Tyco Fire Products LP Facility, Marinette, Wisconsin

Arsenic Migration Pathways Evaluation Work Plan

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Client Name:	Tyco Fire Products LP
Project Manager:	Heather Ziegelbauer
Author:	Jacobs Engineering Group Inc.

Jacobs Engineering Group Inc.

1610 N. 2nd Street, Suite 201
Milwaukee, Wisconsin 53212
United States
T +1.414.272.2426
F +1.414.272.4408
www.jacobs.com

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Acronyms and Abbreviations

µg/L	micrograms per liter
Agencies	U.S. Environmental Protection Agency and Wisconsin Department of Natural Resources
AOC	Administrative Order on Consent
BWGMPU	*Barrier Wall Groundwater Monitoring Plan Update*
CH2M	CH2M HILL, Inc.
DGT	diffusive gradients in thin film
DGT Pilot Work Plan	*Passive Arsenic Sampling Pilot Test Work Plan and Alternatives Evaluation*
DMU	dredge management unit
EPA	U.S. Environmental Protection Agency
FOP	field operating procedure
GPS	global positioning system
HASP	health and safety plan
ID	identification
IDW	investigation-derived waste
IGLD	International Great Lakes Datum
Jacobs	Jacobs Engineering Group Inc.
Legacy Act project	Great Lakes Legacy Act program
mg/kg	milligrams per kilogram
MNR	monitored natural recovery
MS	matrix spike
MSD	matrix spike duplicate
PPE	personal protective equipment
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
SCM	semi-consolidated material
SCUBA	self-contained underwater breathing apparatus
site	Tyco Fire Products LP facility in Marinette, Wisconsin
SWAC	surface-weighted average concentration
TOC	total organic carbon
Tyco	Tyco Fire Products LP
USACE	United States Army Corps of Engineers
WDNR	Wisconsin Department of Natural Resources

1. Introduction

This arsenic migration pathways evaluation work plan describes the activities to be conducted to collect additional data and improve an understanding of the distribution of arsenic at and near the groundwater-surface water interface in the Menominee River, adjacent to the Tyco Fire Products LP (Tyco) facility in Marinette, Wisconsin (site).

Vertical arsenic concentration profile sampling will occur primarily in the Turning Basin where 2018 data and historical data suggest the highest concentrations of arsenic remain following completion of dredging (as was expected, see Section 2.1). Assessing the conditions in these areas will improve understanding of post-remedy arsenic transport mechanisms that could be contributing to soft sediment and surface water conditions, including but not limited to, upwelling of groundwater, as well as provide data necessary to predict future arsenic concentrations in this area.

This work is being performed on behalf of Tyco based on requests by U.S. Environmental Protection Agency (EPA) and Wisconsin Department of Natural Resources (WDNR, collectively referred to as the Agencies) and in response to comments from EPA on the 2018 Five-Year Review (EPA 2019).

This document is organized into the following seven sections:

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2. Background

2.1 Dredging History

Dredging was conducted from 2012 to 2014 as required by the Agencies. Per the 2009 Administrative Order of Consent (AOC; EPA 2009), soft sediments and semi-consolidated materials (SCM) in the Menominee River adjacent to the facility exhibiting greater than 50 milligrams/kilogram (mg/kg) arsenic were dredged from 2012 to 2013. Glacial till and bedrock were excluded from the dredging requirement. Dredge design and data collected in 2010 indicated remnant arsenic impacts greater than 20 mg/kg and up to 310 mg/kg would be present in glacial till exposed at the top of the dredged surface. The AOC stipulated that monitored natural recovery (MNR) would then be used to manage areas where the remaining sediment contains between 20 and 50 mg/kg arsenic. Pursuant to the AOC, a construction completion report (CH2M HILL, Inc. [CH2M] 2014) documenting the removal was prepared and submitted to EPA in March 2014. Subsequently, Tyco, EPA Great Lakes National Program Office, and WDNR partnered to complete removal of sediments located in the area with arsenic concentrations between 20 and 50 mg/kg. The purpose of this “betterment” project was to remove sediment to immediately achieve the final remediation goal of 20 mg/kg for arsenic and eliminate the need for MNR. This “betterment” project, conducted as part of the Great Lakes Legacy Act program (Legacy Act project), was completed between September 2014 and June 2015. In addition, a sand cover, consisting of a 12-inch-thick layer of sand mixed with granular activated carbon, was placed over portions of the exposed glacial till that contained arsenic concentrations exceeding 20 mg/kg and in limited areas where site conditions prohibited the removal of SCM (Environmental Quality Management, Inc. 2015). Because a portion of the dredged area also included the United States Army Corps of Engineers (USACE) authorized navigational channel, placement depth restrictions (that is, the elevation of the sand cover could not exceed an elevation of 554.5 feet International Great Lakes Datum [IGLD] 1985) limited the area of sand cover placement. Confirmation sediment sampling results associated with the Legacy Act project were reported in the Sampling Summary Report and submitted to EPA (CH2M 2015b).

