	Proximity to a historical power house.	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						
CHTC-GW09-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X		X	X		X	
CHTC-GW10-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						

Table 4-1
Sampling and Analysis Summary
C&H Tamarack City Operations Area
Ahmeek Mill Processing Area
Houghton County, Michigan

Proposed Sampling Location	Sampling Rationale	Sample Interval	Anticipated Sampling Method	Sample Type/Matrix						Sample Analyses					Duplicate Analyses				
				Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Drums, Containers, and Building Materials/SACM	VOCs	PNAs	Metals	PCBs	Asbestos	VOCs	PNAs	Metals	PCBs	Asbestos
CHTC-SD01-0-6"	Data Gap - Lack of historical data.	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X				X	X						
CHTC-SD01-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X			X		X						
CHTC-SD01-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD02-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X					X						
CHTC-SD02-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X					X						
CHTC-SD02-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD03-0-6"	Data Gap - Lack of historical data.	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X				X	X						
CHTC-SD03-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X			X		X						
CHTC-SD03-3-6'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD04-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X					X					X	
CHTC-SD04-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X					X						
CHTC-SD04-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD05-0-6"	Data Gap - Lack of historical data.	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X				X	X						
CHTC-SD05-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X			X		X						
CHTC-SD05-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
			Total Sample Count	**14**	**14**	**10**	**0**	**15**	**1**	**15**	**18**	**3**	**53**	**8**	**1**	**1**	**0**	**4**	**0**

Notes:
CHTC = C&H Tamarack City Operations
O = Potential analyte based on field observations
PNAs = Polynuclear Aromatic Hydrocarbons
PCBs = Polychlorinated Biphenyls
SACM = Suspect Asbestos Containing Material
VOCs = Volatile Organic Compounds
X = Planned analyte based on the sampling rationale and the horizontal and vertical location of the sample

Laboratory Quality Assurance/Quality Control Matrix Spike and Matrix Spike Duplicate samples will be a batch quality control sample prepared by the laboratory.
All sampling locations are subject to change based on visual observations or actual field conditions.
Additional analytes may be selected at the descretion of the field sampling team based on visual observations or field conditions.
Surface water and sediment sampling locations area subject to change based on underwater assessment activities.
For the purposes of this investigation, sediments include residues and waste material associated with chemical containers and deposits on the lake bottom historically discarded in Torch Lake.
In areas that have been resurfaced or capped, analytical samples will be collected from directly beneath the cap/resurfacing medium (i.e. soil cap, beach sand, gravel, etc...) so that samples are representative of historical waste deposits.

Table 4-1
Sampling and Analysis Summary
C&H Tamarack City Operations Area
Tamarack Processing Area
Houghton County, Michigan

Proposed Sampling Location	Sampling Rationale	Sample Interval	Anticipated Sample Method	Sample Type/Matrix						Sample Analyses							Duplicates				
				Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Drums, Containers, and Building Materials/SACM	VOCs	PNAs	Metals	PCBs	Asbestos	Chloride/Sulfate	Oil and Grease	VOCs	PNAs	Metals	PCBs	Asbestos
CHTC-SB16-0-6"	Proximity to a historical electrical substation	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X			O					
CHTC-SB16-X-Y'	Proximity to a historical electrical substation	Composite sample from above water table	Direct Push Boring		X					X	X		X			X				X	
CHTC-SB17-0-6"	Proximity to a historical electrical substation	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X	X		O					
CHTC-SB17-X-Y'	Proximity to a historical electrical substation	Composite sample from above water table	Direct Push Boring		X					X	X		X			X					
CHTC-SB18-0-6"	Proximity to a historical electrical substation	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X			O					
CHTC-SB18-X-Y	Proximity to a historical electrical substation	Composite sample from above water table	Direct Push Boring		X					X	X		X			X					
CHTC-SB19-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X	X		O					
CHTC-SB19-X-Y	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X					X	X		X			X					
CHTC-SB20-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X			O					
CHTC-SB20-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X			X					
CHTC-SB21-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X	X							
CHTC-SB21-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X							X	
CHTC-SB22-0-6"	Proximity to historical PCB detections	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X								
CHTC-SB22-X-Y	Proximity to historical PCB detections	Composite sample from above water table	Direct Push Boring		X								X								
CHTC-SB23-0-6"	Proximity to historical PCB detections	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X	X							
CHTC-SB23-X-Y	Proximity to historical PCB detections	Composite sample from above water table	Direct Push Boring		X						X		X								
CHTC-SB24-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X	X							
CHTC-SB24-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X								
CHTC-SB25-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X								
CHTC-SB25-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X						X		X								
CHTC-SB26-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X								
CHTC-SB26-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X							X	
CHTC-SB27-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X								
CHTC-SB27-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X								
CHTC-SB28-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X								
CHTC-SB28-X-Y	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X						X		X								
CHTC-SB29-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X								
CHTC-SB29-X-Y	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X						X		X								
CHTC-SB30-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X								
CHTC-SB30-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X						X		X								
CHTC-SB31-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X								
CHTC-SB31-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X						X		X							X	
CHTC-SB32-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X								
CHTC-SB32-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X								
CHTC-SB33-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X								
CHTC-SB33-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X								

Table 4-1
Sampling and Analysis Summary
C&H Tamarack City Operations Area
Tamarack Processing Area
Houghton County, Michigan

Proposed Sampling Location	Sampling Rationale	Sample Interval	Anticipated Sample Method	Sample Type/Matrix						Sample Analyses							Duplicates				
				Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Drums, Containers, and Building Materials/SACM	VOCs	PNAs	Metals	PCBs	Asbestos	Chloride/Sulfate	Oil and Grease	VOCs	PNAs	Metals	PCBs	Asbestos
CHTC-GW12-X-Y'	Proximity to a historical electrical substation	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X		X						
CHTC-GW13-X-Y'	Proximity to a historical electrical substation	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X		X						
CHTC-GW14-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X		X						
CHTC-GW15-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X		X						
CHTC-GW16-X-Y'	Proximity to historical PCB detections	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X		X						
CHTC-GW17-X-Y'	Proximity to historical PCB detections	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X								
CHTC-GW18-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X								
CHTC-GW19-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X							X								
CHTC-GW20-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X				X	X		X	
CHTC-GW21-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X							X								
CHTC-GW22-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X							X								
CHTC-GW23-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X								
CHTC-GW24-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X								
CHTC-GW25-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X							X								
CHTC-GW26-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X								
CHTC-GW27-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X								
CHTC-GW28-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X								
		Total Sample Count		**18**	**18**	**17**	**0**	**0**	**0**	**17**	**23**	**0**	**53**	**5**	**5**	**10**	**1**	**1**	**0**	**5**	**0**

Notes:
CHTC = C&H Tamarack City Operations
O = Potential analyte based on field observations
PNAs = Polynuclear Aromatic Hydrocarbons
PCBs = Polychlorinated Biphenyls
SACM = Suspect Asbestos Containing Material
VOCs = Volatile Organic Compounds
X = Planned analyte based on the sampling rationale and the horizontal and vertical location of the sample

Laboratory Quality Assurance/Quality Control Matrix Spike and Matrix Spike Duplicate samples will be a batch quality control sample prepared by the laboratory.
All sampling locations are subject to change based on visual observations or actual field conditions.
Additional analytes may be selected at the descretion of the field sampling team based on visual observations or field conditions.
Surface water and sediment sampling locations area subject to change based on underwater assessment activities.
For the purposes of this investigation, sediments include residues and waste material associated with chemical containers and deposits on the lake bottom historically discarded in Torch Lake.
In areas that have been resurfaced or capped, analytical samples will be collected from directly beneath the cap/resurfacing medium (i.e. soil cap, beach sand, gravel, etc...) so that samples are representative of historical waste deposits.

Table 4-1
Sampling and Analysis Summary
C&H Tamarack City Operations Area
C&H Tamarack Sands Area
Houghton County, Michigan

Proposed Sampling Location	Sampling Rationale	Sample Interval	Anticipated Sample Method	Sample Type/Matrix						Sample Analyses					Duplicates				
				Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Drums, Containers, and Building Materials/SACM	VOCs	PNAs	Metals	PCBs	Asbestos	VOCs	PNAs	Metals	PCBs	Asbestos
CHTC-SB15-0-6"	Proximity to observed suspect asbestos panel	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X					X				X	X					
CHTC-SB15-X-Y'	Proximity to observed suspect asbestos panel	Composite sample from above water table	Direct Push Boring		X								X						
CHTC-SB34-0-6"	Proximity to reported dumping/disposal areas	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB34-X-Y'	Proximity to reported dumping/disposal areas	Composite sample from above water table	Direct Push Boring		X						O		X						
CHTC-SB35-0-6"	Proximity to reported dumping/disposal areas	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB35-X-Y'	Proximity to reported dumping/disposal areas	Composite sample from above water table	Direct Push Boring		X						O		X					X	
CHTC-SB36-0-6"	Downgradient of reported dumping/disposal areas	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB36-X-Y'	Downgradient of reported dumping/disposal areas	Composite sample from above water table	Direct Push Boring		X						O		X						
CHTC-SB37-0-6"	Downgradient of reported dumping/disposal areas	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB37-X-Y'	Downgradient of reported dumping/disposal areas	Composite sample from above water table	Direct Push Boring		X						O		X						
CHTC-SB38-0-6"	Proximity to reported dumping/disposal areas	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB38-X-Y	Proximity to reported dumping/disposal areas	Composite sample from above water table	Direct Push Boring		X						O		X						
CHTC-SB39-0-6"	Downgradient of reported dumping/disposal areas	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB39-X-Y	Downgradient of reported dumping/disposal areas	Above the Capillary fringe	Direct Push Boring		X						O		X						
CHTC-SB40-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB40-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X					X	
CHTC-SB41-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X								X	X						
CHTC-SB41-X-Y'	Data Gap - Lack of historical data	Above the Capillary fringe	Direct Push Boring		X							X	X						
CHTC-SB42-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X									X						
CHTC-SB42-X-Y	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X						
CHTC-SB43-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the soil boring	Direct Push Boring	X								X	X						
CHTC-SB43-X-Y'	Data Gap - Lack of historical data	Composite sample from above water table	Direct Push Boring		X								X					X	
CHTC-GW11-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						
CHTC-GW29-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						
CHTC-GW30-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						
CHTC-GW31-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X		X	X		X	
CHTC-GW32-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X				X	X		X						
CHTC-GW33-X-Y'	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X							X						
CHTC-GW34-X-Y	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X							X						
CHTC-GW35-X-Y	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X							X						
CHTC-GW36-X-Y	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X							X						
CHTC-GW37-X-Y	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X							X						
CHTC-GW38-X-Y	Data Gap - Lack of historical data	Screen interval 5 -10 feet below the groundwater surface	Peristaltic Pump			X							X						
CHTC-SD06-0-6"	Data Gap - Lack of historical data.	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X				X	X						
CHTC-SD06-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X			X		X						
CHTC-SD06-3-6'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD07-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X					X						
CHTC-SD07-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X					X					X	
CHTC-SD07-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD08-0-6"	Data Gap - Lack of historical data.	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X				X	X						
CHTC-SD08-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X			X		X						
CHTC-SD08-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						

Table 4-1
Sampling and Analysis Summary
C&H Tamarack City Operations Area
C&H Tamarack Sands Area
Houghton County, Michigan

Proposed Sampling Location	Sampling Rationale	Sample Interval	Anticipated Sample Method	Sample Type/Matrix						Sample Analyses					Duplicates				
				Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Drums, Containers, and Building Materials/SACM	VOCs	PNAs	Metals	PCBs	Asbestos	VOCs	PNAs	Metals	PCBs	Asbestos
CHTC-SD09-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X					X						
CHTC-SD09-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X					X						
CHTC-SD09-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD10-0-6"	Data Gap - Lack of historical data.	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X				X	X						
CHTC-SD10-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X			X		X						
CHTC-SD10-3-6'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X					X	
CHTC-SD11-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X					X						
CHTC-SD11-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X					X						
CHTC-SD11-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD12-0-6"	Data Gap - Lack of historical data.	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X				X	X						
CHTC-SD12-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X			X		X						
CHTC-SD12-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD13-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X					X						
CHTC-SD13-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X					X						
CHTC-SD13-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD14-0-6"	Data Gap - Lack of historical data.	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X				X	X				X	X	
CHTC-SD14-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X			X		X						
CHTC-SD14-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD15-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X					X						
CHTC-SD15-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X					X						
CHTC-SD15-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD16-0-6"	Data Gap - Lack of historical data.	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X				X	X						
CHTC-SD16-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X			X		X						
CHTC-SD16-3-6'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD17-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X					X						
CHTC-SD17-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X					X					X	
CHTC-SD17-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD18-0-6"	Data Gap - Lack of historical data.	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X				X	X						
CHTC-SD18-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X			X		X						
CHTC-SD18-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
CHTC-SD19-0-6"	Data Gap - Lack of historical data	The upper-most 0-6 inches of the sediment sampling location	Vibracore					X					X						
CHTC-SD19-1-3'	Data Gap - Lack of historical data	Sediment from 1-3 feet below the sediment surface	Vibracore					X					X						
CHTC-SD19-3-5'	Data Gap - Lack of historical data	Sediment from 3-5 feet below the sediment surface	Vibracore					X					X						
			Total Sample Count	**9**	**9**	**11**	**0**	**42**	**1**	**5**	**18**	**10**	**75**	**1**	**1**	**1**	**1**	**8**	**0**

Notes:
CHTC = C&H Tamarack City Operations
O = Potential analyte based on field observations
PNAs = Polynuclear Aromatic Hydrocarbons
PCBs = Polychlorinated Biphenyls
SACM = Suspect Asbestos Containing Material
VOCs = Volatile Organic Compounds
X = Planned analyte based on the sampling rationale and the horizontal and vertical location of the sample

Laboratory Quality Assurance/Quality Control Matrix Spike and Matrix Spike Duplicate samples will be a batch quality control sample prepared by the laboratory.
All sampling locations are subject to change based on visual observations or actual field conditions.
Additional analytes may be selected at the descretion of the field sampling team based on visual observations or field conditions.
Surface water and sediment sampling locations area subject to change based on underwater assessment activities.
For the purposes of this investigation, sediments include residues and waste material associated with chemical containers and deposits on the lake bottom historically discarded in Torch Lake.
In areas that have been resurfaced or capped, analytical samples will be collected from directly beneath the cap/resurfacing medium (i.e. soil cap, beach sand, gravel, etc...) so that samples are representative of historical waste deposits.

Table 4-1
Sampling and Analysis Summary
C&H Tamarack City Operations Area
Field-Modified Sampling Locations
Houghton County, Michigan

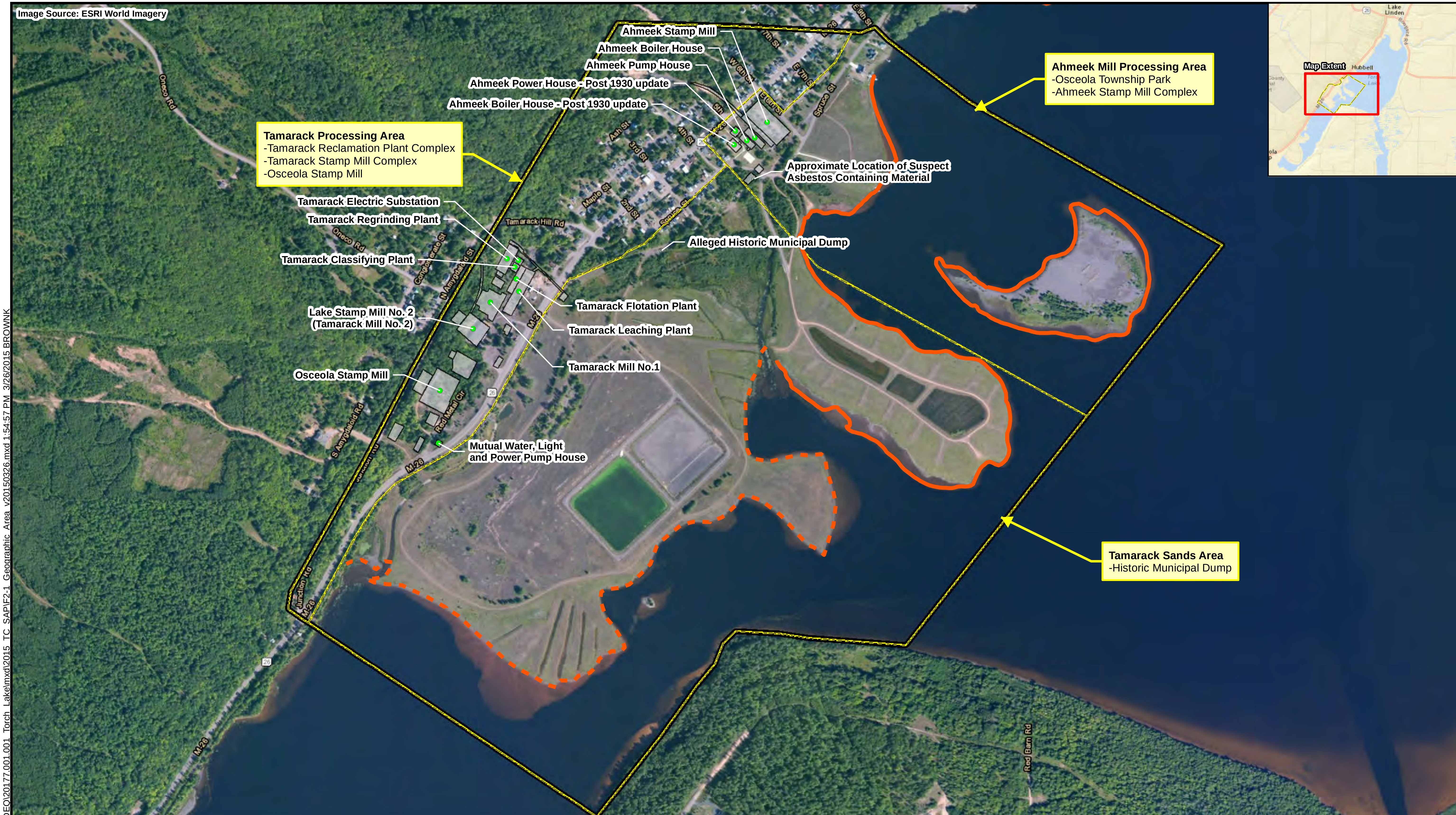
Additional/Revised Sampling Location ID	Sampling Rationale	Sample Interval	Sampling Method	Sample Type/Matrix						Sample Analyses						Duplicate Analyses				
				Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Drums and Containers	VOCs	PNAs	Metals	PCBs	Oil and Grease	Asbestos	VOCs	PNAs	Metals	PCBs	Oil and Grease

Notes:
CHTC = C&H Tamarack City Operations
ID = Identification
PNAs = Polynuclear Aromatic Hydrocarbons
PCBs = Polychlorinated Biphenyls
VOCs = Volatile Organic Compounds

Field sampling teams shall use this form to document additional or revised sampling locations, not otherwise defined in Table 4-1. These sample locations may be added or revised based on accessibility, visual observations, and similar field conditions.

Sample nomenclature shall be consistent with the format defined in the Sampling and Analysis Plan.
Laboratory Quality Assurance/Quality Control Matrix Spike and Matrix Spike Duplicate samples will be a batch quality control sample prepared by the laboratory.
For the purposes of this investigation, sediments include residues and waste material associated with chemical containers and deposits on the lake bottom historically discarded in Torch Lake.
In areas that have been resurfaced or capped, analytical samples will be collected from directly beneath the cap/resurfacing medium (i.e. soil cap, beach sand, gravel, etc...) so that samples are representative of historical waste deposits.