2.2 Agency Concerns Regarding Groundwater Transport

During the December 20, 2017 and February 14, 2018 meetings with EPA and WDNR, it was agreed that Tyco would not be required to move forward with a dye testing investigation outlined in the September 2015 *Revised Barrier Wall Groundwater Monitoring Plan Update* (BWGMPU; CH2M 2015a) due to the unlikelihood that a dye test could be successfully implemented based on data obtained from a dye test pilot study. Based on the evaluation of the alternatives to the dye test presented to the Agencies and discussions held during these meetings, it was agreed that Tyco instead would move forward with evaluating the use of passive on-wall and river bottom sampling (using diffusive gradients in thin film [DGT] samplers), with limited surface water sampling.

In March 2018, Tyco submitted a *Passive Arsenic Sampling Pilot Test Work Plan and Alternatives Evaluation* (DGT Pilot Work Plan; CH2M 2018) that detailed proposed pilot testing to evaluate feasibility of a full-scale evaluation. The conceptual full-scale evaluation provided in the DGT Pilot Work Plan included passive sampling along the river bottom. At a May 16, 2018 meeting, the parties discussed Agency comments on the DGT Pilot Work Plan and on June 4, 2018, EPA sent Tyco a letter indicating that the DGT Pilot Work Plan was not approvable and that Tyco should instead evaluate a long-term, permanent monitoring network along the vertical barrier wall (EPA 2018).

At a June 26, 2018 meeting, Tyco proposed using passive samplers such as peepers, or temporary point wells, to evaluate potential upwelling, and it was agreed that Tyco would provide a work plan for a river bottom evaluation after sediment sampling was complete. Sediment sampling in accordance with the 2015 BWGMPU and in support of the Five-Year Review was completed in July 2018, and the proposed monitoring well network was the primary focus of discussions during meetings on August 1, 2018 and October 22, 2018. At the October 22, 2018 meeting, it was confirmed that Tyco would submit a pore water sampling plan. The 2018 Five-Year Review was submitted in December 2018 (Jacobs Engineering Group Inc. [Jacobs] 2018a) and indicated that a pore water work plan was being prepared; in light of the 2018 sediment results, potential sediment recontamination pathways were reviewed and included, among other processes, transport by groundwater transport. EPA and WDNR provided comments on the 2018 Five-Year Review on March 14, 2019 (EPA 2019) requiring a pore water sampling work plan to evaluate if and where groundwater may be upwelling through the riverbed and a work plan to evaluate potential arsenic migration mechanisms resulting in arsenic concentrations in sediment above 20 mg/kg, and to also evaluate if the remainder of the 2012-2014 dredge footprint not included in the 2018 sampling event has arsenic concentrations above 20 mg/kg.

This work plan has been prepared in lieu of the dye testing approach and in response to the agreements reached during the June 26, 2018 meeting and to comply with the directions provided by EPA in their comments on the *2018 Five-Year Review Report* as discussed during the May 13, 2019 meeting.

2.3 Sediment Cleanup Goal

The arsenic cleanup goal for sediment and SCM was set at 20 mg/kg in the 2009 AOC (EPA 2009). WDNR had used independent lines of ecological and toxicological evidence to determine that an average residual concentration of 20 mg/kg of arsenic would be protective of life in the river, particularly the survival, growth, and reproduction of organisms that live in the sediment and are at the bottom of the food chain (EPA 2007). At the time of the AOC, it was anticipated that sediments would be dredged to remove soft sediment and SCM exhibiting concentration greater than 50 mg/kg, followed by a period of MNR to achieve the cleanup goal of 20 mg/kg by November 1, 2023. An averaging method was anticipated to be used, as indicated by Attachment 1 of the AOC, where EPA responded to a comment that stated, “Ansul is required to submit an averaging proposal which may include a surface-weighted average concentration (SWAC) method for review and approval by the Agencies. The Statement of Basis is clear and allows Ansul to submit a plan for averaging.”