FIGURES



- Identified Industrial Areas of Interest
- Soil and Vegitative Cap (from MDEQ GIS files)
- Estimated Cap Limits
- Mining Era Buildings and Structures
- Study Areas (DRAFT)
- Tamarack City Operations Geographic Area

Mining Era Buildings and Structures from:
- *Michigan Technical University Archive Research Phase II Report Addendum*

N
0 750 Ft
Coordinate System: MIGeoRef(m)

DEQ
Prepared for:
Michigan Department of Environmental Quality

Prepared By:
WESTON SOLUTIONS of MICHIGAN, INC
P.O. Box 577
Houghton, MI 49931

Figure 2-1
Geographic Area Map
C&H Tamarack City Operations Area
Tamarack City, Houghton County, Michigan

FILE: T:\GIS_Projects\MDEQ\20177.001.001_Torch_Lake\mxd\2015_TC_SAP\F2-1_Geographic_Area_v20150326.mxd 1:54:57 PM 3/26/2015 BROWNK

Soil and Vegitative Cap (from MDEQ GIS files)

Estimated Cap Limits

Mining Era Buildings and Structures

Study

N

0 500 Feet

Coordinate System: MIGeoRef(m)

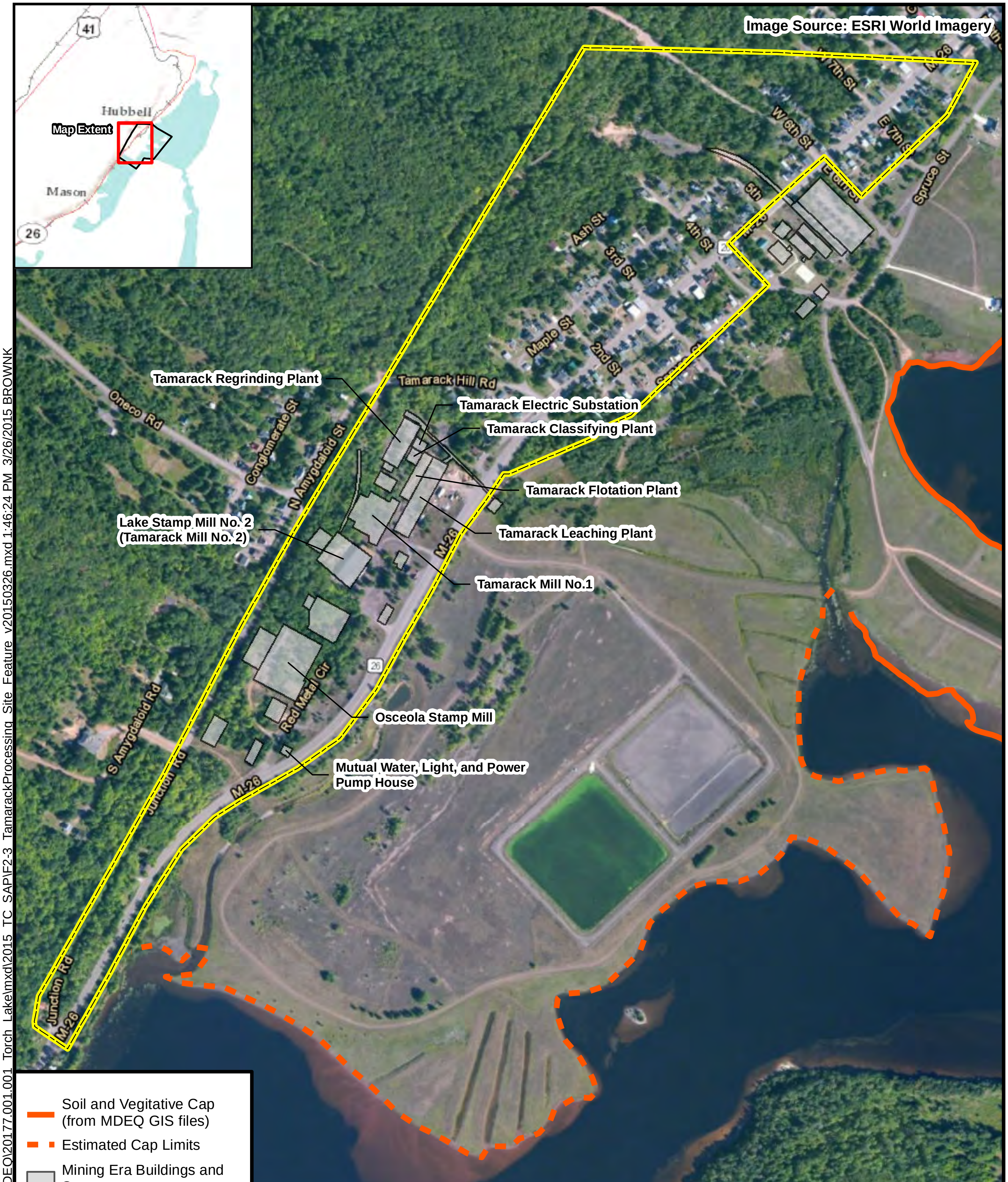
DEQ

Prepared for:
Michigan Department of Environmental Quality

Prepared By:
WESTON SOLUTIONS of MICHIGAN, INC
P.O. Box 577
Houghton, MI 49931

Figure 2-2
Site Location and Features Map
Ahmeek Mill Processing Area
C & H Tamarack CIty Operations
Tamarack City, Houghton County, Michigan

FILE: T:\GIS_Projects\MDEQ\20177.001.001_Torch_Lake\mxd\2015_TC_SAP\F2-2_Ahmeek_Site_Feature_v20150326.mxd 1:51:05 PM 3/26/2015 BROWNK



Prepared for:
Michigan Department of Environmental Quality

Prepared By:
WESTON SOLUTIONS of MICHIGAN, INC
P.O. Box 577
Houghton, MI 49931

Figure 2-3
Site Location and Features Map
Tamarack Processing Area
C & H Tamarack CIty Operations
Tamarack City, Houghton County, Michigan

FILE: T:\GIS_Projects\MDEQ\20177.001.001_Torch_Lake\mxd\2015_TC_SAP\F2-3_TamarackProcessing_Site_Feature_v20150326.mxd 1:46:24 PM 3/26/2015 BROWNK

- Soil and Vegitative Cap (from MDEQ GIS files)
- Estimated Cap Limits
- Mining Era Buildings and Structures
- Study Area

N

0 850 Feet

Coordinate System: MIGeoRef(m)

Prepared for:
Michigan Department of Environmental Quality

Prepared By:
WESTON SOLUTIONS of MICHIGAN, INC
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Houghton, MI 49931

Figure 2-4
Site Location and Features Map
Tamarack Sands Area
C & H Tamarack CIty Operations
Tamarack City, Houghton County, Michigan

FILE: T:\GIS_Projects\MDEQ\20177.001.001_Torch_Lake\mxd\2015_TC_SAP\F2-4_TamarackSands_Site_Feature_v20150326.mxd 1:46:56 PM 3/26/2015 BROWNK

Proposed Sampling Locations

- Soil Boring
- Soil Boring/ Groundwater
- Sediment

Conceptual Site and Geographic Area Boundaries

N

0 375 Ft

Coordinate System: MIGeoRef(m)

Prepared for:
Michigan Department of Environmental Quality

Prepared By:
WESTON SOLUTIONS of MICHIGAN, INC
P.O. Box 577
Houghton, MI 49931

Figure 4-1

Proposed Sampling Location Map - Ahmeek Mill Processing Area
C & H Tamarack City Operations
Tamarack City, Houghton County, Michigan

File: T:\GIS_Projects\MDEQ\20177.001.001_Torch_Lake\mxd\2015_TC_SAP\F4-1_Proposed_Ahmeek_v20150327.mxd, 3/27/2015 2:12:55 PM, BROWNK

Surface water and sediment sampling locations are subject to change based on underwater assessment activities.
All sampling locations are subject to change based on visual observations or actual field conditions.
For the purposes of this investigation, sediments include residues and waste material associated with chemical containers and deposits on the lake bottom historically discarded in Torch Lake.

Proposed Sampling Locations

- Soil Boring
- Soil Boring/ Groundwater
- Sediment

Conceptual Site and Geographic Area Boundaries

N

0 575 Ft

Prepared for:
Michigan Department of Environmental Quality

Prepared By:
WESTON SOLUTIONS of MICHIGAN, INC
P.O. Box 577
Houghton, MI 49931

Figure 4-2

Proposed Sampling Location Map - Tamarack Processing Area
C & H Tamarack City Operations
Tamarack City, Houghton County, Michigan

File: T:\GIS_Projects\MDEQ\20177.001.001_Torch_Lake\mxd\2015_TC_SAP\F4-2_Proposed_TamarackProcessing_v20150327.mxd, 3/27/2015 2:14:18 PM, BROWNK

Surface water and sediment sampling locations are subject to change based on underwater assessment activities.
All sampling locations are subject to change based on visual observations or actual field conditions.
For the purposes of this investigation, sediments include residues and waste material associated with chemical containers and deposits on the lake bottom historically discarded in Torch Lake.

Proposed Sampling Locations

- Soil Boring
- Soil Boring/ Groundwater
- Sediment

Conceptual Site and Geographic Area Boundaries

N

0 625 Ft

Coordinate System: MIGeoRef(m)

Prepared for:
Michigan Department of Environmental Quality

Prepared By:
WESTON SOLUTIONS of MICHIGAN, INC
P.O. Box 577
Houghton, MI 49931

Figure 4-3
Proposed Sampling Location Map - Tamarack Sands Area
C & H Tamarack City Operations
Tamarack City, Houghton County, Michigan

File: T:\GIS_Projects\MDEQ\20177.001.001_Torch_Lake\mxd\2015_TC_SAP\F4-3_Proposed_TamarackSand_v20150327.mxd, 3/27/2015 2:20:44 PM, BROWNK

APPENDIX A

HISTORICAL SUMMARIES

TAMARACK AREA FACILITIES

TASK 3 - PHASE 2 REPORT

Historical Archive Research and Mapping
From Hubbell Beach through Tamarack City
C&H Historic Properties of Torch Lake

Prepared for:

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
Reclamation and Redevelopment Division
55195 US Highway 41
Calumet, Michigan 49913

Prepared by:

MICHIGAN TECHNOLOGICAL UNIVERSITY
Carol MacLennan, Principal Investigator
With John Baeten, Emma Schwaiger, Dan Schneider, Brendan Pelto
Industrial Archaeology and Heritage Program
Department of Social Sciences

October 2014

Contract No. Y4110

TABLE OF CONTENTS

[1] The Ahmeek Mill Facilities include: the mill, pump house, and boiler house.
[2] The Tamarack Reclamation Facilities include: the regrinding plant, electric sub-station, classifying plant, flotation plant, and leaching plant.

[3] Tamarack Reclamation and Ahmeek Mill facilities highlighted in yellow. 1918-1968
[4] Tamarack Reclamation and Ahmeek facilities highlighted in yellow. 1942-1949
[5] Organized chronologically

SECTION 1: INTRODUCTION

Introduction

Phase 2 - Tamarack Area Facilities

This document encompasses the materials collected by Michigan Technological University (MTU) Social Science staff in support of Phase 2, Task 3 of the Michigan Department of Environmental Quality project to study and sample "Abandoned Mining Wastes of the Torch Lake Non-Superfund Site, Contract No. Y14110." It includes only summaries and documents from the historical archive research. Geo-referenced Google and GIS maps will be provided at a later date by MTU/MITRI.

Task 3 is devoted to the historical and archival work on C&H Torch Lake industrial facilities. Phase 2 covers the area from Phase 2 area from Hubbell Beach southward through Tamarack City, ending approximately at the junction of M-26 and Junction Road. The December 2014 Statement of Work (SOW, Appendix A) specifies the following 8 tasks that were to be accomplished by the Social Sciences Department in order to support DEQ, Weston, and MTU in identification of on-water and on-land sampling sites for Phase 2:

1. Identify major contaminants and waste streams of concern from industrial buildings and likely locations: PCBs (completed through Sea Grant Michigan); chemicals in reclamation processes; sludge from reclamation; slag from smelting; coal-related products such as fly-ash; leaching reagents from stamp mills and reclamation (ammonia, xanthates); others identified in archives.
2. Investigate MTU and KNHP C&H archives on building function, production processes, chemical processes, and waste streams by building location.
3. Produce Building Narratives for 13 buildings (in order of location from north to south).[6] Building narratives will be prioritized according to potential to produce significant contaminated wastes to optimize information necessary for soil and sediment sampling in late spring-summer season. Narratives of

[6] Building names are drawn from official names utilized by C&H and Sanborn Co. maps. Data for some buildings are largely collected through study of C&H electrical system and PCB sources.

buildings deemed insignificant for contaminated waste production will be brief, but included in order to document their elimination.

   a. Narratives will detail opening/closing dates; production activities within individual facilities; major updates in processes; repurposing of buildings for different production activities; information on incoming chemical, metal, or other waste and possible exit sites from buildings. Narratives will draw upon archival sources, maps, blueprints, and interviews.
   b. Building Narratives for 13 buildings in Hubbell Beach to Tamarack City region, listed by location north to south: Ahmeek Stamp Mill; Ahmeek Pump House; Ahmeek Boiler House; Tamarack Regrinding Plant; Tamarack Electric Sub-Station; Tamarack Classifying Plant; Tamarack Flotation Plant; Tamarack Leaching Plant; Tamarack Stamp Mill; Lake Milling, Smelting & Refining Co. Stamp Mill No. 2; Osceola Stamp Mill; Mutual Water Light & Co. Pump House.

4. Collect and scan available Sanborn maps (through 1928) and C&H blueprint maps for 13 buildings listed above.
5. Conduct interviews with knowledgeable individuals about individual plant operations.[7]
6. Provide a spreadsheet of sources consulted, relevance for which waste material or chemical – e.g. C&H box and files title/# in MTU or KNHP archives.
7. Provide a bibliography of relevant sources that detail or describe significant processing methods, chemical usages, and waste collection strategies for C&H Mining Co. during period of Torch Lake operations (1880-1970).

We have modified the format of documents presented in Phase 1 Report to include more extensive narratives on the three major facilities and their associated buildings: Ahmeek Mill and Tamarack Reclamation, and Lake Chemical Company, which operated within the Tamarack Reclamation plant. In addition, we have provided more documentation from the historical research in the form of the original notes taken by researchers from the C&H archives, *The Engineering & Mining Journal* and *C&H News and Views*.

[7] Sea Grant Michigan and KNHP have funded interviews during Fall 2013 and Spring 2014 semesters. If any additional individuals are identified during the DEQ funded research, they will be interviewed.

This remainder of this document is organized into the following sections:

Section 2 is organized into two parts. Part 1 includes the narratives and timelines of the most significant buildings and functions: Tamarack Reclamation Plant, Lake Chemical Company, and Ahmeek Mill. These narratives incorporate descriptions that also pertain to the adjacent buildings that support reclamation, chemical production, and milling. Part 2 consists of the "Building Narrative" forms that are outlined in the Statement of Work for Phase 2.

Section 3 includes multiple and extensive forms of documentation from historical archive research. Six Sanborn Maps are provided that cover Ahmeek Mill and Tamarack Reclamation buildings for different years. A list of blueprints located in the MTU Archives details relevant documents stored on a set of CDs provided with this report. Detailed notes from the *Engineering & Mining Journal, C&H News and Views* are have highlighted sections on reclamation, scrapping, and milling in the Tamarack Reclamation and Ahmeek Mill facilities. Interview summaries related to these facilities are also included. Researcher notes from the MTU and KNHP Archives are available for further reference if necessary as DEQ continues its investigation of Torch Lake pollution. They are organized by Series Number, Folder Name, and Box number to make it easy to locate files for further investigation. Finally, the multiple documents scanned from the Archives are provided in chronological. They are noted in the archive researcher notes and also have location information on their scanned copies. Because of the richness of information contained in these documents, they were scanned rather than summarized.

Research during the summer of 2014 was conducted by graduate students John Baeten (Tamarack Reclamation, Lake Chemical), Emma Schwaiger (Ahmeek Mill, Tamarack Reclamation, *C&H News and Views*), Dan Schneider (Interviews), and

Brendan Pelto (Tamarack Reclamation, *Daily Mining Gazette*, and *Native Copper Times*). Carol MacLennan, Principal Investigator and Professor, supervised and directed the research effort. All are members of the Industrial Archaeology and Heritage Program in the MTU Social Sciences Department.

SECTION 2: NARRATIVES AND TIMELINES

Emma Schwaiger

Ahmeek Stamp Mill Narrative

The Ahmeek Mining Company was one of many small copper mining companies operating in the Keweenaw Peninsula between 1870 and 1920. They built the Ahmeek Stamp Mill on the western shore of Torch Lake in 1909 and added four additional stamp mill units in 1914.[1] The mill processed the ore that came from the Ahmeek Mining Company's mines as well as a few other small mining companies that did not have their own mill. A mixed pressure turbine (2000 KW) was installed at the Ahmeek Stamp Mill in 1916 to use the low-pressure steam exhaust instead of letting it go to waste.[2]
In 1917 a fire protection system was installed in the mill to protect the building and equipment from fire.[3]

In 1923 the Ahmeek, Allouez, Calumet & Hecla, Centennial, and Osceola mines consolidated to form the Calumet & Hecla Consolidated Mining Company, which meant that C&H now owned the Ahmeek Stamp Mill.[4] On March 14, 1925, there was a letter sent from the President of C&H, MacNaughton, to E. A. Baalack, who was a C&H employee, that the booster pump currently run on steam should be switched to electricity.[5]

---

1 *Calumet & Hecla Collection, Engineering Miscellaneous (4.4.48 (4.3.40)),* Box 139, Folder 025: "Flow Process Charts, Handwritten Notes, Critique of Ahmeek Mill-Study", Michigan Tech and Copper Country Historical Collections.
2 "Modernization of Lake Linden Power Plant Is Approved By Directors – Two years required to complete job", in Calumet & Hecla News & Views, March 1947 (pp. 3).
3 *Calumet & Hecla Collection, "T" Continued (4.4.40.4),* Box 038, Folder 009: "Tamarack-Osceola-Ahmeek Fire Protection", Michigan Tech and Copper Country Historical Collections.
4 Calumet & Hecla Annual Report: 1923, Michigan Tech and Copper Country Historical Collections.
5 *Calumet & Hecla Collection, Pumps (5.11.2.1),* Box 035, Folder 019: "Ahmeek Mill & Blueprints", Michigan Tech and Copper Country Historical Collections.

1930 was a big year for the Ahmeek Stamp Mill and the accompanying power facilities. The old power and boiler houses were torn down and replaced with new ones.[6] This work was contracted out to the Stone & Webster Engineering Company.[7] Along with these new buildings went new technology, such as an Ash Disposal System.[8] The new Ahmeek Power and Boiler houses went into commission in January 1931 and ran smoothly for the next few years.[9] The Ahmeek facilities again had an update in 1937 when the fire protection system was updated to provide ample protection for the buildings and equipment.[10] In 1938 the Ahmeek Stamp Mill housed eight stamps that could process 900 tons of material per day.[11]

This area was becoming a center for not only stamping but also for power during this time. In 1941 the Ahmeek boiler plant began providing the steam needed at the Tamarack Reclamation Plant because C&H decommissioned the Tamarack boiler plant.[12] For the next six years not much change happened at the Ahmeek Mill. Then, in 1947, two new ball mills were installed along with flotation units so the Ahmeek Mill could start participating in the secondary copper processing.[13] In January 1946 the Ahmeek Mill

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[6] *Calumet & Hecla Collection,* McNaughton: Alphabetical, A-Z (4.4.29 (4.3.22)), Box 073, Folder 51b or 52, 1 of 2: "Stone & Webster-Ahmeek Mill Power Plant", Michigan Tech and Copper Country Historical Collections.
[7] *Calumet & Hecla Collection, Ahmeek Mill (8.1.1.6),* Box 151, Folders 5-18: "Power Plant-Memorandum of Contract", Michigan Tech and Copper Country Historical Collections.
[8] *Calumet & Hecla Collection,* McNaughton: Alphabetical, A-Z (4.4.29 (4.3.22)), Box 073, Folder 51b or 52, 1 of 2: "Stone & Webster-Ahmeek Mill Power Plant", Michigan Tech and Copper Country Historical Collections.
[9] Calumet & Hecla Annual Report: 1931, Michigan Tech and Copper Country Historical Collections.
[10] *Calumet & Hecla Collection, "T" Continued (4.4.40.4),* Box 038, Folder 009: "Tamarack-Osceola-Ahmeek Fire Protection", Michigan Tech and Copper Country Historical Collections.
[11] Benedict, C. Harry, ". Steam Stamps hold their ground at Ahmeek Mill", in *The Engineering and Mining Journal,* Vol. 139, No. 12 (pp. 53-56).
[12] Calumet & Hecla Annual Report: 1941, Michigan Tech and Copper Country Historical Collections.
[13] Calumet & Hecla Annual Report: 1947, Michigan Tech and Copper Country Historical Collections.

power plant turbines were repaired and machinery in the boiler house was modernized.[14] In 1947 it is stated that the power for C&H was centered at both the Lake Linden and the Ahmeek Mill powerhouses.[15]

On November 12, 1954, a report was released called 'Report on Lightning Protection for the Electrical Transmission System of Calumet & Hecla, Inc.' which address the fact that many electrical outages have taken place due to lightning strikes, but it also addresses any changes that should be taken place at each sub-station or power plant location. Since the Ahmeek Power Plant was still fairly new at this time, all of the lightning arresters were new and in place and the report said that no changes were needed at the Ahmeek location.[16]

Then, on November 5, 1958, another report entitled 'Report on The Leaching of Ahmeek Mill Concentrates' by L.C. Klein attempted to give answers to questions about leaching Ahmeek Mill concentrates for production of copper powder and it covers "capacities of present leaching and distillation facilities; changes in leaching and distillation equipment necessary to adapt this equipment to the leaching of concentrates and distillation of the rich solutions produced; material handling; changes in leaching techniques; leaching solution control; types of concentrates that can be leached; and the control of impurities in the oxide produced. A rough estimate is also given for capital expenditures necessary and the cost of oxide production."[17] It also mentions what Torch

---

[14] "Turbines are Repaired" in Calumet & Hecla News & Views, January 1946 (pp. 7).

[15] "Modernization of Lake Linden Power Plant Is Approved By Directors – Two years required to complete job", in Calumet & Hecla News & Views, March 1947 (pp. 3).

[16] *Calumet & Hecla Collection,* "T" Continued (4.4.40.4), Box 038, Folder 022: "Report on Lighting Protection for Electrical Transmission System", Michigan Tech and Copper Country Historical Collections.

[17] *Calumet & Hecla Collection, Ahmeek Mill (8.1.1.6),* Box 085, Folder 015: "Leaching of Concentrates", Michigan Tech and Copper Country Historical Collections.

Lake water had in it during this period because tests of the water were done to see how it would react with the chemicals in the leaching process.[18]

In 1957 we see a note that says the Ahmeek Mill Flotation process was using Dow-Froth and not pine oil like the other flotation plants.[19] This is the only mention of this so far found, and may show a difference between the processes at the Lake Linden and Tamarack facilities compared to the Ahmeek.

Between 1959 and 1968 the Ahmeek Mill was also recovering copper from slag, tailings, and brick, apart from processing ore from mines.[20] This allowed the mill to stay alive when it would otherwise have been forced to shut down for a period of time. Between 1965 and 1966 there were pushes to increase the overall efficiency at the Ahmeek Mill and they even broke up the sections of the upgrade to Phases I, II, & III, but this project never went any further.[21] C&H was slowly loosing their Calumet Division as copper prices and demand for copper fell. April 14, 1967 saw an R&D Study on Sampling & Effluent Handling at the Ahmeek Mill by L. C. Klein come out which mentions where the waste streams came from and what different types of wastes could be.[22] This was meant to be a project that would take multiple outputs and narrow them down to just one, but with the

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[18] "Leaching of Concentrates"

[19] *Calumet & Hecla Collection, Bureau of Mines (5.7.1),* Box 166, Folder 019: "Ahmeek (Form 6-1178-A)", Michigan Tech and Copper Country Historical Collections.

[20] *Calumet & Hecla Collection, Ahmeek Mill (8.1.1.6),* Box 151, Folder 019: "Mill Return & Mill Yields", Michigan Tech and Copper Country Historical Collections.

[21] *Calumet & Hecla Collection, Ahmeek Mill (8.1.1.6),* Box 151, Folder 025: "Conversion of Mill Circuits for Increased Capacity and Proc. of Con. Ore", Michigan Tech and Copper Country Historical Collections.

[22] *Calumet & Hecla Collection, Ahmeek Mil (8.1.1.6),* Box 078, Folder 010: "Operation", Michigan Tech and Copper Country Historical Collections.

selling of the Calumet Division to Universal Oil Products in 1969, this project, along with the Ahmeek Stamp Mill and power facilities, were shut down for good.[23]

[23] Calumet & Hecla Annual Report: 1969, Michigan Tech and Copper Country Historical Collections.

<u>Ahmeek Stamp Mill Timeline – Emma Schwaiger</u>

From the Michigan Tech Archives & Copper Country Historical Collections

1908 or 1909: Ahmeek Concentrator was built by the Ahmeek Mining Company. 4.4.48 (4.3.40) Engineering Miscellaneous. Box 139 – Folder 25. 8.1.1.6 Ahmeek Mill. Box 78 – Folder 9.

1912-1920: Appraisals of buildings and equipment. 5.10.2.1 Insurance Appraisals of C&H's physical holdings–Reports to general manager. Box 207 **–** Folder 6.

1917: Correspondence about sprinklers and the fire protection system at the Ahmeek Mill. 4.4.40.4 "T" Continued. Box 38 – Folder 9.

Oct. 26, 1921: Document copied: C&H Mining Co – Lake Superior Water Mains. 4.4.40.4 "T" Continued. Box 38 – Folder 13.

March 14, 1925: Document copied: Letter from MacNaughton to E.A. Baalack – Booster pump currently run on steam should be switched to electricity. 5.11.2.1 Pumps. Box 35 **–** Folder 19.

1925: Worthington Pump & Machinery Corporation – Proposal: New Centrifugal Pump for the Ahmeek Mill. 5.11.2.1 Pumps. Box 35 **–** Folder 19.

1925-1931: Correspondence about the pumps for the Ahmeek Mill, C&H & Worthington Pump & Machinery Corporation about increasing capacity. 5.11.2.1 Pumps. Box 35 **–** Folder 19.

1926: Water in Torch Lake is low and they are having a hard time reaching the water from the Ahmeek pumps. 5.11.2.1 Pumps. Box 35 **–** Folder 19.

1928: C&H Electric Power Line to Tailings Plant at Ahmeek Mill + Map, Mineral Range Railroad permission to cross property with drawings of the proposed trestle along with the C&H electric line crossing**.** 8.1.1.6 Ahmeek Mill. Box 151 **–** Folder 3.

1930: Drawing showing the Tamarack Regrinding, Osceola, & Lake Mill #2, along with the pole line crossing for the C&H power line, map of the Ahmeek Stamp Mill showing the Boiler House & nearby companies. 8.1.1.6 Ahmeek Mill. Box 151 **–** Folder 4.

1930: Contracts for steam generating equipment between C&H and the Stone & Webster Engineering Co. 8.1.1.6 Ahmeek Mill. Box 151 **–** Folders 11-14.

1930: Contracts and Specifications for the Ahmeek Mill Boiler & Power Plant – Stone & Webster. 8.1.1.6 Ahmeek Mill. Box 151 **–** Folders 15-18.

- *Boiler House, Turbine Room, & Electrical Bay comprise the Ahmeek Mill Power Plant.*

1930-1931: Contract between C&H and the Stone & Webster Engineering Co. to furnish the proper equipment for the Ahmeek Power Plant. 8.1.1.6 Ahmeek Mill. Box 151 – Folders 5-10.

1937: Correspondence about changes in the fire protection system at the Ahmeek Mill. 4.4.40.4 "T" Continued. Box 38 – Folder 9.

1946-1956: Ahmeek Mill Production Statistics by year. 8.1.1.6 Ahmeek Mill. Box 78 **–** Folder 10.

July 26, 1950: Ahmeek Mill – Proposed Replacement of Steam Stamps & Rolls, Report by: J.J. Vitton. 8.1.1.6 Ahmeek Mill. Box 78 **–** Folder 11.

Dec. 15, 1951: Ahmeek Mill – Stage Crushing of Native Copper Ore with Nordberg Crushers, Report by: J.J. Vitton. 8.1.1.6 Ahmeek Mill. Box 78 **–** Folder 11.

1952: Ahmeek Mill – Proposed Addition, Preliminary Estimate. 8.1.1.6 Ahmeek Mill. Box 78 **–** Folder 11.

- *Proposed "in order to have one head as a standby unit to facilitate regular maintenance, extra ordinary repairs and take an occasional overflow of rock from the mines."*
- *Drawing 11238 – Ahmeek Mill, Flow Sheet.*
- *Ahmeek Mill – Proposed Head #9 (Steam Stamp) Addition to Building. Also shows the Old Boiler House.*

Jan. 30, 1952: Ahmeek Mill – Open & Closed Circuit Crushing of Native Copper Ore with 48" Nordberg Gyradisc Crusher, Report by: J.J. Vitton. 8.1.1.6 Ahmeek Mill. Box 78 **–** Folder 11.

1953-1957: Correspondence about how or when to upgrade the Ahmeek Mill (Crushing & Concentrator Plant addition in Lake Linden). Talk amongst C&H employees & Anaconda. 8.1.1.6 Ahmeek Mill. Box 78 **–** Folder 12.

1953-1968: Flow Process Charts – lists about where the rock starts and ends. 4.4.48 (4.3.40) Engineering Miscellaneous, 1953-1968. Box 138 – Folder 15.

1953-1968: Procedure for Mill Sampling and Accounting for Mine Yield. 4.4.48 (4.3.40) Engineering Miscellaneous, 1953-1968. Box 138 – Folder 15.

Dec. 8, 1956: Ahmeek Mill – Modernization or Replacement. By: C.H. Benedict. 8.1.1.6 Ahmeek Mill. Box 78 **–** Folder 12.

- *Benedict says the Ahmeek Mill is fine and with some equipment changes the mill could last for many years.*

Aug. 1, 1957: Calumet & Hecla, Inc. Mill Modernization Project. 8.1.1.6 Ahmeek Mill. Box 78 **–** Folder 12.

- *Report from a Task Force to study a mill modernization program.*
- *Includes some Ahmeek Mill Flowsheets.*
- *Map & Drawing of the proposed crushing & concentrator plants in Lake Linden.*
- *Page 22: "In order to furnish 60 cycle power for a new mill in the Lake Linden area it would be necessary to increase the 60 cycle generation at the Lake Linden Power Plant. Although the frequency changers presently are not fully loaded, by the time that a new*

mill could be completed, the projected load, as we see it today, would be above the capacity of the frequency changers.

To add just enough 60 cycle generating capacity at Lake Linden to take care of the new mill requirements would cost roughly $1,000,000. However, if the 60 cycle generation were to be expanded, I believe it would be wiser to put in a unit large enough to replace the present frequency changers and to supply the new mill load. The cost of power plant expansion for a unit of this size would be about $3,200,000. The cost to provide a transmission line from the Lake Linden plant to the mill site, erect a substation, and install main feeders up to each of the buildings would be an additional $250,000. These figures do not include any power or lighting installations within the mill buildings since it is understood that the Anaconda estimate has already allowed for these."

- *Drawing 11852 – New Mill & Crushing Plant, 6000 T/Day Crushing Plant, 12 Hour Operation, Flow Sheet, 1955.*

1957: Ahmeek Mill using Dow-Froth for flotation, not pine oil. 5.7.1 Bureau of Mines Box 166 – Folder 19.

1957: Insurance Appraisals for the Ahmeek Mill in Hubbell, MI. Buildings 1-5, Junction & Conveyor Houses, Fire Station, Oil House, & Pump House, Structural details and values, & Equipment details and values. 5.10.2.2 Insurance Appraisals of C&H, Incorporated's physical holdings. Box 207 – Folder 1.

Nov. 5, 1958: Document copied: Report on The Leaching of Ahmeek Mill Concentrates. By: L.C. Klein. 8.1.1.6 Ahmeek Mill. Box 85 – Folder 15.

- *Report will attempt to give answers to questions about leaching Ahmeek Mill concentrates for production of copper powder.*
- *Covers "capacities of present leaching and distillation facilities; changes in leaching and distillation equipment necessary to adapt this equipment to the leaching of concentrates and distillation of the rich solutions produced; material handling; changes in leaching techniques; leaching solution control; types of concentrates that can be leached; and the control of impurities in the oxide produced. A rough estimate is also given for capital expenditures necessary and the cost of oxide production."*
- *Mentions what Torch Lake water had in it during this period because tests of the water were done to see how it would react with the chemicals in the leaching process.*

1959-1968: Mill Returns – By month for the different mines, & amount reclaimed from slag, tailings, & brick. 8.1.1.6 Ahmeek Mill. Box 151 – Folder 19.

1960: Drawings of the Ahmeek Mill (showing Boiler House & Turbines), drawing of the Ahmeek Mill Tailings & Ash Discharge Line. 8.1.1.6 Ahmeek Mill. Box 151 – Folder 2.

1961: Proposal Letter by Fuel Economy Engineering Co. for a Pulverized Coal and Spreader Stoker. 8.1.1.6 Ahmeek Mill. Box 151 – Folder 20.

1963: Document copied: Ahmeek Concentration. 4.4.48 (4.3.40) Engineering Miscellaneous, 1953-1968. Box 139 – Folder 25.

1963-1967: Document copied: Ahmeek Power Plant – Ash Handling. 4.4.48 (4.3.40) Engineering Miscellaneous, 1953-1968. Box 139 – Folder 25.

1965: Appropriation Requisition for Intake Well Repairs & Drawing 12618 – Ahmeek Mill Pump House, Intake Well Floor & Screen Guides, Details. 8.1.1.6 Ahmeek Mill. Box 151 – Folder 22.

1965-1966: Conversion of Mill Circuits for Increased Capacity and Processing of Conglomerate Ore. 8.1.1.6 Ahmeek Mill. Box 151 – Folder 25.

- *Mechanical & Structural Engineering Dept. – Revision to Additional and Improved Milling Facilities, Phase II.*
- *Document copied: Ahmeek Mill Project M. C. Order Numbers. Phase I, II, & III.*
- *Mechanical & Structural Engineering Dept. – Additional Facilities to Reduce Tailings Losses in Conglomerate Ore, Phase III.*
- *Mechanical & Structural Engineering Dept. – Additional and Improved Milling Facilities, Phases I & II.*
- *Mechanical & Structural Engineering Dept. – Proposed Ball Mill 6a and Accessories Circuit.*
- *Mechanical & Structural Engineering Dept. – Additional & Improved Milling Facilities, Phase I & II.*
- *Document copied: C&H Meeting Minutes – Revision of Ahmeek Mill to Provide Greater Capacity.*
- *Document copied: C&H 17248 – Ahmeek Mill – Treating Conglomerate Mine Ore, Additional Equipment Required, Flow Sheet.*
- *Correspondence about feed rate on stamps between C&H & Milltronics w/ Proposal.*

October 20, 1966: Document copied: Ahmeek Mill, Mineral Processing – Flowsheet. By: J.J. Vitton. 8.1.1.6 Ahmeek Mill. Box 78 – Folder 9.

1966: Samples taken from the Ahmeek Mill for study – Copper Content in lbs/ton. 8.1.1.6 Ahmeek Mill. Box 78 – Folder 10.

1966: Document copied: Ash Pump at Ahmeek Mill. 8.1.1.6 Ahmeek Mill. Box 78 – Folder 10.

- *Letter between L.F. Engle & L.C. Klein talking about where the waste streams currently come from and about possibly narrowing it down so there is only one waste stream coming from the mill.*

1966: Estimates for refitting the Ahmeek Mill. 8.1.1.6 Ahmeek Mill. Box 78 – Folder 10.

1966: Tailings Bank Analyses. 8.1.1.6 Ahmeek Mill. Box 78 – Folder 10.

- *Mentions sampling being done on the sand bank on both the tailings side and the ash line side, to look at the total copper content.*

1966: A Limited Examination of the Ahmeek Mill, by: A.D. Kennedy & R.A. Campbell. 8.1.1.6 Ahmeek Mill. Box 78 – Folder 10.

- *Brief report on the Ahmeek Mill and opinions for better operation.*

1966: Cost Reduction Program. 8.1.1.6 Ahmeek Mill. Box 78 – Folder 10.

- *Sheet listing costs and a few ways of which they can reduce them.*

1966: Drawing 11898 – Gravity Flow Sheet – Ahmeek Mill 1956, rev. 1966. 8.1.1.6 Ahmeek Mill. Box 78 – Folder 9.

1966: Mechanical & Structural Engineering Department Estimate – New Turbine for No. 7 Generating Unit, Replace Existing Terry Turbine. 8.1.1.6 Ahmeek Mill. Box 151 – Folder 23.

1966: Metal Processing-Purchase & Appropriation Requisitions, Quotations. 8.1.1.6 Ahmeek Mill. Box 151 – Folder 24.

- *Purchase Requisition – To Replace Badly Worn Rough Classifiers #3 & #4 Unit at Ahmeek Mill, sent to Continental Sales & Equipment Co – Hibbing, MN*
- *Quotation – Krebs Cyclone, Krebs Engineers*
- *Appropriation Requisition – Krebs Cyclone Classifier*
- *Purchase Requisition – Ahmeek Mill-Washing #5 & #6 Units*
- *Receiving Report – Slurry Pump for Hydraulic Table Rejects – Denver Pump*
- *Receiving Report – Akins Simplex Classifier*
- *Purchase Requisition – Slurry Pump for Hydraulic Table Rejects – Denver Pump*
- *Appropriation Requisition – Slurry Pump for Hydraulic Table Rejects – Denver Pump*

1966-1967: Process & Practice Analysis Spillage Flowsheet Report – Bull Jigs & Pit Launder through Concentration Tank, to Flotation Area, & Ash Pump. 8.1.1.6 Ahmeek Mill. Box 78 – Folder 10.

Feb. 24, 1967: Metal Processing Automating the Fuel to Steam Stamps 1, 2, 4, 5 – Proposals. Proposal for Automating the Feed to Steam Stamps 1, 2, 4, & 5. Submitted by: B.C. Peterson, Vice-President, C&H, General Manager, Calumet Division. 8.1.1.6 Ahmeek Mill. Box 151 – Folder 26.

April 14, 1967: Document copied: R&D Study on Sampling & Effluent Handling at the Ahmeek Mill, L. C. Klein's Memo. 8.1.1.6 Ahmeek Mill. Box 151 – Folder 27.

April 14, 1967: Document copied: R&D Study on Sampling & Effluent Handling at the Ahmeek Mill, L. C. Klein's full document. 8.1.1.6 Ahmeek Mill. Box 78 – Folder 10.

- *Mentions where the waste streams came from and what different types of wastes could be.*

October 1967: Operating Manual – Ahmeek Power Plant & Lake Linden Power Plant, Master Copy, Assigned to: T. W. Knight – Step my Step Guide to Operation. 8.1.1.6 Ahmeek Mill. Box 151 – Folder 29.

1967: Appropriation Request – Maintenance & Alterations to Sampling & Effluent Handling System. 8.1.1.6 Ahmeek Mill. Box 151 – Folder 27.

- *"Work would provide for elimination of wastes from the mill at only two points instead of three. Materials leaving would be flotation tailings and unprocessed wastes. Unprocessed wastes would be deposited away from the general tailings pile where settled portion will* *be accessible to the dredge. This also would contribute to a more reliable sampling system and aid mill operations."*

1968: Document copied: Figure 1: Ahmeek Mill Flowsheet – Crushing & Gravity Concentration. 8.1.1.6 Ahmeek Mill. Box 78 **–** Folder 9.