Tyco submitted a draft MNR plan (CH2M 2012c) that indicated future sediment sample results would be compared to the 20 mg/kg cleanup goal on a sample-by-sample basis, as well as SWAC calculations, with details to be provided in a field sampling plan. Before the draft MNR plan could be finalized (and a field sampling plan produced), however, Tyco and EPA agreed to a Legacy Act project to dredge soft sediment and SCM to a concentration of 20 mg/kg; therefore, an averaging approach was not finalized.

2.4 2018 Soft Sediment Sampling Results

As part of a 2014 *Agreement on Resolution of 2013 Five Year Review Technical Issues* (EPA 2014), Tyco agreed to conduct soft sediment sampling near the vertical barrier wall and in the Turning Basin prior to the 2018 five year review. Results from 2018 sampling of soft sediments at the bottom of the Menominee River indicated arsenic concentrations greater than 20 mg/kg in six of the eighteen locations sampled (Jacobs 2018a, 2018b). Of the six exceedances, five were in the Turning Basin where glacial till exhibiting concentrations greater than 20 mg/kg was exposed by remedial dredging efforts and where sand cover could not be placed because of federal navigation restrictions. Accumulated sediment thicknesses were generally low (less than 6 inches in all but one location) with no accumulated sediment observed in some attempted sample locations. Additionally, ponar sampling methods were used at five of the six sediment sampling locations that exhibited concentrations greater than 20 mg/kg. 2018 sediment results therefore may be biased high due to incorporation of underlying arsenic-impacted materials and not representative of soft sediment arsenic concentrations. Additional information is necessary to improve understanding of the mechanism(s) behind the observed soft sediment concentrations and predict future arsenic concentrations in soft sediment.

2.5 Post-Dredging Surface-Weighted Average Concentrations

Draft SWAC calculations for arsenic in the upper 6 inches of soft sediment and SCM were presented at the May 13, 2019 meeting with the Agencies.[1] At the meeting, it was agreed that additional information on

[1] Note that in some locations, less than 6 inches of soft sediment was above the glacial till.

the SWAC calculation and approach would be provided in this work plan. A revised SWAC has been calculated using the following approach:

- Sediment/SCM arsenic concentration data from the upper 6 inches (or less) of soft sediment and SCM were used. Data representing the post-dredging surface were used, including data from the 2010 sediment investigation (in areas not dredged), 2012/2013 dredging project (for areas not redredged during the Legacy Act project), 2014 Legacy Act project, and 2018 sediment sampling (CH2M 2010b, 2014, 2015b; Jacobs 2018a, 2018b).[2]
- Sample results from exposed glacial till were not included because the glacial till was specifically excluded from the remedial approach outlined in the 2009 AOC and the hard substrate of the glacial till is not conducive to the benthic organisms that are the basis of the cleanup goal.
- Sample results from glacial till covered with sand were also excluded. 2018 sediment sample results indicate that the sand cover is effectively preventing recontamination of the sediment and the presence of the sand cover prevents benthic organisms from direct contract with underlying impacted materials.
- Similar to the sand-covered glacial till, areas dredged to 50 mg/kg during the 2012/2013 dredging project that were covered by riprap along the vertical barrier wall are also inaccessible to benthic organisms and were excluded from the analysis.
- Each sample was assigned a Thiessen polygon to which the sample's arsenic concentration was applied to calculate a weighted concentration for that polygon.
- The polygons of influence, or Thiessen polygons, were delineated within a geographic information system computer application, such that a polygon contains all the area that is closer to a given sample point than to any other sample point.
  - Thiessen polygons were adjusted to reflect whether there was a sand cover present or not (so that a sample collected above the sand cover was not assigned any area outside the sand cover footprint, and vice versa).
  - A total of 249 Thiessen polygons were assigned a concentration, representing an average area of 6,778 square feet. Polygons and concentrations are depicted on Figures 1a and 1b (Figure 1a is an 11 x 17 inch version without individual sample labels and concentrations, while Figure 1b is a 22 x 34 inch version that includes these labels and concentrations).
- Weighted concentrations for each Thiessen polygon were summed and divided by the total area to calculate the SWAC.
- Sub-area SWACs were calculated based on historical divisions (Main Channel; Turning Basin; Transitions Areas 1, 2, and 3; 6th Street Slip; and South Channel) that are shown in different colors on Figures 1a and 1b.