1968: Document copied: Figure 2: Ahmeek Mill Flowsheet – Fines Concentration – Flotation. 8.1.1.6 Ahmeek Mill. Box 78 **–** Folder 9.

1968: Correspondence about sending the Ahmeek Mill Flowsheets & Flowsheet Description to the US Dept of Interior to help them further understand the processes. 8.1.1.6 Ahmeek Mill. Box 78 **–** Folder 9.

John Baeten

Tamarack Reclamation Plant Narrative

Starting in the 1870s Calumet & Hecla, along with mines such as the Ahmeek, Osceola, and Tamarack, sent the ore from its mines in Calumet to be processed at the stamp mills located at Torch Lake. The early technologies employed at these stamp mills consisted primarily of stamp batteries, which crushed the ore into particles, separating the copper metal from the mineral gangue. The copper would then be sent to a smelter for further refining, and the waste material, or tailings, were dumped into Torch Lake. Since the early milling technologies used by Calumet & Hecla failed to include such devices as regrinding machines, flotation units, and classifiers such as Wilfley and Dyster tables, a large percentage of marketable copper was laundered away from the mills in the form of tailings. Calumet & Hecla was fully aware that their milling process was inefficient and that thousands of tons of copper remained within the stamp sands at the bottom of Torch Lake. As the cost of extracting copper ore increased during World War I, Calumet & Hecla began devising plans to reclaim the stamp sands that were beginning to fill Torch Lake.

By 1914, Calumet & Hecla purchased property in Lake Linden and by 1918 they finished constructing a reclamation plant near the location of their two stamp mills there.[1] The reclamation plant at Lake Linden was designed to treat both amygdaloid and conglomerate tailings by means of ammonia leaching. The reclamation process at Lake Linden utilized a suction dredge to recover the tailings, which were then sent to a regrinding unit, consisting of ball mills. The reground

[1] Benedict, C.H. "Six-cent Copper from Calumet & Hecla Tailings", in *The Engineering and Mining Journal*, Vol. 117, No. 7, February 16, 1924 (pp. 277-284).

tailings were then leached in a bath of ammonia. By late 1918, an oil flotation unit was installed to further increase the recovery of copper from the stamp sands.

Around this same time period, Calumet & Hecla began purchasing many of the mining interests in the area, including the Tamarack and Osceola, and by 1923 merged with the Allouez, Centennial and Ahmeek mines to form Calumet & Hecla Consolidated Copper Company. In addition to now controlling most of the underground mines north of Hancock, Calumet & Hecla also owned the milling facilities and their adjacent stamp sands at Torch Lake, leading to the design of a second reclamation plant to treat the conglomerate sands from the Tamarack mill near Hubbell, Michigan. Construction of the Tamarack reclamation plant began in 1920, and the facility was completed in August of 1925.[2]

The Tamarack Reclamation Plant was designed as a smaller version of the Lake Linden plant, with a capacity of 850,000 tons of sands per year, recovered by a suction dredge of local construction.[3] Owing to its more contemporary construction, the Tamarack Reclamation Plant was fitted with an array of more modern equipment, consisting of devices such as separators, tables, conveyors, regrinding mills, settling tanks, and flotation and precipitation units.[4] By 1926, the Tamarack plant was running smoothly, with coarse sands being sent first to regrinding units and table treatment, and the finer tailings being sent directly to the

[2] "News by Mining District", in *The Engineering and Mining Journal*, 1920-1925, Vols. 110-119. From 1920 to 1925 progress on the construction work at the reclamation plant in Hubbell is frequently mentioned.
[3] The Mining News", in *The Engineering and Mining Journal*, 1922 and 1923, Vols. 114, 115.
[4] "News by Mining District: Calumet & Hecla Sees More Economical Production Ahead", in *The Engineering and Mining Journal*, 1924, Vol. 117 (pp. 68).

leaching and flotation units. In addition to reclaiming the stamp sands in Torch Lake, Calumet & Hecla also became interested in attempting to recover some of the copper contained in their smelting works' waste slag at Hubbell, which was also being dumped into Torch Lake, and by 1929 the Tamarack Reclamation Plant was regrinding and treating this slag by flotation.[5]

The Tamarack Reclamation Plant was efficiently operating three distinct treatment processes consisting of regrinding, leaching and flotation by 1931. The same year saw the facility achieve acclaim from the mining world for its centralized approach to reclamation, housing all three plants under one roof. The leaching plant within the Tamarack Reclamation Plant contained the largest structural features, consisting of six large (54 ft. in diameter) leaching tanks, while the flotation plant contained four large (40 ft. diameter) thickening tanks and associated mineral separating machines.[6] Although the Tamarack Reclamation Plant was recovering copper profitably, the Great Depression of the 1930s forced Calumet & Hecla to run only the larger Lake Linden plant for an extended period of time, idling the Tamarack plant for roughly 7 years. Calumet & Hecla continued dredging the Tamarack conglomerate sands from Torch Lake into 1944, but by the end of that year Calumet & Hecla shifted its focus to treating scrap materials as part of the effort to produce munitions for World War II.

The scrapping program and newly formed Secondary Department dominated activity at the reclamation plants into the mid-1950s, producing billets for

[5] "News by Mining District: C&H Reclamation Work May Have Eleven Years Left", in *The Engineering and Mining Journal*, 1929, Vol. 127 (pp. 930).
[6] Haskell, Robert M., "Flotation Practice: Calumet & Hecla", in *The Mining Congress Journal*, October 1931, (pp. 528-530).

Wolverine Tube and a variety of copper oxide compounds for agricultural uses. By 1956, Calumet & Hecla began dredging the plentiful Ahmeek stamp sand deposit within Torch Lake and sending the tailings to their Tamarack Reclamation Plant.[7] Calumet & Hecla worked the Ahmeek deposit into the late 1960s, with Calumet & Hecla employing upwards of 50 men within the Tamarack reclamation plant, the last functioning reclamation plant in the region[8]. In 1968, the Tamarack Reclamation Plant permanently closed, joining the idle Quincy and Lake Linden Reclamation Plants.

[7] "Annual Reports: Calumet & Hecla", in *The Engineering and Mining Journal*, 1956, Vol. 157, No. 8 (pp. 200).
[8] "Mining News", in *The Engineering and Mining Journal*, 1968, Vol. 169, No. 1 (pp. 129).

Tamarack Reclamation Plant Timeline:

Oct. 16, 1920: First mention of the Tamarack Reclamation Plant in E&MJ. Reports that, *"The site of the Tamarack reclamation plant is practically cleared of the old Tamarack stamp mill and equipment. Excavation for the flotation and leaching buildings are well under way."*

Nov. 26, 1921: Roughly a year later, Tamarack is once again promoted:
"*It is estimated that there are 12,000,000 tons of sand in the Tamarack conglomerate tailings in Torch Lake, assaying at 12 ½ lb. of copper to the ton. Calumet & Hecla plans to complete the reclamation plant there next summer, and the recovery of this metal will than begin. Though the deposit is not as extensive or as rich as that of the Calumet & Hecla proper, the copper can be recovered at a low cost and the plant investment will yield a large return."*

July 29, 1922: In 1922, C&H begins to describe the actual process that they plan to use at the Tamarack plant, including regrinding (likely by ball mills), washing (a step that I am not familiar with), leaching and flotation.

"Calumet & Hecla Resumes Construction of Torch Lake Re-treatment Plant – Work has been resumed on the construction of the reclamation plant on the Tamarack conglomerate sands, Torch Lake. Calumet & Hecla will push the project although its completion will not be possible before the spring of 1924. The plant will be designed to treat 850,000 tons per year, as compared with a maximum capacity of 1,500,000 tons for the Calumet & Hecla plant. There is approximately 12,000,000 tons in the Tamarack deposit, which averages by assay 12 ½ lb. of copper to the ton, 10lb. of which can be reclaimed. Costs under normal conditions are from 4 ½ to 5 c. per lb. The four processes used in reclamation are regrinding of the coarser sands, washing, leaching and flotation. The leaching and flotation will be practically one. The foundations are already in."

April 14, 1923: Further progress on the construction of the buildings is noted, as well as assumed monthly quantities of treatable material:
"The Tamarack reclamation plant, which will go into operation in the spring of 1924, should add approximately 800,000 lb. of refined copper per month to Calumet & Hecla production. Tamarack tailing assays an average of 2lb. less per ton than that of C.&H., and the capacity of the Tamarack plant will be a little more than half that of the Calumet. The greater part of the machinery and tank equipment of the Tamarack plant will be installed this summer, work on the buildings being about completed."

May 12, 1923: In addition to the completed structures, the machinery for the reclamation plant is now also on site. Plans to construct the dredge are under way.
"All equipment for the reclamation plant, which Calumet & Hecla is building on the Tamarack conglomerate tailing deposit in the Michigan copper district, is on the ground, and shipment of dredge parts will be made soon. The dredge will be assembled at the Calumet & Hecla drydock at Point Mills."

January 12, 1924: Work is still ongoing at the reclamation plant in early 1924. The assumed cost of reclamation has increased from the 1922 estimate. Additionally, this posting makes note of specific pieces of equipment being installed:
"Construction work in the new Tamarack reclamation plant, which will reclaim copper from the waste Tamarack conglomerate sand in Torch Lake, is proceeding. Installation of equipment involves the setting up of separators, tables, conveyors, regrinding mills, settling tanks, and flotation and precipitation units. Work on the dredge is well underway and the completion and operation of the entire plant is expected in the spring. Copper will be made for around 6c. per pound judging from the work done in the C&H plant."

May 3, 1924: A bit of a redundant post, although it does contain the first mention of the estimated longevity of the Tamarack sands, at 15 years:
"Work is proceeding on final stages of construction at the Tamarack reclamation plant of Calumet & Hecla Consolidated, in the Michigan copper district, and it will be ready for use this summer if needed. Ten pounds or better of refined copper per ton should be reclaimed from the waste sands or tailings of the old Tamarack conglomerate mill. It is estimated the deposit contains 12,000,000 tons of sand and operating at capacity it will take about 15 years to exhaust the supply. The capacity of the plant will be approximately 850,000 lb. of refined copper per month."

June 7, 1924: Construction of the plant is still not completed, and due to low copper prices, C&H plans to hold off on operating the plant until the price increases. However, this post does make note of the construction of a trestle from the sands to the plant, as a means of transporting the deposit to the facility, a feature that does not transfer to other reclamation plants in the region.
"Construction work is proceeding at Calumet & Hecla Consolidated's reclamation plant on the Tamarack conglomerate sands, in the Michigan copper district. The trestle for the launder from the outer edge of the sand deposit to the plant is being built, and in the interior of the plant itself the installation of equipment is well toward completion. The plant probably will not resume operation until the metal market strengthens."

October 4, 1924: Another slightly redundant post, but it does make mention of the construction of "a channel", which I assume to be a launder of some sort. This post also estimates an increase of 50,000 lb. of refined copper production from the May 1924 estimate:
The new Tamarack reclamation plant of the Calumet & Hecla Consolidated is nearing completion. A channel is being built into the shore plant, and installation of equipment is in its final stages. The entire project will be completed, it is estimated, in eight weeks. It has not been decided, however, when the plant will go into operation. This is dependent on the metal market, and there is no demand in sight for additional production. The plant, working at capacity, will recover approximately 900,000 lb. of refined copper per month from the Tamarack conglomerate sands, or about half the capacity of the Calumet plant."

February 7, 1925: Another fairly redundant post, but note that the estimated quantities of production and cost of reclamation keep changing. This new estimated production total is 200,000 lbs. per month lower than the October 1924 post. Also the cost of reclaiming the sands has increased almost double from what the 1922 estimate.

"Calumet & Hecla Consolidated's new reclamation plant on the Tamarack conglomerate sands, in the Michigan copper district, will be "turned over" on March 1 for adjustments. After a thorough testing, the plant will go into operation, probably April 1 or May 1. It will produce about 700,000 lb. of refined copper per month at an estimated cost of 9c. per lb.

The capacity of the plant is approximately three-eighths that of the Calumet plant. Tamarack sands are not as rich as those of the Calumet & Hecla, and consequently recovery of refined copper will be less and cost per lb. higher. It is estimated that there are 12,000,000 tons of sand in the Tamarack deposit, from which 120,000,000 lb. of copper should be recovered. On this basis, it will require about fourteen years to treat the entire supply."

May 2, 1925: The plant is still not yet operating, but a new estimate of the extent of the Tamarack deposit takes a nosedive from a lifespan of 14 years to 12 years.

"The new plant on the Tamarack conglomerate sands will go into operation soon. Its capacity is not quite half that of the plant on the Calumet & Hecla sands. It should produce around 700,000 lb. per month and continue this rate twelve years or more."

August 29, 1925: The reclamation plant is now in operation with positive results:

"A yield exceeding expectations is being obtained from the new reclamation plant of Calumet & Hecla Consolidated, in the Michigan copper district. Present rate of production is 900,000 lb. per month. The Calumet plant also is obtaining a higher yield than usual, production now being at the rate of 2,000,000 lb. per month, the largest in its history. This does not mean , however, that this high yield will continue. The respective dredges happen to be operating in sand bed areas rich in copper and the yield will vary as the dredges are moved."

April 3, 1926: This note contains a brief note on the operating practice of the plant as well as mention of the dredge employing suction recovery, rather than bucket line.

"*It is estimated that the Calumet deposit is good for twelve to fourteen years more, and the Tamarack deposit should last equally as long. Regrinding of the coarser sand, table treatment, ammonia leaching, and oil flotation are employed in the recovery of the copper, brining the total recovery of the metal content of the conglomerate lode as mined up to over 98 per cent. The sand is removed from the lake by means of a suction dredge."*

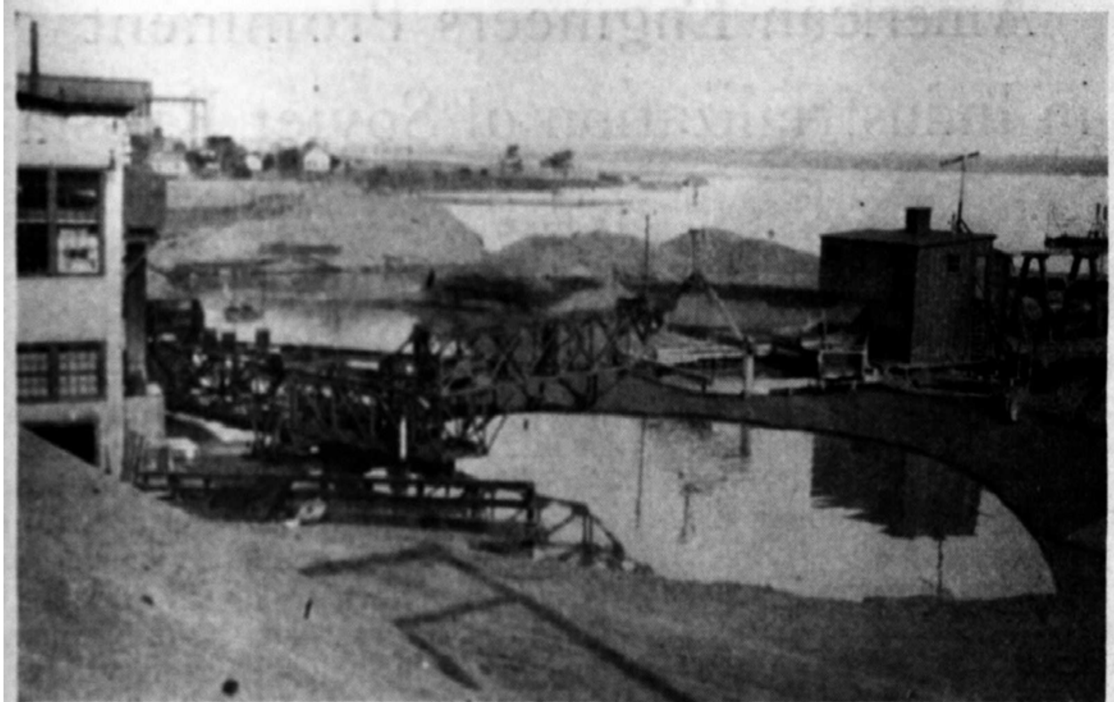
April 16, 1927: This post is a summary of production totals for the prior year and makes mention of the different consistencies of the sands recovered, either coarse or fine:

"There has been ample evidence of improvements in milling practice in the district by the recovery of 8,290,076 lb. of copper by table treatment of waste conglomerate sands at the Lake Linden and Tamarack reclamation plants of Calumet & Hecla Consolidated last year. The coarse sands were subjected to table treatment, and the fines to leaching and flotation. About 18,212,000 lb. was recovered through leaching, and 4,486,000 lb. through flotation. Results at the plants vary as new areas of sands are dredged. When deposits dumped into Torch Lake during the earlier years of Calumet & Hecla are encountered the yield is higher on account of the cruder methods of extraction employed in the earlier days. Sands deposited in later years contain considerably less copper, the losses decreasing as methods improved.
At the Lake Linden plant during last year, sand above the average grade was treated, and as a result a new high record of copper production was made in spite of a lower yield at the Tamarack plant which resulted through encountering a considerable amount of amygdaloid sand. For the two plants, 11.24 lb. of copper per ton of sand treated was recovered. An average yield of 10.49 lb. has been made since treatment of the sands was started at the Lake Linden plant some years ago."

April 21, 1928: Another summary of the previous years production, showing an increase in the leaching process.
"Results of operation of the company's Lake Linden and Tamarack reclamation plants during 1927 have been made public. These plants recover copper from the waste conglomerate sand. Costs decreased from 7.10c. a pound in 1926 to 6.63c. in 1927, and, of the copper recovered, 62 per cent was obtained through leaching, compared with 58 per cent during the preceding year. Total amount of copper reclaimed by the plants since they started in 1915 amounts to 187,392,000 lb. of refined metal. It is said that the production of reclamation plant is greater than that of any amygdaloid property in the Michigan copper district with the exception of the Ahmeek mine."

June 8, 1929: C&H estimates that the existing deposit at Torch Lake is more extensive than previously thought, and believe that the reclamation plants have enough conglomerate tailings to treat for an additional eleven years. This note also includes the only mention of direct dumping of slag into Torch Lake:
"*Copper tailing at Torch Lake, Mich., will keep Calumet & Hecla's reclamation plants in commission seven to eight years more, but it is possible it may be stretched to eleven years if the conglomerate sand is not contaminated too much by amygdaloid sand. In the rich Calumet sand bank, only an eight to ten months supply remains. Tailing in which there is more or less amygdaloid will have to be treated then. Both the Hecla and Tamarack sand deposits are contaminated by tailing of lesser copper content. The Calumet sand bank originally contained about 18,000,000 tons of high-grade tailing, which came from the mills in the early days when metallurgical practice was not so highly developed as now.*
At the Calumet & 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."

November 30, 1929: Photo showing the plant, no date given.



The Calumet & Hecla reclamation plant at the Tamarack mill

A 1931 report from the **Mining Congress** also gives a detailed description of the interior of the reclamation plant (see pics below):

"*The Tamarack plant has its three treatment operations of regrinding, leaching and flotation practically under one roof. Instead of Hardinge mills 8 ft. in diameter by 18 in. cylindrical length, the 8 ft. mills are 72 in. in length and about three times the capacity of the smaller mill with a better efficiency* (**basically the regrinding mills are larger here than they are at Lake Linden**). *The entire plant has a capacity approximately two-thirds that of the Lake Linden plant.*

The dredge and shore plant of the Tamarack do not differ materially from that at the older plant (**in Lake Linden**) – *in fact the dredge now being used at Tamarack was the one originally purchased for Lake Linden. Correspondingly, pumps and drag classifiers are similar in operation in both plants and the coarse material is likewise conveyed by means of a belt conveyor to the top of the regrinding plant. There are 18 of these 8-ft. mills and the coarse sand after grinding is treated on Wilfley tables. The table tailings are classified into coarse sand for leaching and fine sand for flotation.*

The leaching plant consists essentially of six tanks, 54 ft. in diameter by 12 ft. high, with the necessary storage facilities for solutions and circulating pumps for the conveying of the solutions. There is a single distillation unit in the leaching bay and one crane suffices for all purposes. The flotation equipment consists of four Dorr thickeners 40 ft. in diameter, four compartments each, and the thickened product is treated on a 16-cell minerals separation machine.

The entire plant is very compact but costs are slightly higher than at Lake Linden owing to the lower capacity, and also to the fact that at Lake Linden a large part of the overhead is shared by the operation of treating mine rock. The following figures will show the costs at the Tamarack plant for the year 1930. It was operating on reduced schedule to November 15, at which time all operations were suspended pending recovery in the demand of copper."

General administration , mine and mill	9.2c
Dredge and pontoons	8.3 c
Shore plant and belt conveyor	3.9c
Grinding	11.6c
Leaching	16.5c
Flotation	2.2c
Miscellaneous	7.3c

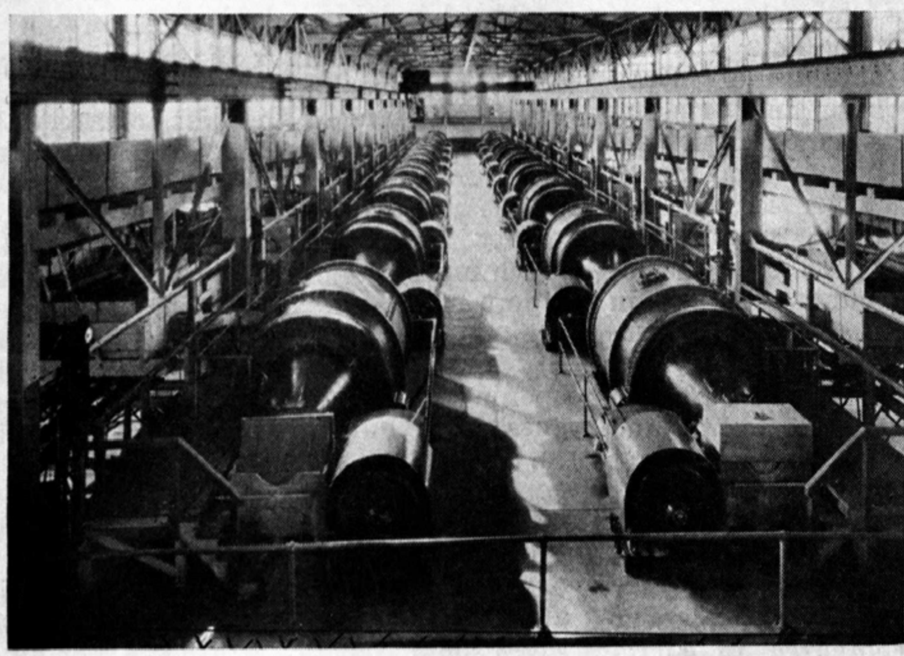


Figure 15. Regrinding plant, Tamarack reclamation plant.

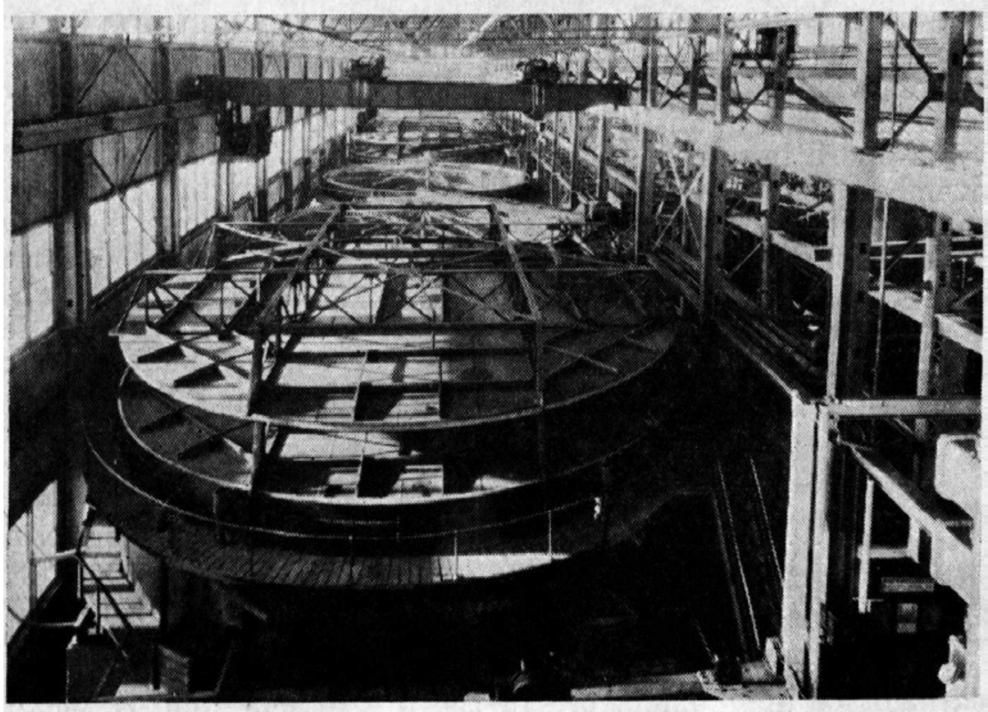


Figure 16. Ammonia leaching tanks, Tamarack reclamation plant.

September 1936: First note in a number of years regarding the Tamarack operation:
"The Tamarack reclamation plant remains idle, but at the Lake Linden plant the richest available sands are yielding a high percentage of copper."

July 1937: The Tamarack plant is back in operation and has been "reconditioned". No real note of what the reconditioning entailed.
"*Calumet & Hecla Consolidated has reconditioned its Tamarack reclamation plant, idle since the latter part of 1930. Tonnage of material available for treatment is estimated to be sufficient for five years' operation. At the Lake Linden reclamation plant, the remaining conglomerate sands will keep the plant in operation approximately seven years."*

April 1938: Post contains a summary of reclamation work for the prior year:
"*The reclamation plants at Lake Linden and Hubbell produced 20,398,000 lb. Average cost sold per pound was 7.59 c. and 6.63 c. respectively, not including depreciation and depletion….Tons of sand treated at the Lake Linden and Hubbell reclamation plants totaled 2,226,000, yielding 9.16 lb. of refined copper per ton. Dredges at both plants are working in areas necessitating inclusion of overlying low-grade amygdaloid sands in order to treat underlying and richer conglomerate."*

June 1941: Another yearly summary. This post mentions table treatment as a recovery option, which relates to the use of Wilfley tables, rather than leaching or flotation.
"Both the Lake Linden and the Tamarack plants operated throughout 1940 under normal conditions. Of the 1940 production 8,646,000 lb. was from table treatment, 17,251,000 lb. from leaching, and 3,785,000 lb. from flotation."

February 1943: The treatment of scrap copper is discussed in this month's issue of C&H News & Views:

May Expand Lake War Work Plant - "Treatment of steel clad with brass is now being successfully carried on at the Lake Linden Reclamation Plant. This material is the scrap which results from operations in the manufacture of small calibre jacketed bullets. Scrap is rolling into Lake Linden from all parts of the United States, from steel mills, ammunition makers and from Government ordnance plants. After the copper and zinc are leached off, the resulting steel is sold to steel makers. The zinc is lost but the copper is refined at the Calumet and Hecla smelter and soon finds its way back to war plants.

At the request of the Government, plans are being made to expand the Lake Linden plant in order to treat a much larger tonnage. Financing will be done by Calumet and Hecla. This company has the only plant in the United States capable of decopperizing clad steel scrap." (P. 1)

Selecting Scrap Requires Expert Knowledge of Metal – "Perhaps you thought the billet casting crew were commandos; the scrap gang looks even worse. You have read in the newspapers all about saving scrap, but did you ever wonder what becomes of it? Well, it is picked over and sorted out by scrap gangs all over the country. Sorting scrap requires careful men with experience and most of all a good nose for distinguishing metals. It isn't easy to tell what you are going to find in a car of scrap until you pick it over piece by piece.

Scrap can save the country – so they say. It can also make money for the company or it can lose money if not properly handled. You may not have realized that fifteen pounds of lead would be enough to spoil a whole furnace charge of copper. Almost every car of scrap has a lot more lead than that and it is up to the scrap gang to go after it and get it. They may have a carload or truckload or a box full of wash boilers, automobile radiators, broken radio sets or cigarette lighters; some can be melted and some must be leached. Nice clean scrap isn't often seen.

The Calumet & Hecla scrap gang has worked together for years. They are building up a new line of business for the company and one that may keep it alive some day, if there is a depression after the war is over. It is a dirty job but there is something interesting about it; something different is always happening.

To mention a few names: George Tornuff, Clifford Sibilsky, Albert Anderson, Leo Jolly, Henry DeRoche and Tony Brinkman would make good super sleuths for finding gold in any dirty mess you may have in the cellar. Tony Brinkman is in the scrap business for Uncle Sam just at present and doing all right." (P. 4)

March 1943: This post contains the first mention of the exhaustion of the conglomerate deposit, and includes a new flow sheet for the treatment of the less valuable amygdaloid deposit within the Tamarack tailings – note that the leaching process will be abandoned, leading to the empty leaching tanks we will see be used for scrapping.
"Calumet & Hecla's conglomerate tailing deposit at the Tamarack mill will be exhausted during the winter of 1943-44, according to the management. Adjacent is a large block of low-grade amygdaloid tailings. Preparations already are being made for the treatment of these sands, which will require a change from the present method. The flowsheet will include closed circuit grinding using Akins classifiers and Forrester flotation machines. No leaching will be necessary. Alteration of the grinding mills, motors, and foundations, and erection of new flotation units, are being carried on without interruption to present operations. It is felt that the gamble is justified, considering the importance of prolonging the life of the company."

June 1943: This month's issue of C&H's News & Views continues the discussion regarding scrapping, this time mentioning the removal of materials from the properties of Calumet & Hecla:

Scrap Drive Continues – "The wrecking of abandoned equipment around the company's property continues daily, adding to the splendid tonnage of vital scrap metal being contributed to the war effort. While the exact amount of scrap provided by the company must remain a war secret, it is certain that Calumet and Hecla had provided more of this valuable material than any other similar plant in the country.

After the old machinery has been removed from the buildings the stone walls are broken down, to make the premises safe. The breaking down of these walls is an interesting process, but also dangerous. The public is asked to remain at a safe distance while such operations are in progress." (P. 4)

September and October 1943: The scrapping of old equipment from the mines and facilities of C&H continues to dominate the activity at the reclamation plants and the content of C&H's News & Views for the later part of 1943:

September: **Scrap Shipments Mount** – "The razing of abandoned plant equipment continues here and increasing tonnage of steel, iron and non-ferrous metals is being rushed to mills for conversion into war materials. The exact number of tons shipped is a military secret, but it is permissible to state that C. & H. is making a record in this connection comparable with the best in the country.

Huge compressors, pumps and hoisting equipment, which once were the mechanical wonders of the country, have been broken into scrap, loaded into cars and transported to the mills. This project will continue until all the available scrap on C. & H. property had been salvaged." (P. 7)

October: **Tons of Scrap Steel Have Been Salvaged –** "Thousands of tons of steel and other scrap metal have been removed from the abandoned plants of the Company and shipped to War Industries.

The demolishment of these plants, and the handling of the scrap metal has been done by the Republic Steel Corp., of South Chicago. Fred Welsh, of Cleveland, has been in charge of this work for the past two years. He has employed as many as sixty men, all of which assist in razing buildings and removing scrap metal from the ruins. Considerable of this equipment is taken whole, so that is can be used again in the construction of new plants. All of the work is under the direct supervision of Superintendent Carl Fichtel." P. 4

October 1944: This post details the transfer of the leaching tanks from treating sand to scrap materials.
"The fact that sand is no longer leached does not mean that the leaching plant will not be utilized. For some time excess tank capacity has been used for treating copper-clad materials and other secondary copper products. The management expects that sufficient scrap of various kinds can be obtained in the open market to permit a larger rather than smaller production of copper oxide by the leaching process. The oxide is of particular value as a wartime commodity because it is used as a base for all the non-fouling, anti-barnacle paints necessitated particularly by activity in the warm waters of the South Pacific. The entire Tamarack production of oxide is being diverted by WPB to this use."

January 1945: Scrapping of copper becomes a new focus for C&H, and the organization of a "Secondary Department" to oversee this action has formed:
"A new department known as the secondary department, has been formed by Calumet & Hecla to purchase and treat scrap copper-bearing material. H.C. Kenny, smelter superintendent, will be in charge. Experiments conducted in the treatment of scrap led to the decision to enter this field. Scrap will be purchased in the market for treatment at the Torch Lake plants. This is another step in the company's policy of expansion, which includes the continued exploration for new ore bodies as well as research work leading to new uses of copper."

February 1945: More mention of the scrapping process, which at this time is focused on producing copper oxide, is mentioned.
"The entire copper oxide output of the Tamarack and Lake Linden leaching plants of Calumet & Hecla is going into the manufacture of barnacle-inhibiting paint and corrosion resisting paint used on ship bottoms by the U.S. Navy and Maritime Service. Recently a committee representing the U.S. Navy, the WPB and the manufacturers of ship-bottom paints visited Calumet and conferred with company officials in an effort to bring about increased production. The firms represented are the Metropolitan Refining Co., of Indiana Harbor, and the C.K. Williams Co., of Easton, PA., both of which are large users of copper oxide in the manufacture of paint."

April 1945: A detailed account of the Secondary Department, productions shifts at Lake Linden, and mention of the first representative for the Secondary unit.

"The secondary copper business, into which Calumet & Hecla Consolidated has gone on a large scale, is handled by a new department. Material is received at either the smelter or at the leaching plants for classification and handling. The department has smelter facilities open to it and has full possession of the Tamarack leaching plant. Additional equipment will be installed as conditions warrant. At the outset of the war, large quantities of secondary material began to come on the market in the form of gilding metal clad steel. The leaching plant at Lake Linden is treating such material almost exclusively. About the same time, copper oxide from the Tamarack leaching plant became an important factor in producing ship-bottom paint. When the Tamarack deposit of sands ran out, the company purchased secondary copper for making copper oxide. K.S. Williams, of Pittsburgh, formerly with the Copperweld Steel Co., is the new department's first direct representative in the field. He will supervise purchases made in the East and endeavor to secure a steady supply of secondary copper."

June 1945: More info on scrapping, specifically "steel scrap clad with gilding metal":
"Calumet & Hecla has in sight sufficient steel scrap clad with gilding metal to insure operation throughout the year. Last year nearly 12 million pounds of copper was recovered from this source by treating a total of 11,600 tons of bi-metal. The clean steel goes to steel plants"
"Calumet & Hecla has embarked on a comprehensive study of the possibility of using its idle leaching plant capacity for the treatment of various grades of copper bearing material in substantial tonnages. It is felt that if the investigation proves favorable, this field may have attractive postwar possibilities."

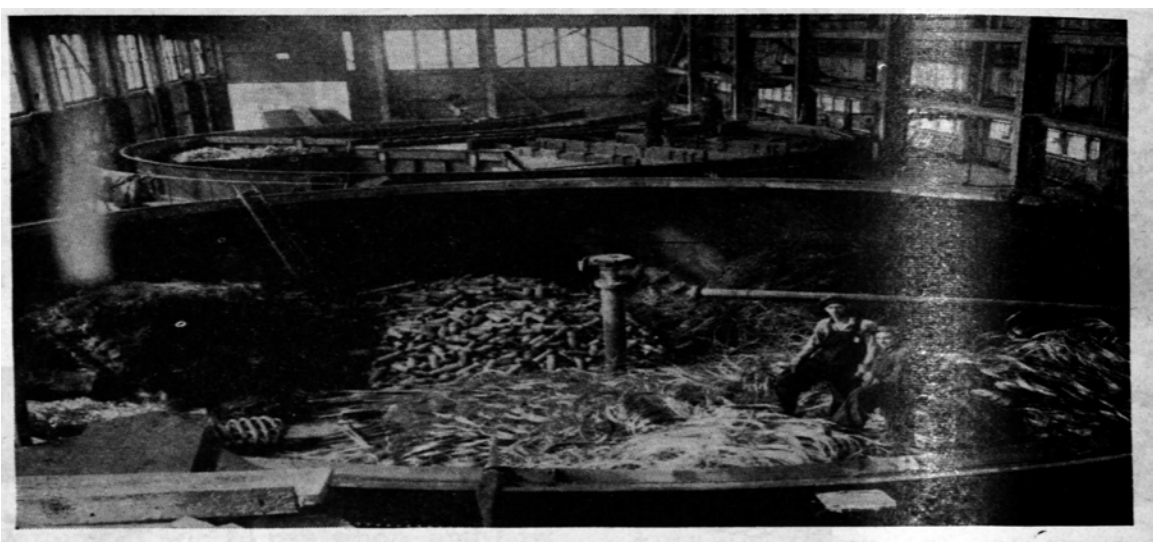
August 1945: This post describes the ongoing diversification of C&H's secondary department, including the production of copper hydrate. Percy Rowe is also identified as the chemist at the plant.
"Copper hydrate, a new product, is ready to be placed in commercial production by Calumet & Hecla, according to George L. Craig, research director of the company. This compound is a component part of copper naphtenate and Quartermaster departments of the U.S. Army for mildew-proofing fabrics and canvas used by the armed forces. Calumet & Hecla built a pilot plant, which has been in operation for more than two months, turning out copper hydrate for the tests needed to meet government specifications. Percy Rowe, chemist of the Tamarack reclamation plant, developed the process. A production unit is being installed at the latter plant. A monthly output of 100 tons is expected."
"Machinery will be purchased by Calumet & Hecla for drying mixed copper oxide for the paint trade. This oxide is in demand in marine circles because of barnacle-resisting qualities."

September 1945: This post details where the scrap is coming from, and what types of things are being scrapped.
"Most of the secondary copper handled by the Calumet & Hecla plants is of the industrial variety. Much of it comes from material scrapped in the making of munitions or damaged in service. Some of it consists of heavy cable such as is used in

wiring battleships. Telephone wire used by the Army Signal Corps is another fruitful source of secondary copper, some of it recovered from battlefields. Secondary copper activities are not limited to war-time scrap but also include such standard items as trolley wire and bars."
"Because the ammonia leaching process is particularly adaptable to mixed materials such as steel and copper or tin and copper, scrap of the latter kind is being treated at the Tamarack plant. Tinned copper wire, copper clad steel wire, and motor parts are being leached in quantity."

October 1945: This post contains the excellent picture below, plus some information of the Wolverine Tube's role in assisting with production the atomic bomb.
"With some of the secrecy unveiled in the development of the atomic bomb, it can now be reveled that copper taken from Calumet & Hecla mines aided greatly in the completion of the most devastating weapon used during World War II. This announcement came in a War Department realese as follows:

> *"That the Calumet & Hecla Consolidated Copper Co., through the Wolverine Tube division, contributed its share in the development of the atomic bomb has not been greatly known. It can be told, however, that the raw material from the company's mines and fabricated by the Wolverine Tube division played an important part in the manufacture of the devastating bomb that brought Japan to her knees."*



LOADING SECONDARY COPPER into tank for leaching at Tamarack reclamation plant at the Calumet & Hecla Consolidated Copper Co. plant. Subdivided tank in the background is used to treat lots separately. **See article on operations p. 89.**

November 1945: This post details the formation of the Lake Chemical Co., it's board, and what it plans to produce:
"Calumet & Hecla Consolidated Copper Co. and Harshaw Chemical Co., of Cleveland, have formed the Lake Chemical Co., organized to manufacture and distribute copper chemicals. This new company, a Michigan corporation, with its principal office in

Calumet, Mich., has an authorized capital of $300,000, divided into 3000 shares of common stock of par value of $100 per share. Calumet and Harshaw have each subscribed to 1,500 shares. Calumet will supervise the manufacture of he new products, and the sales will be handled by Harshaw.
A large section of Calumet & Hecla's Tamarack reclamation plant will be used for the operation f the new company. Equipment is being installed to manufacture copper oxychloride sulphate (a patented copper fungicide) and copper hydroxide. Copper hydroxide is used in making mildew-proofing compounds, insecticides, fungicides, and other products."