SWAC results are summarized in Table 1 and on Figures 1a and 1b. Additional maps and, based on a request from the Agencies at the May 13, 2019 meeting, details on locations with arsenic concentrations greater than 20 mg/kg are provided in Appendix A. The overall sitewide SWAC is 18.6 mg/kg indicating that, on a sitewide basis and consistent with the AOC, the cleanup goal of an average concentration of 20 mg/kg has been achieved. Sub-area SWACs have been calculated to identify areas of concern. Sub-area SWACs ranged from 7.5 mg/kg in Transition Area 2 to 63.2 mg/kg in the Turning Basin. All sub-areas had SWACs below the cleanup goal of 20 mg/kg except for the Turning Basin.

Within the Turning Basin, the SWAC for areas with sand cover was 8.0 mg/kg, indicating the sand cover is successfully preventing recontamination of soft sediments. The SWAC for the Turning Basin sub-area where there is no sand cover (because of restrictions on placement of sand cover due to USACE navigation channel depth requirements) was 95 mg/kg. This arsenic concentration may be a result either of non-representative soft sediment samples due to incorporation of underlying arsenic-impacted glacial till materials, dredge residuals, or migration of arsenic from the underlying arsenic-impacted glacial till. Therefore, this investigation is primarily focused on using a different soft sediment sampling method than

[2] Nondetect data were conservatively assigned the method detection limit.

used in 2018 (collection by divers) and improving an understanding of arsenic migration processes in the Turning Basin, specifically in areas without sand cover, and evaluating whether arsenic migration processes are likely to result in decreasing arsenic concentrations in the upper 6 inches (or less) of sediment in the Turning Basin. Because of the low SWAC concentrations for the other areas, Tyco has concluded that the additional sediment sampling requested by EPA outside the Turning Basin is not necessary, except for investigating SD-018 location in Transition Area 2, where a 2018 arsenic concentration of 210 mg/kg in the upper 6 inches of soft sediment is believed to be related to the presence of dredge residuals.

3. Potential Migration Pathways for Arsenic Transport to Sediments, Pore Water, and Surface Water

As discussed in Section 2.4, the 2018 data indicate some areas where arsenic concentrations in the upper 6 inches in soft sediment exceed 20 mg/kg, primarily in areas where soft sediment is being deposited directly on top of impacted glacial till. Several possible sources exist for these conditions, as detailed in the following subsections.

3.1 Arsenic-Impacted Sediment Dredging Residuals

As with any sediment removal project, dredge residuals may include impacted materials that were inadvertently left in place. Inherent to any confirmation sampling approach, including the approved dredge management unit (DMU) approach used at the site, it is not uncommon to find concentrations above the cleanup goal at locations not specifically targeted as part of post-dredge confirmation sampling. Other dredge residual sources could include redeposition of suspended impacted materials during and shortly after dredging, or downslope transport of dredge residuals along steeper riverbed slopes that formed post-dredging (due to deepening of the dredged areas).

3.2 Ongoing Diffusive or Advective Transport of Arsenic from Glacial Fill and/or Bedrock

Diffusive flux might continue to exist as another mechanism of arsenic transport. Post-dredging, the glacial till and bedrock are expected to now exhibit higher arsenic concentrations than the overlying soft sediments, pore water, and surface water. Because diffusion results in contaminant migration from areas of high concentration to low concentration, diffusive flux likely occurs upwards into the sediments, pore water, and surface water.

Vertical advective groundwater transport through glacial till to soft sediment, pore water, and surface water remains a concern of the Agencies; however, it is unlikely that this acts as a significant mechanism. Ongoing monitoring data show that bedrock groundwater concentrations of arsenic are generally declining, and previous vertical profiles of glacial till indicate the highest concentrations near the top of the profile, which is inconsistent with a vertical transport pathway. Moreover, the low permeability of glacial till materials limit groundwater flow. However, with the upward vertical hydraulic gradients present and the removal of overlying highly impacted SCM and soft sediment, this pathway may have an increased importance post-remedy.

3.3 Sedimentation

Deposition of sediment from upstream sources are anticipated to have low arsenic concentrations. Deposition of these sediments at a sufficiently high rate is expected to support MNR of arsenic concentrations at the site.

3.4 Other Processes

Additional processes may be occurring but are unlikely to significantly affect arsenic migration at the site. These include bioturbation/biomixing (which is expected to be minimal in the hard glacial till), and redistribution of sediment by river transport (unlikely to be important in the lower velocity Turning Basin) or propeller wash (less likely to be important because of the recent dredging that deepened the Turning Basin). As discussed in Section 2.4, soft sediment sample results from 2018 may be biased high due to the ponar sampling approach that may have incorporated underlying arsenic-impacted materials.

4. Investigation Goals and Approach

4.1 Project Quality Objectives

The project quality objectives and goals are summarized below and detailed in Table 2.