February 1946: C&H's reclamation plant treated an immense amount of scrap during WWII, and profited heavily from its ammonia leaching process:
"…The last of the clad-steel scrap for the Metals Reserve Co. has been treated and final returns have been made. Calumet & Hecla's ammonia leaching process was the only method that could be used to separate the copper and the steel. Approximately 60,000 tons of scrap were treated during the war, which returned 21,000,000 lb. of copper to the Metals Reserve Co. and 45,000 tons of scrap to the steel plants. The copper salvaged was in excess of the settlement with the original suppliers of the material.

The contract was an excellent one for Calumet & Hecla because it furnished employment to a large number of men during its two year's life and called for the payment of a fixed profit per ton over cost of treatment. In treating this material, the company's railroad crew handled a total of 4,800 cars."

September 1946: While the scrapping process seems to have been C&H's first successful diversion from metal mining, its subsidiary Lake Chemical, allowed C&H to throw its hat into another ring. During 1946 Lake Chemical began ramping up the production of chemicals. This post gives a detailed account of the chemical company's second unit and a visceral description of the copper oxychloride process:
"After many months of construction the second unit of Calumet & Hecla's Lake Chemical Co. went into production on July 15, making copper oxychloride (COCS) in commercial quantities. The unit consists of six lead-lined reaction tanks, each 7 ft. in diameter by 12 ft. high, in which scrap copper is reacted with chlorides and sulphates to form COCS. Approximately 16 hours are required to make the conversion, following which the blue slurry is pumped into one of two 18,000-gal. tanks. After blending and conditioning in the tanks, the slurry is dewatered on a large continuous Oliver filter, where the greater part of the liquid is separated from the blue solid. The wet cake is loaded on trays and dried in large truck-tray driers until the material is commercially free of water. The truck and tray driers will eventually be replaced with a large Proctor and Schwartz continuous aerofrom drier. Delivery of this unit will not be made before the end of the year. The dried product is treated in a micro-pulverizer to break up lumps and is discharged into a storage bin.

The so-called "fixed coppers" sprays and dusts, of which COCS is on type, are essential ingredients in many of the commonly used sprays and dusts for the control of a myriad of fungicidal growths on fruits, vegetables and flowering plants. The "fixed coppers" may be effectively used in combination with the well known insecticides – lead arsenate, calcium arsenate, rotenone, nicotine, sulphur, and DDT."

October 1946: When C&H produced copper wire, the process created a product called copper mud. As the company continued to strive to be as economically efficient as possible it devised engineering methods to recover the copper and profit off of the waste material. I found this post to be one of the more illuminating accounts regarding the extent that C&H went to diversify its operation:
"Calumet & Hecla Consolidated Copper Co.'s experience with diversified types of copper scrap has led to development of numerous treatment processes whereby undesirable impurities in or associated with scrap are separated from the copper, leaving the metal in a form suitable for direct smelting into high-conductivity commercial grades. The increasing use of such methods has made it possible to for the company's secondary department to purchase and handle larger and larger tonnages of materials previously not considered desirable for treatment at the smelter. These processes are delivering million of pounds of copper to the furnaces.

The latest addition to this group of processes is one which makes it possible to treat "copper mud" a waste product resulting from the drawing of copper wire. The material as received is a pasty mixture of fine copper, oil, grease and floor sweepings, having an average copper content of 25 percent and a combination of animal, vegetable and mineral oils of approximately 40 percent. As received, it is not suitable for direct furnacing, due to the high percentage of fat and water, but after months of experimenting, a procedure was worked out which recovers copper in a highly concentrated, useful form and the fat byproducts as well.

The processing includes a large lead-lined digester, filters, grease-accumulation tanks, copper-recovery tank, and a 10,000 gal. storage tank for grease. Installation work was started in June and production on a limited basis began in mid-August. The unit is operating continuously. The copper thus recovered runs approximately 75 percent metal and is suitable for direct furnacing with other concentrates. The fat is reclaimed as a semi-clear liquid and is accumulated in 8,00 to 10,000-gal. batches (40,000 to 60,000 lb.) for shipment in than cars."

November 1946: This is the first post which provides employment numbers for the secondary department, as well as describing some of the progress at the company's foundry at Hubbell:
"…Calumet & Hecla has organized a secondary copper department , employing 108 men, and is treating large tonnages of scrap copper.

In conjunction with the Harshaw Chemical Co., of Cleveland, the Lake Chemical Co. was organized in 1945 and located at Hubbell for the purpose of manufacturing and selling chemicals. The company has embarked on the commercial foundry business and is using its excess foundry capacity to make castings for mid-western concerns. The company is about to set up a new department for the manufacturer of detachable drill bits for its own use and for sale in a large part of the United States. The lands owned by the company are being rapidly developed for resort purposes."

January 1947: The C&H foundry seems to be expanding its operations during the early part of 1947, producing products for local mills as well as company's outside

the area. This post also mentions the first shipment of fat sent to Chicago for the soap making industry:
"Calumet & Hecla foundry is one of fewer than a dozen plants in the United States that have been licensed by the International Nickel Company Inc. to make the patented wear-resisting iron known as Ni-Hard. This nickel-chromium iron was developed for use where wear resistance is important. Calumet & Hecla's experience with the metal has led to its adoption exclusively for parts such as ball mill liners, pump shells, impellers, stamp shoes, and other castings that are subjected to conditions under which ordinary irons fail in a matter of weeks. Ni-Hard is only one of several types of irons produced by the foundry. A large tonnage of soft, gray iron is required in Calumet & Hecla's own operations for hundreds of replacement parts. The foundry also makes substantial quantities of "white iron" grinding balls for use in the stamp mills at Lake Linden, Ahmeek, and Tamarack; aluminum castings; brass and bronze bearings and bushings."

"Calumet & Hecla has shipped the first tank car of byproduct fat recovered in its plant for the treatment of spent wire-drawing lubricant. Both fat and copper are reclaimed from this waste material. The shipment went to the Darling & Co. in Chicago. The acute shortage of raw materials for producing soap and other fat products has provided an attractive market for the type of material being recovered by the company's secondary department."

February 1948: C&H has fully embraced its role as a producer of agricultural supplies, and has entered the realm of biocides and fertilizers:

"Investigations sponsored by Calumet & Hecla Consolidated Copper Co. are in progress in Florida to determine the value of copper oxides for agricultural applications.

Dust mixtures containing copper oxide are being examined by the Potato Research Laboratory at Hastings; dusts, sprays and fertilizers by the Citrus Experiment Station, Lake Alfred; fertilizers and pasture treatment by the Everglades Experiment Station, Belle Glade; soil treatment at the Gainesville Station on grain crops, and fertilizer and pasture treatment by various independent researchers.

Copper is required for normal plant growth to provide adequate yields, and is essential to the production of grains, such as oats and barley. These grains do not ordinarily "head out" under growing conditions in Florida unless copper is added."

April 1948: The reclamation plant at Tamarack has been slightly modified to include machinery tailored specifically for making copper oxide. This post also includes mention of producing "clinkered or coarse particle", which was used in the production of batteries:
"At the Tamarack reclamation plant of Calumet & Hecla Consolidated, an addition to the mixed oxide plant for the production of cupric oxide has been completed. The relatively small, but carefully planned installation makes it possible to add a new product, copper oxides, to the line of Calumet & Hecla. The equipment consists of automatic feeds, conveyors, receivers, a roasting furnace, and a pulverizer.

Cupric oxide is a finely divided powder which is ideal for chemical purposes, and for use in ceramics, where a rapid and uniform dispersion of coloring agent is desired.

Research is being conducted to provide clinkered or coarse particle for the use in the manufacture of primary batteries. This is one of the few important uses where a large particle is desirable because battery plates of pressed cupric must be porous and porosity depends on a coarse structure.

Sales will be confined to a few large customers , who will resell it to the industrial field. If primary battery manufacturers can use clinkered or coarse particles for making plates, sales probably will be made direct to them."

June 1948: This post gives a spatial account of the dispersal of copper oxide from C&H's plant to farmers across the United States.

"The company's copper hydrate plant was expected to operate at near capacity in May, and it is indicated that continuous operation may be justified. Several encouraging new commercial applications of copper hydrate have been developed, and interest renewed in copper soaps for mildew-proofing and wood preservation."

"Calumet & Hecla's agricultural research program now includes 38 individual projects in Florida. Copper oxide is being extensively tested in plant feeding, both as a constituent of fertilizers and in nutritional sprays, on pasture grasses, cover crop, oranges, grapefruit, sugar cane, snap beans, escarole, grains, potatoes, and celery. The results obtained on Florida plantings during the past winter will be carried out into other states during the summer. Use of copper in various types of soil is currently recommended for certain crops by the agricultural experiment stations in Florida, Georgia, North Carolina, New York, Indiana, Wisconsin, New Jersey, Oregon, and Michigan."

July 1948: A brief post mentioning the installation of a bailing machine used to compress loose scrap for easier handling during and after the leaching process:

"Calumet & Hecla has installed a hydraulic bailing press in its smelter yard to bale copper-clad steel scrap before leaching. This will save many hours in handling the scrap in and out of the leaching tanks to the railroad cars, and will double the tonnage put into the leaching tanks. Certain kinds of copper scrap also can be compressed into convenient size bundles for charging into the smelter furnaces."

August1948: Another brief post describing C&H's attempt to again profit from waste, this time the reclaimed conglomerate sands:

"Thousands of tons of tailings, stamp sand dumped into Torch Lake, Houghton County by Calumet & Hecla, have been the subject of investigation for some time to determine whether they have industrial value after the removal of copper. The 2 types of tailings, conglomerate and amygdaloid, are in separate banks. Amygdaloid has been used locally for concrete. It is the hardness and red color of the conglomerate sands that may make them useful. Though no substantial market has been found, tests have been made for such purposes as grinding wheels, polishing compounds, enameling frits, and roofing granules. Samples varying from small 5-pound lots up to a 50-ton carload have been shipped to users."

December 1948: Another post regarding the production of agricultural chemicals, this time oxychloride sulphate. This post also includes production estimates:
"Calumet & Hecla has resumed the production of oxychloride sulphate (C-O-C-S) Oct. 11. The plant will be operated continuously until July 1, 1949. The agricultural market is seasonable, and in most areas copper fungicide are not used during the fall months. Carload shipments were started late in October. Several months will be required to provide sufficient stocks for the California and Florida markets. The plant is scheduled to produce approximately 2 million pounds of C-O-C-S during the 1948-1949 season."

January 1949: This is a complex post related to the temporary shut down of the Tamarack plant, the temporary preservation of the now idle Lake Linden reclamation plant, and the promotion of the innovative uses for reclaimed conglomerate sand:
"In cooperation with Poor & Co. of Chicago, Calumet & Hecla Consolidated Copper Co. is instituting an experimental program which may eventually lead to a new business in the Michigan copper district. Poor & Co. has been investigating at its Waukegan, Ill. Laboratory for the use of finely ground conglomerate sand as in abrasive in buffing bars, deburring compounds and liquid abrasives. These items are widely used by the metal-finishing industry in preparing products for planning.

Poor & Co.'s facilities, however, are not sufficient to permit large-scale commercial testing. An arrangement now has been made for Calumet & Hecla to produce about 150 tons per month of finely ground conglomerate sand for shipment to Waukegan for blending and testing, on a commercial basis. If the tests prove successful, consideration will be given to equipping a plant at Lake Linden for production of the matrial on a commercial basis.

To produce the necessary dried conglomerate sand, the copper-oxide drying and bagging equipment at the Tamarack reclamation plant probably will be used."

"The secondary leaching department of Calumet & Hecla's Tamarack reclamation plant has been shut down temporarily. The company has been unable to sell copper oxide as fast as the plant can produce it and has a large amount of bagged copper oxide on hand."

"Calumet & Hecla has announced that it will not dismantle or scrap equipment and buildings of the Lake Linden reclamation plant, which was recently shut down because of the exhaustion of the conglomerate tailings. It may be possible to utilize the facilities for other products."

February 1949: Another detailed post which provides specific byproducts of C&H, and the shutdown of the Lake Linden reclamation plant:

"*Calumet & Hecla's foundry has been modernized. It will supply the company needs and do custom work. Eventually the foundry and machine shop will be coordinated so that a large number of rough and finished products can be sold. Other byproducts of C&H are copper hydrate, copper oxychloride and copper oxide, made in cooperation with Lake Chemical Co. Still another which is now being produced in a* *quantity permitting it to be distributed outside of the company's operations is the Liddicoat one-use drill bit.*

The copper oxide is already being marketed in large quantities. This product has proved satisfactory in the agricultural industry, particularly in the Florida fruit and vegetable belt. It is used as a spray to control fungi, as fertilizer amendment, and in feeding cattle.

George L. Craig, of the company's staff, has been appointed director of the secondary industry, in charge of sales and research."

"Part of Calumet & Hecla's reclamation plant at Lake Linden has been shut down, including the regrinding plant, due to the exhaustion of coarse tailings. It has been one of the most profitable of the Calumet & Hecla properties for over 30 years. Part of the plant including dredge, is being used to recover copper from slimes which had been sloughed off from the shore plant pool during clean-up operations. Between 30,000 and 40,000 tons of slime per month is being treated, or about a third of the average output of the entire plant when treating rough sands. Quantity of slime available ranges from four to six months' supply."

April 1949: First mention of the newly formed Prozite Co., organized to market the reclaimed conglomerate sands, as well as the resumption of work at the Tamarack plant:
"The Prozite Company has been organized by Calumet & Hecla and Poor & Co. of Chicago, to make buffing and polishing compounds from conglomerate copper sands.

The necessary equipment will be installed in the Calumet stamp mill at Lake Linden and the products will be manufactured by Calumet & Hecla. Poor & Co. will handle the sales. Officers and directors of the Prozite Company are: cahirman of the board, F.A. Poor; president, E.R. Lovell; vice presidents, A.E. Chester, P.W. Moore, A.H. Wohlrab; secretary and treasurer, W.B. Devlin. Directors will comprise the officers, also A.E. Peterson and George L. Craig of Calumet."

"Production of mixed copper oxide has been resumed at C&H's Tamarack leaching plant. The plant was down for three months. Supplementing several large orders from industry, others have been received for agricultural applications in Florida. In recent weeks, several cars of oxide have been shipped from the Lake Linden plant to the Tamarack plant to be dried and bagged."

February 1950: This is a slightly redundant post, but it makes note of the resumption of scrapping by C&H:
"After a lull of several months, Calumet & Hecla's secondary department is active again. Copper bearing scrap is purchased throughout the United States and shipped to Hubbell, where the copper is reprocessed and refined. The company's chemical department also is producing different copper oxides and hydrates for nationwide consumption."

March 1950: Lake Chemical is now producing a number of products, and C&H is exploring the expansion of its Wolverine Tube unit:
"…Mr. (E.R.) Lovell says progress is production and sales is being made in Lake Chemical, a subsidiary; in the secondary department; in industrial and agricultural

copper oxide; in the manufacture of Liddicoat underground drill bits; Prozite, a polishing compound molded into bars for use in metal work, and in production of commercial castings in the company's foundry. The creation of new products has created work for 400 men.

Both the Wolverine Tube division in Detroit, and the new tube plant in Decatur, Ala., are doing well, according to Mr. Lovell. New business is being sought by enlarging the sales force and getting additional warehouses throughout the country. Foreseeing keen competition in the sale of tubing, Calumet & Hecla is considering the manufacture of aluminum, steel and plastic tubing, in addition to copper. The Rosenquist elecro-formed tube is being produced in large quantity."

August 1956: This is the first mention of the Tamarack plant since 1950:
"Calumet & Hecla, Inc. produced some 27-million lb. of copper from Calumet Division. Major project was the unwatering of the Osceola lode. Mining started on lower levels at No. 13 shaft. No. 6 was about 70% unwatered. Production of copper from Tamarack reclamation Plant continued. Although Tamarack sands have not been exhausted, reclamation was started on Ahmeek bank sands to keep output high."

May 1957: The Tamarack plant seems to have shifted from scrapping to treating the Ahmeek bank sands:
"….In Michigan the company has nine shafts in operation and is developing ore reserves in several other locations. Calumet produced 37,813,735 lb. of copper in 1956. Production increased at Tamarack reclamation plant. And over one-million tons of tailings were processed from the Ahmeek bank, which has about ten more years production at present rate."

August 1960: A brief post providing production statistics from the mines and the Tamarack reclamation plant:
Calumet & Hecla, Inc. produced 15,876 tons of copper in 1959 from its mines in the Calumet area in addition to over 1500 tons from its Tamarack reclamation plant on Torch Lake."

January 1968: This is the first and last mention of the Tamarack reclamation plant, which was employing 50 people at the time:
"The Calumet Div. of Calumet & Hecla Inc., at the end of November, suspended operations of its Tamarack copper reclamation plant near Hubbell. The facility reclaimed copper from stamp sand dredged from Torch Lake.

A company spokesman said that it was no longer economical to attempt to get copper from the sand. But he added that stamp sand from other locations would be studied to determine profitability and thereby enable resumption of operations at the plant.

It is reported that 50 employees of the reclamation operation have not been laid off immediately and might be transferred to other Calumet & Hecla operations.

The Tamarack plant was the last reclamation project in the area. The Quincy Mining Col closed its smelter last spring when the operation became unprofitable because of stamp sand depletion."

Lake Chemical Narrative

During World War I, Calumet & Hecla began to shift some of its attention away from traditional mining and milling into research, materials science, and chemical engineering as the company strived to attain higher levels of engineering efficiency as it coped with an unfriendly copper market and competition from the burgeoning open-pit mines of the West. A longstanding inefficient practice of Calumet & Hecla was the milling of its copper ore at Torch Lake, where large amounts of native copper were discarded into Torch Lake in the form of tailings. To combat this waste, Calumet & Hecla employed new classifying equipment within its mills, and began to retreat the copper-rich tailings through a leaching process at its reclamation plant at Lake Linden. The leaching process consisted of retreating the tailings, which after being ran through a series of classifiers, were dumped into ammonia-filled leaching vats, where, after a number of hours, the copper in the tailings became dissolved into a solution. Next, the copper-ammonia solution was distilled, where the ammonia vapor was recovered and recycled, and the copper solution was precipitated into an oxide, which could later be fed to the smelter.[1]

While the leaching process introduced a more sophisticated degree of metallurgical engineering to the Calumet & Hecla toolbox, the production of copper oxides was not a new occurrence at Torch Lake, where copper oxides were produced simply from milling, where the crushed ore became exposed to oxygen and after time, began to decompose, forming a thin crust of copper-oxide around the

[1] Leisk, R.D., "Hydrometallurgical Treatment of Michigan Copper Tailings", in Metallurgical & Chemical Engineering, Vol. 13, April, 1915 (pp. 233-234).

surface of the crushed ore. The treatment of tailings by Calumet & Hecla at its reclamation plant at Lake Linden, and later at its reclamation plant at Hubbell, continued to send the reclaimed tailings first to the leaching vats, and then to the smelter up to the early 1930s, when C&H faced with another economic downturn due to the Great Depression, began to explore more extreme diversification schemes then ever before.

As a means to combat the food shortage created by the Great Depression and the Dust Bowl conditions throughout the Great Plains, the government and private enterprise began to explore soil science and invest in the use of fertilizers to help barren farms become fertile. Since copper is a common ingredient in both fertilizers and fungicides, Calumet & Hecla began shipping samples of cupric oxide to a handful of companies in the Midwest and western United States, including large shipments to The Harshaw Chemical Company of Cleveland, Ohio.[2] In addition to agricultural uses, copper oxides were used in a number of other industries during the 1930s onward, such as dyes for ceramics, paints, and synthetic materials like rayon, and Calumet & Hecla sought to have their mixed copper oxides included in all of them. From 1934 to 1944, Calumet & Hecla shipped over 50 million pounds of cupric and mixed oxides to manufacturers throughout the United States.[3] With the United States becoming involved in World War II during December of 1941, the

[2] "Cupric Oxide Shipments" from *The Calumet & Hecla Collection, President's Office Alphabetical* (4.3.30), Box 084, Folder 001: "Oxide – Copper", Michigan Tech and Copper Country Historical Collection.
[3] "Cupric Oxide Shipments"

government began demanding barnacle-inhibiting and corrosion resisting paints to be used for coating the bottoms of ships operated by the U.S. Navy.[4]

In addition to the cupric oxide business, Calumet & Hecla was also becoming heavily involved in the procurement and refinement of scrap metals, creating a "Secondary Department" in January of 1945.[5] That same year, Calumet & Hecla partnered with The Harshaw Chemical Company to create the Lake Chemical Co., organized with the "purpose of engaging in the manufacture and sale of Copper Oxychloride Sulphate and Cupric Hydroxide, and such other copper chemicals as may be determined upon at a later date."[6] Lake Chemical was established within Calumet & Hecla's Tamarack Reclamation Plant, and the responsibilities of the company were divided with C&H overseeing all aspects of production and Harshaw responsible for the sale and distribution of the various copper chemicals.

By September of 1946, Lake Chemical began to expand, installing equipment for a second unit to produce larger quantities of copper oxychloride (COCS) to be used in a variety of air borne insecticides. This second unit consisted of:

"*six lead-lined reaction tanks, each 7 ft. in diameter by 12 ft. high, in which scrap copper is reacted with chlorides and sulphates to form COCS. Approximately 16 hours are required to make the conversion, following which the blue slurry is pumped into one of two 18,000-gal. tanks. After blending and conditioning in the tanks, the slurry is*

[4] "C&H Urged to Produce More Copper Oxide in Leaching Plants", in *The Engineering and Mining Journal*, Vol. 146, No. 2 (pp. 165-166).
[5] "C&H Enters Secondary Metal Field", in The Engineering and Mining Journal, Vol. 146, No. 1 (pp. 114).
[6] Internal Correspondence, from *The Calumet & Hecla Collection, Corporate Records* (8.3.2.2), Box 022, Folder 001: "Articles of Incorporation, Minutes of Board Meetings", Michigan Tech and Copper Country Historical Collection.

dewatered on a large continuous Oliver filter, where the greater part of the liquid is separated from the blue solid. The wet cake is loaded on trays and dried in large truck-tray driers until the material is commercially free of water. The truck and tray driers will eventually be replaced with a large Proctor and Schwartz continuous aerofrom drier."[7]

From 1945 to 1956 Lake Chemical produced commercial quantites of COCS, Copper Hydrate and Tri-Basic Copper Sulfate (TBCS), totaling 30,666,108 pounds of COCS, 3,928,894 pounds of copper hydrate, and 1,573,498 pounds of TBCS.[8] This same time period saw Lake Chemical issuing research grants to a number of Universities and Agricultural Research Stations, such as The Florida Agricultural Experiment Station, The Ohio Agricultural Experiment Station, Purdue University's Agricultural Experiment Station, New York State College of Agriculture, Michigan State, University of Minnesota, and West Virginia University amongst others related to experiments with copper oxide as a fertilizer and the use of copper as an effective fungicide.[9] The experiments proved for the most part to be futile, as the copper chemicals shipped from Lake Chemical were generally considered to be subpar when compared against other fertilizers or fungicides.

While Lake Chemical continued to produce and ship large quantities of COCS and copper hydrate into 1956, production of TBCS appears to have been nearly

[7] "Second Unit of Lake Chemical Co. Producing COCS", in *The Engineering and Mining Journal*, Vol. 147, No. 9 (pp. 118-119).
[8] "Lake Chemical", from *The Calumet & Hecla Collection, Corporate Records* (8.3.2.2), Box 022, Folder 001: "Articles of Incorporation, Minutes of Board Meetings", Michigan Tech and Copper Country Historical Collection.
[9] Correspondence, from *The Calumet & Hecla Collection, Corporate Records* (6.3.4), Box 200, Folder 021: "Memorandums of Agreement", Michigan Tech and Copper Country Historical Collection.

discontinued by 1954. From the mid 1950s on, the research department at Lake Chemical explored a wide array of avenues into which their copper chemicals could align, ranging from livestock feed to catalytic converters. Due to a decline in sales, and the decreasing quality of their product, Lake Chemical dissolved in 1965. Calumet and Hecla absorbed all of Harshaw's interests in the company, and continued making copper chemicals up until the late 1960s. In 1968 the Tamarack Reclamation Plant officially, and presumably so too did the last vestiges of Lake Chemical.

John Baeten

Lake Chemical Timeline

This timeline covers the history of The Lake Chemical Co., a company joint-owned by Calumet & Hecla and The Harshaw Chemical Co. from 1945 to 1965. Prior to 1944, both Calumet & Hecla were producing copper chemicals, such as copper oxide and cupric sulphide, however with the merger of the two corporations, the production and distribution of copper chemicals was extended to a scale greater than if undertaken alone. Calumet & Hecla was responsible for the Lake Chemical Co.'s production facility, which was operated located at Hubbell, Michigan within the Tamarack Reclamation Plant. The Harshaw Chemical Co., based out of Cleveland, Ohio oversaw the sale and distribution of copper chemicals used primarily for agricultural operations and as an algicide for ship bottoms, but also refined the copper chemical shipments from the Lake Chemical Co. and converted them into various weapons-grade fuel for World War II. The relationship between Calumet & Hecla and The Harshaw Chemical Company appears to have been forged around 1934, when Calumet & Hecla first recorded shipping over 125,000 lbs. of Cupric Oxide to Harshaw's plant in Cleveland. In 1965 the Lake Chemical Co. dissolved, and Calumet & Hecla absorbed all of company from The Harshaw Chemical Co., and continued to produce copper chemicals for the next few years.

August, 1944: In an internal letter between Craig and Lovell of Calumet & Hecla, the production of C-O-C-S is discussed, along with the installation of a production plant within one C&H's existing facilities:

"Harshaw Chemical has made a proposal to C & H for the latter company to install production equipment for C-O-C-S (Copper Oxychloride Sulphate) at one of its existing facilities".

The letter describes the production process and lists the raw materials for a batch of CO-C-S:

1,210 lbs Copper Wire (5-24 gauge, iron and solder free)
350 lbs salt (Commercial, Chippewa, Ohio Salt Co.)
620 lbs Sulphuric Acid **(Commercial 66^{0}Be!, General Chemical Company)**
477 lbs Aqua Ammonia **(26^{0}Be!, Du Pont)**
110 lbs Caustic Soda (76% Flake, Columbia Alkali Company)

July 6, 1945: In correspondence between Harshaw and Lovell the two companies are hashing out their plans for Lake Chemical, including production totals:

Early plans called for a yearly production of "3,600,000 lbs of COCS or its equivalent Cupric Hydroxide," also the production of 300,000 lbs of black copper oxide. Harshaw also recommended "provisions should be made for the manufacture of Red Cuprous Oxide used primarily in the formulation of anti-fouling paints."

July 31, 1945: In a letter between Lovell and Harshaw, the construction of the new Lake Chemical facility is described.:

"We are proceeding as rapidly as possible to lay out both units in our Tamarack Reclamation Plant building. The scrapping and removal of idle flotation equipment will proceed promptly in order to provide the necessary space."

September 8, 1945: In a draft of the lease to Lake Copper Company, the plant is to be located in the southwest corner of C & H's Tamarack Reclamation Building.

November 1945: The Lake Chemical Co. was incorporated in September of 1945, as a subsidiary unit of Calumet & Hecla and the Harshaw Chemical Co. Lake Chemical Co. was constructed at Hubbell, within or adjacent to the existing Tamarack Reclamation Plant. In a document outlining the minutes from a meeting of Lake Chemical's directors from Nov. 12, 1945, the original purpose of the company is described as:

"Lake was organized for the purpose of engaging in the manufacture and sale of Copper Oxychloride Sulphate and Cupric Hydroxide, and such other copper chemicals as may be determined upon at a later date…"

April 1946: One of the first posts from the Engineering and Mining Journal related to the production of copper chemicals by Calumet & Hecla:
"…The company's entry into the secondary copper field, to compensate so far as possible for the loss of production from the Calumet sands, has been successful. Another phase of operations is the production of copper chemicals in the leaching plants at Lake Linden and Tamarack mills."

September 1946: This post from the Engineering & Mining Journal provides a nice overview of the equipment, the basic operating procedure of Lake Chemical, and the array of products that include COCS:

"After many months of construction the second unit of Calumet & Hecla's Lake Chemical Co. went into production on July 15, making copper oxychloride (COCS) in commercial quantities. The unit consists of six lead-lined reaction tanks, each 7 ft. in diameter by 12 ft. high, in which scrap copper is reacted with chlorides and sulphates to form COCS. Approximately 16 hours are required to make the conversion, following which the blue slurry is pumped into one of two 18,000-gal. tanks. After blending and conditioning in the tanks, the slurry is dewatered on a large continuous Oliver filter, where the greater part of the liquid is separated from the blue solid. The wet cake is loaded on trays and dried in large truck-tray driers until the material is commercially free of water. The truck and tray driers will eventually be replaced with a large Proctor and Schwartz continuous aerofrom drier. Delivery of this unit will not be made before the end of the year. The dried product is treated in a micro-pulverizer to break up lumps and is discharged into a storage bin.

The so-called "fixed coppers" sprays and dusts, of which COCS is on type, are essential ingredients in many of the commonly used sprays and dusts for the control of a myriad of fungicidal growths on fruits, vegetables and flowering plants. The "fixed coppers" may be effectively used in combination with the well known insecticides – lead arsenate, calcium arsenate, rotenone, nicotine, sulphur, and DDT."

September 12, 1946 – In a letter between Harshaw Chemical and Lovell, early production totals appear promising:

"The production of 50 tons for the month is very pleasing. I think this is almost

a record for a new installation."

November 1946: In this post from the Engineering& Mining Journal, the secondary department of Calumet & Hecla is expanding to include foundry work, either in Ripley or Calumet:

"In conjunction with the Harshaw Chemical Co., of Cleveland, the Lake Chemical Co. was organized in 1945 and located at Hubbell for the purpose of manufacturing and selling chemicals. The company has embarked on the commercial foundry business and is using its excess foundry capacity to make castings for mid-western concerns. The company is about to set up a new department for the manufacturer of detachable drill bits for its own use and for sale in a large part of the United States. The lands owned by the company are being rapidly developed for resort purposes."

April 1948: This post from the Engineering and Mining Journal provides a detailed account of the cupric oxide market in the late 1940s, and shows the further diversification of Calumet & Hecla into an organization dedicated to scientific research and chemical engineering:

"At the Tamarack reclamation plant of Calumet & Hecla Consolidated, an addition to the mixed oxide plant for the production of cupric oxide has been completed. The relatively small, but carefully planned installation makes it possible to add a new product, copper oxides, to the line of Calumet & Hecla. The equipment consists of automatic feeds, conveyors, receivers, a roasting furnace, and a pulverizer.

Cupric oxide is a finely divided powder which is ideal for chemical purposes, and for use in ceramics, where a rapid and uniform dispersion of coloring agent is desired.

Research is being conducted to provide clinkered or coarse particle for the use in the manufacture of primary batteries. This is one of the few important uses where a large particle is desirable because battery plates of pressed cupric must be porous and porosity depends on a coarse structure.

Sales will be confined to a few large customers , who will resell it to the industrial field. If primary battery manufacturers can use clinkered or coarse particles for making plates, sales probably will be made direct to them."

February 1949: This post from the Engineering & Mining Journal describes the various commercial agricultural products that Lake Chemical's copper products have been added to:

"Calumet & Hecla's foundry has been modernized. It will supply the company needs and do custom work. Eventually the foundry and machine shop will be coordinated so that a large number of rough and finished products can be sold. Other byproducts of C&H are copper hydrate, copper oxychloride and copper oxide, made in cooperation with Lake Chemical Co. Still another which is now being produced in a quantity permitting it to be distributed outside of the company's operations is the Liddicoat one-use drill bit.

The copper oxide is already being marketed in large quantities. This product has proved satisfactory in the agricultural industry, particularly in the Florida fruit *and vegetable belt. It is used as a spray to control fungi, as fertilizer amendment, and in feeding cattle.*

George L. Craig, of the company's staff, has been appointed director of the secondary industry, in charge of sales and research."

March 1950: The commercial success and expansion in production of Lake Chemical is described in the post from the Engineering and Mining Journal:

"…Mr. (E.R.) Lovell says progress is production and sales is being made in Lake Chemical, a subsidiary; in the secondary department; in industrial and agricultural copper oxide; in the manufacture of Liddicoat underground drill bits; Prozite, a polishing compound molded into bars for use in metal work, and in production of commercial castings in the company's foundry. The creation of new products has created work for 400 men."

May 1957: In an internal document from 1957, the production of T.C.B.S. or Tri-Basic Copper Sulfate is described along with one of the first discussions of altering the built environment of the Chemical Co. with the installation of a ventilation hood over the COCS reaction tanks:

"Mr. Poull presented the problem of ventilation over the C.O.C.S. reaction tanks. The State Health department has made an issue of this and is currently insisting that hoods and blowers be installed. The estimated cost is about $4,200, which will be a capital expenditure. Before proceeding with this, however, Mr. Kromer will discuss the subject with Mr. Stott and we will attempt to review the recommendation with the State Health Department inspector, pointing out that the condition has existed for approximately twelve years and there has been no apparent hazard indicated in that time."

1965: In 1965, the Lake Chemical Co. dissolved, and Calumet & Hecla absorbed all of the company from Harshaw Chemical Co.

Torch Lake Building & Site Narratives

Ahmeek Stamp Mill to Mutual Water, Light, & Power Co. Pump House

(Prepared by Emma Schwaiger)

CONTENTS

Buildings & Sites from North to South

NARRATIVE TEMPLATE

Building Name: ______________________________

Alternative (common) names for building:

Dates:

1. Built: ________
2. Modified (external structure)______________
3. Ceased operations: ____________________
4. Structure removed: _______________________

Maps available

(Title, date, location, information present for building)

Building Narrative:

(Descriptive history of building uses, processes, major modifications described with dates where available. Includes list of major sources of information and location)

Supporting Documents:

(Copies of articles with extensive description, scientific papers on relevant processes)

Potential Waste/Pollution Concerns:

23. Ahmeek Stamp Mill

See Ahmeek Mill Facilities Narrative and Timeline

Significant: Yes
Alternative (common) names for building:
Tamarack Mill – used by local community to designate location of the only remaining mill ruins in the Tamarack City area. Mill also

Dates:

1. Built: 1908 or 1909
2. Modified (external structure): 1912 or 1914 & 1930
3. Ceased operation: 1969
4. Structure removed: after 1969
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1928, 1935.
Archives drawer 67 - Blueprints
Board of County Road Commissioners Houghton Co. Engineer: T.A. Coon, Surveyor: W.L. Kaiser, Plotter: A. Sippola, August 1928. Map Folder 27 bb.
Calumet and Hecla Consolidated Copper Company. *Trap Rock Valley Railroad, General Map Calumet and Vicinity.* April 11, 1924. Map Folder 27 w.
General Map of Mills Along Torch Lake. 1:200. April 1, 1923. Map Folder 61 c.
Osceola, Lake N° 2, Tamarack and Ahmeek Mill Sites. 1:600. March 1, 1918. Map Folder 61 c.
Property at Mill, Ahmeek Mining Co. 1:100. April 1, 1923. Map Folder 61 c.

Building narrative:

The Ahmeek Stamp Mill was originally owned and operated by the Ahmeek Mining Co, and began producing in 1910. In 1923 it was purchased by C&H when they were expanding down the waterfront and used to process the ore from their mines. It kept producing until the company was sold and eventually closed in 1969. The mill did not operate between 1934 and 1936, and in 1947 2 new ball mills and flotation units were installed.

Supporting documents:
See the drawing in Section 3 of this report of Ahmeek Sand Bank (1914-1927).

Potential Waste and Pollution Concerns:
The Ahmeek Mill began depositing stamp sands into Torch Lake in 1910 and did so continuously until 1968. These sands came from both amygdaloid and conglomerate rock of the mines from the Ahmeek Mining Company and subsequently C&H Mining Co. They contain copper and heavy metals in the original course sands. These sands were reclaimed by Tamarack Reclamation Plant and re-deposited as fine-grained tailings in a location further south of the Ahmeek Mill, just off the waterfront from the Tamarack Reclamation facilities. The finer grained tailings are almost flour-like in their consistency.

24. Ahmeek Pump House

See Ahmeek Mill Facilities Narrative and Timeline

Significant: No
Alternative (common) names for building:

Dates:

1. Built: before 1921
2. Modified (external structure): 1930
3. Ceased operation: 1969
4. Structure removed:
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1928, 1935.

Building narrative:

The Ahmeek Pump House was the pumping house for the Ahmeek Stamp Mill. It was used to provide water from Torch Lake that was used in the milling process.

Supporting documents:

In 1925 there was a report stating that the Torch Lake water level was down and that the Ahmeek Pumps were having a hard time reaching the water to pump to the mill.[1] Also, on March 14, 1925, a letter was sent from MacNaughton to E.A. Baalack saying that the booster pump currently run on steam should be switched to electricity.[2]

Large-scale insurance appraisals were also done in 1957, where the mill and all area buildings were appraised and values were set for the buildings as well as the equipment.[3]

Potential Waste and Pollution Concerns:

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[1] MTU Archives, C&H Collection, Box 35 – Folder 19.
[2] Box 35 – Folder 19.
[3] Box 207 – Folder 1.

Solvents used to clean machinery; potential PCBs between Pump House and Power House as the former converted from steam to electricity after 1930.

25. Ahmeek Power House

See Ahmeek Mill Facilities Narrative and Timeline

Significant: Yes
Alternative (common) names for building:

Dates:

1. Built: Old: Before 1930   New: 1930
2. Modified (external structure): 1930
3. Ceased operation: 1969
4. Structure removed:
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1935.
13200 Volt – Electric Distribution System. March 13, 1931. MS005-9654.
Osceola, Lake N° 2, Tamarack and Ahmeek Mill Sites. 1:600. March 1, 1918. Map Folder 61 c.
Single Line 13KV System Diagram. March 4, 1948. MS005-11461.
Single Line Diagram. September 8, 1960. MS005-12307.

Building narrative:

The New Ahmeek Power House provided power for the Ahmeek Stamp Mill. Originally separate, it was eventually incorporated into the C&H electrical system. It was erected by the Stone & Webster Engineering Company in 1930 and was operational by 1931.