- Evaluate whether arsenic-impacted dredge residuals are present and their potential effects on soft sediment, pore water, and surface water arsenic concentrations
- Evaluate whether vertical advective groundwater transport is occurring and its potential effects on soft sediment, pore water, and surface water arsenic concentrations
- Evaluate effect (if any) of diffusion from arsenic-impacted remnant glacial till, SCM, and/or dredge residuals on soft sediment, pore water, and surface water arsenic concentrations
- Evaluate whether vertical transport of groundwater, if occurring, is affecting surface water concentrations above regulatory criteria
- Predict future average concentrations of arsenic in the upper 6 inches of soft sediment in the Turning Basin

If historic data, 2019 data, future data, and predicted future concentrations indicate that average arsenic concentrations are improving in the Turning Basin, this will be interpreted to mean that the site continues to meet the cleanup goal of 20 mg/kg average arsenic concentration. The prediction of future average concentrations of arsenic in the Turning Basin also will be assessed to evaluate the need for additional risk management measures or MNR beyond the post-remedy period of performance (November 1, 2023).

4.2 Investigation Approach

Areas with the highest concentrations of arsenic in sediment over uncovered glacial till in the Turning Basin are the primary focus of this investigation; however, other areas in the Turning Basin and one in the Transition Area also will be evaluated.[3] Vertical profile samples from the six proposed sampling locations at the site will be analyzed for arsenic concentrations to evaluate potential transport mechanisms. At each vertical profile, vertical water-phase arsenic concentration profiles will be collected composed of surface water samples and groundwater. Direct collection of pore water samples is difficult because of limited soft sediment thicknesses and dense sub-bottom conditions. Thus, pore water arsenic concentrations will be estimated using bulk soft sediment concentrations and the established solid-liquid partitioning relationship for site arsenic and soft sediments.

Soft sediment (where available), sand cover (where present), dredge residual (where present), SCM, and native glacial till samples will be collected to develop vertical solid-phase arsenic concentration profiles. Additionally, undisturbed soil cores will be collected to evaluate the hydraulic conductivity of native materials underlying the Turning Basin (glacial till) and measurements of soft sediment thickness will be made to refine sedimentation rates.

These data will be used to evaluate the presence of dredge residuals, importance of diffusion from underlying arsenic-impacted native materials (such as glacial till), and advective vertical groundwater transport. These data will be used to inform a contaminant transport model, CapSim, that will be used to predict future arsenic concentrations in sediments in the Turning Basin. Additionally, two soft sediment-only locations will be sampled in the Turning Basin area to better define the sediment concentrations in the non-sand cover areas of the Turning Basin near SD-09, where the highest arsenic concentrations were detected during the 2018 sampling activities.

[3] These areas are also adjacent to the upland areas with the highest groundwater concentrations and where evidence of historical (pre-remedy) groundwater transport was observed in SCM that likely also affected the top of the glacial till.

5. Proposed Field Approach

5.1 Types of Field Data to be Collected

Field data, also identified in Step 3 of Table 2, to be collected include the following:

- Soil arsenic concentration profiles from the river bottom to the top of bedrock
- Groundwater arsenic concentration profiles from the river bottom to the top of bedrock
- Soft sediment arsenic concentrations
- Surface water arsenic concentrations near the river bottom (6 to 12 inches above the soft sediment layer, or flocculant layer if present)
- Soil geotechnical data to evaluate vertical hydraulic conductivity
- Soft sediment thicknesses above sand cover to evaluate sedimentation rate

Pore water concentrations will be estimated using the previously developed sediment-water partitioning relationship. Data from previous sampling efforts also will be considered and evaluated where appropriate.

5.2 Sampling Approach

Samples will be collected using a combination of scientific self-contained underwater breathing apparatus (SCUBA) divers (to collect surface water and soft sediment samples) and borings (to collect groundwater, sand cover, soil samples). The diver-led sampling will be conducted first to limit disturbances, with deeper drilling-collected vertical profile samples reoccupying the same locations, to the extent possible and practicable.

The sampling locations described in the following subsections are target locations. Some of these locations may not be able to be sampled because of lack of sediment, inaccessibility (for example, shallow water, debris blocking passage), substrates encountered (such as debris or riprap), or health and safety considerations. Reasonable attempts will be made to acquire samples at the target locations; in instances where this is not feasible, samples from the nearest location representing similar conditions will be collected, if possible. Up to two attempts (borings) will be made at each proposed location to collect samples. If samples cannot be collected for a sample interval (for example, there is insufficient groundwater recovery from a sample interval, or insufficient soil core recovery), that sample will not be collected and the next sample/interval will be attempted. If an area is not accessible, then staff will consult with the project manager and senior technical consultants to determine if relocating or abandoning a location is appropriate, or if alternative sampling methods are appropriate. Difficulties and deviations will be recorded in the field documentation.

Before the water and sediment sampling can be conducted, various reconnaissance-level activities must first be completed to support overall dive planning for the scientific divers. These activities generally include evaluating environmental conditions (for example, river flow, water clarity, boating activity), sampling boat and equipment checkout, and overall safety evaluations (for example, route to hospital, establish key points of contact). Specific reconnaissance activities will include:

- Establishing the sampling locations
- Diving to measure soft sediment thicknesses
- Documenting underwater visual observations

5.2.1 Proposed Sample Locations

Vertical profile samples will be collected at six locations, with two additional locations having soft sediment sampling only (Figure 2). These locations were chosen for the rationales summarized in Table 3. Table 4 summarizes the proposed laboratory analyses.

5.2.2 River Bottom Inspection and Samples Collected by SCUBA Divers

A team of scientific SCUBA divers will measure sediment thicknesses, assess and document river bottom conditions, and collect surface water and soft sediment samples. To minimize the disturbance of fine-grained bottom sediments, which may adversely impact sampling, the field activities will be conducted in the following order:

1. Reconnaissance (including sediment thickness measurements and river bottom observations)
2. Water sampling
3. Sediment sampling

Reconnaissance activities will be conducted before, but not on the same day as, water or sediment sampling.

The targeted sampling locations will be obtained by boat using a handheld global positioning system (GPS) unit. Because of vessel traffic, weather, and other local conditions, the targeted sampling stations may be adjusted in the field, as necessary. Final latitude-longitude coordinates of sampling stations will be recorded at the time of sample collection. Based on previous site investigations, it is assumed for these field activities that water depths at all sampling stations will not exceed 30 feet. A fathometer or sounding line will be used to measure water depth at each sample/measurement location.

Once the sampling locations have been established, a weighted line with a surface marker float will be lowered to the bottom to mark each sampling location. This line also will serve as the descent/ascent line for the divers and as a reference point during sampling (since low or potentially zero visibility conditions can be expected during sampling). Determining the location of the river bottom-surface water interface may be difficult at some sampling locations because of thick layers of flocculant, unconsolidated sediments obscuring the bottom. Thus, establishing the hard river bottom depth is an important consideration. To accomplish this, the anchor used for the surface marker float assembly will be used to define the depth of the hard bottom (that is, where it comes to rest on the bottom). Since the anchor also will be used as the diver's reference/down line, it must have sufficient weight so that movement of the line will not cause disturbance of the bottom sediments.

A reconnaissance dive will be conducted at each of the proposed sampling locations to ascertain and verify the water depth, bottom conditions, sediment type(s), presence of vegetation, water clarity, or other conditions that could impact the study approach used (and the time required) for sampling activities. River levels from the onsite staff gauge will be recorded periodically to verify that calculations of river bottom elevation are accurate.

Sediment Thickness Measurements

During the reconnaissance dives, measurements of flocculant/unconsolidated sediment thickness will be conducted. At up to 15 locations, including the 8 sampling locations described above, divers will measure soft sediment thicknesses. Because the sand cover has a known placement date (spring 2015), measurement locations will be biased toward areas with sand cover so that sedimentation rates can be calculated. The specific locations of these additional stations will be determined in the field. During the reconnaissance dive, qualitative sediment "probing" will be conducted.

While various methods may be employed to take thickness measurements, the primary method for accomplishing this task will be to use a long, thin piece of metal (such as a metal ruler, doweling, rebar, or a rigid length of tubing) to measure the depth of the unconsolidated sediments and qualitatively assess the grain size of the sediment layer (since silt, sand, and coarse-grained sediments 'feel' differently when probed in this manner). The sediment thickness measurements will be conducted at multiple locations around the station marker anchor, as this will demarcate the depth of the hard river bottom. The divers will record average sediment thickness measurements at each sampling location, including assumed sediment type(s) encountered and the depth to refusal (if applicable).

River Bottom Observations

To determine the potential presence of dredge residuals and document visual observations, video and/or photographs of the sediment conditions will be recorded. This task will be accomplished if conditions (that is, water clarity) in the river are suitable to enable photography. Alternatively, a GoPro (or equivalent) camera mounted to a telescoping pole may be used as a drop camera to provide a visual record of water clarity and the conditions near the bottom where sampling activities will occur. The drop camera method may eliminate the need for divers to enter the water where the potential for disturbance of bottom sediments may occur.