Supporting documents:

On February 20, 1930, a letter from Stone & Webster to C&H says that the old power and boiler houses are not up to snuff and that new ones should be built. This report included cost estimates and drawings of where the old buildings were and where the new ones should go.[4] Because of this report, the entire Ahmeek Mill area was redone in 1930 by C&H, who contracted the work on the Power Plant to Stone & Webster Engineering

[4] MTU Archives, C&H Collection, Box 73 – Folder 51b or 52, 1 of 2

Company. [5] On April 1, 1930, a Revised Preliminary Estimate of Construction Costs was sent to C&H specifically for the Boiler Plant and the Turbine Plant.[6]

On July 26, 1930, another letter from Stone & Webster to C&H has the specifics for the new power house and equipment and they are telling C&H to go ahead with the installation of the equipment.[7] On August 5, 1930, Stone & Webster sent a document to C&H looking at the "possibility of operating the generators at Lake Linden in parallel with each other, and with the new Ahmeek generator." [8]

Large-scale insurance appraisals were also done in 1957, where the mill and all area buildings were appraised and values were set for the buildings as well as the equipment.[9]

On November 12, 1954, a report was released called 'Report on Lightning Protection for the Electrical Transmission System of Calumet & Hecla, Inc.' which address the fact that many electrical outages have taken place due to lightning strikes, but it also addresses any changes that should be taken place at each sub-station or power plant location. Since the Ahmeek Power Plant was still fairly new at this time, all of the lightning arresters were new and in place and the report said that no changes were needed at the Ahmeek location.[10]

Potential Waste and Pollution Concerns:

PCBs were introduced to the large transformers throughout C&H's electrical system beginning in the 1930s. Since the plant operated until 1968, the major concern is with disposal of PCB oils from the transformers when this building was dismantled in the 1970s. No information in the MTU Archives discusses the decommissioning of the Ahmeek power plant.

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[5] Box 151 – Folders 5-18).
[6] Box 73 – Folder 51b or 52, 1 of 2.
[7] Box 73 – Folder 51b or 52, 1 of 2.
[8] Box 73 – Folder 52, 2 of 2.
[9] Box 207 – Folder 1.
[10] Box 38 – Folder 22.

26. Ahmeek Transformer House

See Ahmeek Mill Facilities Narrative and Timeline

Significant: Yes
Alternative (common) names for building:

Dates:

1. Built: before 1928
2. Modified (external structure):
3. Ceased operation: before 1931
4. Structure removed:
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1928.
Osceola, Lake N° 2, Tamarack and Ahmeek Mill Sites. 1:600. March 1, 1918. Map Folder 61 c.

Building narrative:

The Ahmeek Transformer House held the transformers, which were used in the powering of the Ahmeek Power Plant before it was incorporated into the C&H electrical system.

Supporting documents:

On February 20, 1930, a letter from Stone & Webster to C&H says that the old power and boiler houses are not up to snuff and that new ones should be built. This report included cost estimates and drawings of where the old buildings were and where the new ones should go (Box 73 – Folder 51b or 52, 1 of 2). Because of this report, the entire Ahmeek Mill area was redone in 1930 by C&H, who contracted the work on the Power Plant to Stone & Webster Engineering Company (Box 151 – Folders 5-18).

Potential Waste and Pollution Concerns:

27. Ahmeek Boiler House

See Ahmeek Mill Facilities Narrative and Timeline

Significant: Yes
Alternative (common) names for building:

Dates:

1. Built: Old: Before 1930   New: 1930
2. Modified (external structure): 1930
3. Ceased operation: 1969
4. Structure removed:
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1935.
Archives drawer 67 - Blueprints

Building narrative:

The Ahmeek Boiler House housed the boiler for the Ahmeek Stamp Mill.

Supporting documents:

On February 20, 1930, a letter from Stone & Webster to C&H says that the old power and boiler houses are not up to snuff and that new ones should be built. This report included cost estimates and drawings of where the old buildings were and where the new ones should go.[11] Because of this report, the entire Ahmeek Mill area was redone in 1930 by C&H, who contracted the work on the Power Plant to Stone & Webster Engineering Company.[12] On April 1, 1930, a Revised Preliminary Estimate of Construction Costs was sent to C&H specifically for the Boiler Plant and the Turbine Plant.[13]

[11] Box 73 – Folder 51b or 52, 1 of 2
[12] Box 151 – Folders 5-18
[13] Box 73 – Folder 51b or 52, 1 of 2

Large-scale insurance appraisals were also done in 1957, where the mill and all area buildings were appraised and values were set for the buildings as well as the equipment. [14] In 1961 there was a movement to increase the efficiency of the mill by installing new steam generating units, but this never came to be.[15]

Potential Waste and Pollution Concerns:
There are similar concerns as with the Ahmeek Pump House (solvents). However, this facility was part of the conversion to electric power for the Ahmeek Mill and was the site of the new (after 1930) power system for the mill.

[14] Box 207 – Folder 1
[15] Box 151 – Folder 20

28. Tamarack Reclamation Regrinding Plant[16]

See Tamarack Reclamation Facilities Narrative and Timeline
See also Lake Chemical Narrative and Timeline

Significant: Yes
Alternative (common) names for building:

Dates:

1. Built: 1920
2. Modified (external structure):
3. Ceased operation: 1956
4. Structure removed:
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1928.
Archives drawer 67 - Blueprints
13200 Volt – Electric Distribution System. March 13, 1931. MS005-9654.

Building narrative:

The Tamarack Regrinding Plant reground the tailings previously deposited by the Ahmeek, Tamarack, Lake Milling, Smelting & Refining, and the Osceola stamp mills. It was operational in 1925, remodeled in 1936, and 1943-44, and it closed in 1956. In 1945 space was leased to Lake Chemical, which produced copper oxychloride sulphate and copper hydrate.

Supporting documents:
In Section 3: See *Engineering & Mining Jounral* articles on Tamarack Reclamation; see also 1960 Flow Sheet.

Potential Waste and Pollution Concerns:
Tamarack reclamation tailings were reprocessed sands from Ahmeek, Tamarack, Osceola, and Lake #2 mills. As a finely ground, flour-like substance they were re-deposited into Torch Lake. Unlike the original course sands, they had the ability to spread through the

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[16] The Tamarack Regrinding Plant was one section of several facilities housed under one roof and known as the Tamarack Reclamation Plant.

lake as suspended solids which eventually settled on lake sediments beyond the actual stamp sand deposit. They contain copper and heavy metals.

29. Tamarack Reclamation Electric Sub-Station[17]

See Tamarack Reclamation Facilities Narrative and Timeline

Significant: Yes
Alternative (common) names for building:
Tamarack Mill

Dates:

1. Built: 1920
2. Modified (external structure):
3. Ceased operation: 1941
4. Structure removed:
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1928.
Archives drawer 67 - Blueprints
13200 Volt – Electric Distribution System. March 13, 1931. MS005-9654.
Single Line 13KV System Diagram. March 4, 1948. MS005-11461.
Single Line Diagram. September 8, 1960. MS005-12307.

Building narrative:

This sub-station helped power the Tamarack Reclamation Plant until 1941 when the boiler was shut down and the Ahmeek boiler supplied the steam instead.

Supporting documents:

Potential Waste and Pollution Concerns:
Although it was closed in 1941, it is likely that this short-lived sub-station utilized PCB oils in its transformers after 1930.

[17] The Tamarack Reclamation Electric Sub-Station was one section of several facilities housed under one roof and known as the Tamarack Reclamation Plant.

30. Tamarack Reclamation Classifying Plant[18]

See Tamarack Reclamation Facilities Narrative and Timeline

Significant: Yes
Alternative (common) names for building:

Dates:
1. Built: 1920
2. Modified (external structure):
3. Ceased operation: 1956
4. Structure removed:
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1928.
Archives drawer 67 - Blueprints
13200 Volt – Electric Distribution System. March 13, 1931. MS005-9654.

Building narrative:

The Classifying Plant processed the material that came from the regrinding plant to get rid of some of the non-copper material. It was operational by 1925 and was remodeled in 1936 and 1943-44. It was closed in 1956.

Supporting documents:

Potential Waste and Pollution Concerns:
The classifiers in this facility separated out much of the waste material included in the stamp sands transported from the various mill sand deposit sites along Torch Lake. Waste

[18] The Tamarack Reclamation Classifying Plant was one section of several facilities housed under one roof and known as the Tamarack Reclamation Plant.

material in the sands might include residue sands (with non-copper metals) and other waste material originally deposited in the stamp sands.

31. Tamarack Reclamation Flotation Plant[19]

See Tamarack Reclamation Facilities Narrative and Timeline

Significant: Yes
Alternative (common) names for building:

Dates:

1. Built: 1920
2. Modified (external structure):
3. Ceased operation: 1956
4. Structure removed:
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1928.
Archives drawer 67 - Blueprints
13200 Volt – Electric Distribution System. March 13, 1931. MS005-9654.

Building narrative:

The Flotation Plant to treat smiles from the Regrinding Plant was operational in 1925. It was remodeled in 1936 and 1943-44. It was closed in 1956

Flotation is a process which uses xanthates and pine oil to get particular mineral particles, in this case copper, to adhere and float to the top of large vats in the form of foam and froth, which is then skimmed off and separated from the other materials and collected.

Supporting documents:
See multiple documents in Section 3 under Tamarack Facility, pertaining to reclamation of stamp sands and scrap material.

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[19] The Tamarack Flotation Plant was one section of several facilities housed under one roof and known as the Tamarack Reclamation Plant.

Potential Waste and Pollution Concerns:
The Tamarack flotation plant was utilized only for material from stamp mills and for reclamation of stamp sand banks. It did not handle scrap material, the main chemicals of concern were pine oils and xanthates (toxic to aquatic biota) used to float copper from native rock and sands. In combination with the leaching facility, waste sludge was a likely by product. There is no information on how sludge was handled in the archive, but one interviewee suggests they were deposited directly down from the plant on the shoreline of Torch Lake.

32. Tamarack Reclamation Leaching Plant[20]

See Tamarack Reclamation Facilities Narrative and Timeline

Significant: Yes
Alternative (common) names for building:

Dates:

1. Built: 1920
2. Modified (external structure):
3. Ceased operation: 1956
4. Structure removed:
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1928.
Archives drawer 67 - Blueprints
13200 Volt – Electric Distribution System. March 13, 1931. MS005-9654.

Building narrative:

The Leaching Plant was operational in 1925. It was remodeled in 1936 and 1943-44. It was closed in 1956.

Leaching is a process where an ammonia solution is mixed with copper bearing sands and put into large holding tanks where the ammonia dissolves the copper. This ammonia and copper solution is then separated from the rest of the material and heated. The ammonia is evaporated and recycled, whereas the copper is precipitated into copper oxide, which was then sent to the smelter to be processed into pure copper.

Supporting documents:
See multiple documents in Section 3 under Tamarack Facility, pertaining to reclamation of stamp sands and scrap material.

[20] The Tamarack Reclamation Leaching Plant was one section of several facilities housed under one roof and known as the Tamarack Reclamation Plant.

Potential Waste and Pollution Concerns:
Ammonia was the primary chemical utilized in leaching copper from material produced by stamp mills and in later years, tailings and scrap metals (recovery from secondary materials). Benedict claims in *Lake Superior Milling,* that the ammonia was continuously recycled in the leaching process. A common waste material from leaching was finer stamp sand, known as tailings, which had the consistency of flour and would settle far into Torch Lake beyond the visible stamp sand bank of re-deposited sands. A third waste product in leaching (and flotation) was sludge, composed of material, heavy metals, and chemicals remaining after copper had been recovered. One interviewee believes that the sludge from Tamarack Leaching/Flotation plants was likely deposited down from the plants on the Torch Lake Shoreline.

33. Tamarack Stamp Mill

Significant: No
Alternative (common) names for building:

Dates:

1. Built: 1887
2. Modified (external structure):
3. Ceased operation: 1919
4. Structure removed: 1920
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1917.
Board of County Road Commissioners Houghton Co. Engineer: T.A. Coon, Surveyor: W.L. Kaiser, Plotter: A. Sippola, August 1928. Map Folder 27 bb.
Calumet and Hecla Consolidated Copper Company. *Trap Rock Valley Railroad, General Map Calumet and Vicinity.* April 11, 1924. Map Folder 27 w.
General Map of Mills Along Torch Lake. 1:200. April 1, 1923. Map Folder 61 c.
Osceola, Lake N° 2, Tamarack and Ahmeek Mill Sites. 1:600. March 1, 1918. Map Folder 61 c.

Building narrative:

The Tamarack Stamp Mill was originally owned by the Tamarack Mining Co. C&H purchased the majority of shares in 1910 and was remodeled between 1910 and 1914, until the Tamarack went out of business in 1917.

Supporting documents:

See Section 3 (Supporting Documents) for Tamarack Sand Bank (1954 drawing)

Salvage Old Steam Pumps for Foundry Metal – "Two steam pumps which formerly were used in supplying water for the Osceola and Tamarack Mills, now dismantled, have been converted into scrap metal to be used at our foundry. Over 600 tons of cast iron scrap were gleaned from the equipment, which was in service for many years.

The first pump was purchased from the Nordberg firm in 1898 and the second, which cost the company $40,000 was purchased in 1905. Both were in constant use until the discontinuance of operations at these two mills.

A similar pump which is located at the Ahmeek Mill has been out of service since an electrically driven pump was installed several years ago, and it too, will be scrapped in the near future."[21] (p. 8)

Potential Waste and Pollution Concerns:

The Tamarack Mill began depositing stamp sands into Torch Lake in the 1880s and did so continuously until 1917. The original course sands contained copper and heavy metals. These sands were reclaimed by Tamarack Reclamation Plant and re-deposited as fine-grained tailings in a location just north of the original sand bank and directly down from the Tamarack Reclamation Plant into Torch Lake. The finer-grained tailings were more likely to spread throughout Torch Lake due to their flour-like consistency.

[21] *C&H News & Views*, September 1944, p. 8

34. Lake Milling, Smelting & Refining Co. No. 2 Mill

Significant: No
Alternative (common) names for building:
Tamarack #2 Stamp Mill, Lake Chemical Warehouse

Dates:

1. Built: 1898 as Tamarack #2
2. Modified (external structure):
3. Ceased operation: 1930
4. Structure removed: 1947, then warehouse built
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1917, 1928.
Board of County Road Commissioners Houghton Co. Engineer: T.A. Coon, Surveyor: W.L. Kaiser, Plotter: A. Sippola, August 1928. Map Folder 27 bb.
General Map of Mills Along Torch Lake. 1:200. April 1, 1923. Map Folder 61 c.
Osceola, Lake N° 2, Tamarack and Ahmeek Mill Sites. 1:600. March 1, 1918. Map Folder 61 c.

Building narrative:

The Lake Milling, Smelting & Refining Co. Mill was the Tamarack #2 Stamp Mill before 1917. It was closed between 1927 and 1929, but in 1930 it finally closed and remained closed until it was liquidated in 1945.

Supporting documents:

See Section 3 (Supporting Documents) for Tamarack Sand Bank (1954 drawing)

New Warehouse for Lake Chemical Plant – "Owing to the variation in demand for copper oxide and the seasonal needs for C-O-C-S, a large amount of these products have to be stored at times. The available storage space in the Lake Chemical and Secondary departments is not sufficient to take care of this quantity, so additional space has to be provided.

The Lake Mill is conveniently located for this purpose as it adjoins the Tamarack Reclamation plant on the south. The upper part of the mill is not needed and will be scrapped this fall but part of the lower portion is being converted into a warehouse. All machinery and foundations in this part of the mill have been removed and openings for pumps or launders will be filled in and a cement floor laid on the fill. The roof will be replaced and made water tight. It will be necessary to put in a new wall on the west side of the warehouse before the remainder of the building is torn down.

One column was removed and a ramp provided at the north entrance so trucks can enter the building. A tow-motor will remove the pallets – on each of which 30 or 40 bags are placed – and stock them from the trucks in piles so they can be easily taken out as required.

The southern part of the building will not be needed for bag storage so will be used to house unused machinery and electrical equipment. As the building is about 80x200 feet, there will be ample space for both purposes.

As two of the four stamps in the Lake Mill are duplicates of those in the Ahmeek Mill they will be dismantled and used for spare parts for the Ahmeek heads." [22]P. 5

Depreciation, 1923-1964: Folder All: Plant Depreciation Record for LaSalle, Mutual Water Light & Power, L M S & R, Ahmeek, Osceola and L S S Co.

- Depreciation of the plants by year from the 1900s to the 1940s, but no info on Ahmeek.[23]

Potential Waste and Pollution Concerns:
The Lake Mill #2 began depositing stamp sands into Torch Lake around 1900 and did so continuously until 1930. The original course sands contained copper and heavy metal. These sands were reclaimed by Tamarack Reclamation Plant and re-deposited as fine-grained tailings in a location just north of the original sand bank and directly down from the Tamarack Reclamation Plant into Torch Lake. The finer-grained tailings were more likely to spread throughout Torch Lake due to their flour-like consistency.

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[22] *C&H News & Views*, September 1947, p. 5.
[23] MTU C&H Collection, 5.10.3 (5.10.3) Depreciation, 1923-1964, Box 605

35. Osceola Stamp Mill

Significant: No
Alternative (common) names for building:

Dates:

1. Built: 1899
2. Modified (external structure):
3. Ceased operation: 1921
4. Structure removed: 1941
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1917, 1928.
Board of County Road Commissioners Houghton Co. Engineer: T.A. Coon, Surveyor: W.L. Kaiser, Plotter: A. Sippola, August 1928. Map Folder 27 bb.
General Map of Mills Along Torch Lake. 1:200. April 1, 1923. Map Folder 61 c.
Osceola, Lake N° 2, Tamarack and Ahmeek Mill Sites. 1:600. March 1, 1918. Map Folder 61 c.

Building narrative:

The Osceola Stamp Mill was owned and operated by the Osceola Mining Company before C&H bought a controlling interest in 1906 and merged it with C&H in 1911. In 1941 the mill and boiler house were scrapped.

Supporting documents:

See Section 3 (Supporting Documents) for Tamarack Sand Bank (1954 drawing)

Salvage Old Steam Pumps for Foundry Metal – "Two steam pumps which formerly were used in supplying water for the Osceola and Tamarack Mills, now dismantled, have been converted into scrap metal to be used at our foundry. Over 600 tons of cast iron scrap were gleaned from the equipment, which was in service for many years.

The first pump was purchased from the Nordberg firm in 1898 and the second, which cost the company $40,000 was purchased in 1905. Both were in constant use until the discontinuance of operations at these two mills.

A similar pump which is located at the Ahmeek Mill has been out of service since an electrically driven pump was installed several years ago, and it too, will be scrapped in the near future." [24]

Depreciation, 1923-1964: Folder All: Plant Depreciation Record for LaSalle, Mutual Water Light & Power, L M S & R, Ahmeek, Osceola and L S S Co.

- Depreciation of the plants by year from the 1900s to the 1940s, but no info on Ahmeek.[25]

Potential Waste and Pollution Concerns:
The Osceola Mill began depositing stamp sands into Torch Lake around 1900 and did so continuously until about 1920. The original course sands contained copper and heavy metal. These sands were reclaimed by Tamarack Reclamation Plant and re-deposited as fine-grained tailings in a location just north of the original sand bank and directly down from the Tamarack Reclamation Plant into Torch Lake. The finer-grained tailings were more likely to spread throughout Torch Lake due to their flour-like consistency.

[24] *C&H News & Views*, September 1944, p. 8.
[25] MTU Archives, C&H Collection, 5.10.3, Box 605.

36. Mutual Water, Light & Power Co. Pump House

Significant: Yes
Alternative (common) names for building:

Dates:

1. Built: 1907
2. Modified (external structure):
3. Ceased operation: 1937
4. Structure removed: 1944
5. Last time seen on map/aerial photo:

Maps available:

Sanborn Fire Insurance Maps, Michigan Tech Archives: 1917, 1928.

Building narrative:

The Mutual Water, Light & Power Company was incorporated in 1907 to furnish water and steam power to stamp mills. In 1944 it was owned by C&H and the Lake Milling, Smelting & Refining Co. when it was liquidated, and it was inactive between 1938 and 1944.

Supporting documents:

Depreciation, 1923-1964: Folder All: Plant Depreciation Record for LaSalle, Mutual Water Light & Power, L M S & R, Ahmeek, Osceola and L S S Co.

- Depreciation of the plants by year from the 1900s to the 1940s, but no info on Ahmeek.[26]

Potential Waste and Pollution Concerns:
It is likely (but not certain) that this power facility ceased operations before new transformers with PCB oils were installed. There is no information on this in archival materials.

[26] MTU Archives, C&H Collection, 5.10.3, Box 605.