Surface Water Samples

Before collecting sediment samples, a surface water sample will be collected approximately 6 to 12 inches above the sediment-water interface (or top of flocculant layer, if present) at each of the six vertical profile sampling locations. Surface water samples will be collected with minimal disturbance of the underlying sediments to prevent bias from artificially-elevated suspended sediments. The primary water sampling method will be using the direct grab technique, which consists of the following basic steps:

- Using an unpreserved sample container to collect the sample, the diver will hold the container at the required sampling location (6 to 12 inches above sediment) and will remove the container cap.
- The bottle will be inverted so the opening is upright and pointing toward the direction of water flow (if applicable).
- The diver will allow water to fill the container, then replace the cap and return to the surface. To perform this task, the diver must exhibit a high degree of buoyancy control so as not to disturb the bottom sediments and potentially affect the sample.

If circumstances prevent the use of direct grab sampling methods (for example, particulates in water resulting from bottom sediment disturbance or current), at least two alternate techniques may be employed, use of a peristaltic pump or use of a Kemmerer sampler.

For the peristaltic pump, the following methods would be used:

- This sampling method employs using a peristaltic pump (for example, Geotech Geopump, or equivalent) and dedicated tubing positioned to precisely collect water at the specified depth.
- The battery-operated peristaltic pump will be rigged with a length of Teflon tubing sufficient to extend from the pump to the river bottom.
- The subsurface end of the tubing will be fixed (for example, cable tie, tape) to a rigid pole (for example, polyvinyl chloride pipe) with the tubing positioned at 6 to 12 inches above the sediment/flocculant surface. This positioning will be conducted by a diver while minimizing disturbance of the sediment.
- Several tubing volumes will be slowly pumped through the system to flush the tubing and verify that disturbed sediment is not being collected, followed by filling sample bottles at the boat from the discharge end of the tubing.

The Kemmerer sampler is a cylinder with rubber stopper that leave the ends of the sampler open while being lowered to the target sample depth. When the sampler is at the target depth, a weight “messenger” is dropped down the line that releases a latch and causes the rubber stoppers to close around the cylinder and retain a sample at the target depth. The sample is then retrieved and transferred to appropriate containers for laboratory analysis.

Samples will be analyzed for total and dissolved arsenic content (Table 4). Dissolved arsenic samples collected underwater will be field-filtered at the surface.

Soft Sediment Samples

Soft sediment samples will be collected at the six vertical profile sampling locations and two additional soft sediment-only sampling locations. SCUBA divers will collect the samples for total arsenic and total organic carbon (TOC) analysis. At two locations, samples will be analyzed for bulk density and grain size analysis. The uppermost sample will be collected from the upper 6 inches of soft sediment (if less than 6 inches of sediment is present, a sample will be collected from the soft sediment interval if practicable, being careful not to incorporate deeper materials). If more than 9 inches of soft sediment is present, a second sample will be collected from the 6- to 12-inch interval.

The primary sediment sampling method will be using a handheld coring device. In general, handheld corers use a clear plastic core tube that is pushed or driven into sediment by the diver. The main advantage of this type of corer is that samples can be obtained from otherwise inaccessible areas or in areas with limited amounts of sediment. The main disadvantage is the small diameter of the core and the relatively short length, which can limit the sample volume collected per core. High-quality samples can be obtained in cohesive and cohesionless sediments using this method.

Divers will collect surficial sediment samples using dedicated 3.25-inch-diameter, 6-inch-long, clear Lexan core tubes that will be pushed by hand into the sediment until they are flush with the sediment surface. If refusal is met before the core tube is inserted entirely (that is, flush with the sediment surface), a small sledge hammer and striking plate designed to protect the core tube may be used. Once inserted to the desired depth (or to refusal, whichever comes first), the top of the core tube will be sealed with a plastic cap. This cap will create a vacuum upon removal from the sediment and will prevent the sediments from falling out of the bottom of the tube. Once a plastic cap is secured onto the top of the tube, a large decontaminated stainless-steel spoon will be used to reach to the bottom of the tube and to carefully lift it out of the substrate while containing the collected sediment. The bottom of the tube will then be capped with another plastic cap. The primary purpose of these samples is to obtain sufficient sediment volume for analytical testing. To collect the required amount of material needed for analysis, this sampling procedure may need to be repeated using multiple cores.

As an additional method to the diver coring method described above, and to collect deeper sediment sample intervals if present, the diver will insert a K-B Core liner (2-inch-diameter Lexan liner 18 inches long) into the sediment and push it to refusal. To obtain the maximum 18-inch length of core, the coring device will then be attached to the core tube and driven to the extent of the core (or to refusal). The primary purpose of the longer core samples is to characterize sediments in the profile down to the depth of the indicator (sand cover or glacial till if no cover material is present) layer.

The number of core tubes collected at each location will be adjusted to meet volume requirements for both native samples and quality control (QC) (duplicate) samples, as appropriate. Sediment sampling methods may also be adjusted based on site conditions and degree of core recovery. The core sampling will be used to collect as much of the sediment profile as possible at each location, ideally down as far as the indicator (sand cover) layer or the glacial till. If the layer of sediments is relatively thin (1 to 2 inches thick), additional sets of samples will be collected to obtain the volume required for analysis or a decontaminated sampling spoon will be used to collect material.

Once the sediment cores have been returned to the support vessel, the sample custodian will inspect and measure the cores and record a physical description of the sediments. Sample compositing of multiple cores will be necessary if an individual core contains an insufficient volume of sediment for the required analyses. Sediment material at a station will be placed into a decontaminated, precleaned stainless-steel compositing bowl, and the unrepresentative material will be removed (for example, infauna, vegetation, woody debris, etc.), then thoroughly homogenized to a uniform appearance using a decontaminated, precleaned, stainless-steel spoon. Homogenized sediment then will be spooned into clean, laboratory-supplied sample containers for sample collection.

5.2.3 Samples Collected by Drilling Equipment

To obtain soil profiles below the river bottom, this study will require a barge-mounted drill rig. It is anticipated that a hollow-stem auger drill rig will be used, although alternative drilling methods (such as rotosonic or vibracore) may be used based on driller capabilities and site conditions. The samples collected by the drill rig will target the sand cover (if present) and deeper soils (for example glacial till). The augers (or rods) will be enclosed in an outer temporary casing to seal off from the river and prevent water from intruding the borehole. The following sample types will be collected:

- Continuous soil core samples for arsenic concentration profiles
- Continuous groundwater samples
- Collection of undisturbed soil samples for geotechnical analyses

Continuous Soil Core Samples for Arsenic Profiles

Borings will be advanced at each of the six proposed vertical profile locations (VP-101 through VP-106). The subsoil will be continually sampled from the top of the sand cover (if present) through native material to the bottom of the boring (top of bedrock). Continuous soil cores will be retrieved and sampled at 6-inch intervals (if sufficient soil core recovery). Soil cores will be visually characterized for sediment/soil type, color, moisture content, texture, grain size and shape, consistency, visible evidence of staining, and any other observations. Soils will be described using the Unified Soil Classification System (modified slightly for sediment characterization) based visual-manual identification in accordance with the ASTM International 2488 standard practice (ASTM International 2017). Digital photographs of each core will be taken to visually document the undisturbed core structure. Each photograph will include a scale (that is, tape measure), station identification (ID), and date of core collection. Samples will be laboratory analyzed for percent moisture, arsenic, and TOC (Table 4). Detailed boring logs will be kept to evaluate the stratigraphy and potential presence of dredge residuals in the soil cores.

Discrete Groundwater Samples

Groundwater will be sampled at 2-foot intervals by placing a 1- to 2-foot temporary screen inside the borehole or advancing a stainless-steel screen ahead of the rods/augers. Samples will be collected, if feasible, every 2 feet to bedrock. Samples will be analyzed for total and dissolved arsenic and TOC. Dissolved arsenic samples will be field-filtered. Groundwater samples will be collected using a peristaltic pump and new tubing for each sample. Purging will be minimized because of anticipated low recharge rates; if a sample interval does not produce sufficient water initially, the screen will remain in place for up to 1 hour to allow for recharge. If after 1 hour insufficient sample volume has been collected, the screen will be removed and the boring advanced to the next sample interval. If recovery of groundwater is limited, samples will be collected in the order of total arsenic, TOC, and dissolved arsenic.

Undisturbed Soil Cores for Geotechnical Analysis

A Denison sampler (or similar) will be used to collect an undisturbed soil core, targeting the glacial till, in a separate borehole adjacent to the borehole(s) for the environmental samples at three of the vertical profile locations. The sample depth will be selected based on the lithological observations from the environmental borehole. The undisturbed soil core will be collected in a 2-foot interval from the glacial till. The undisturbed soil cores will be collected in 2-foot-long plastic sleeves and submitted to a geotechnical laboratory for vertical hydraulic conductivity, bulk density, and grain size analysis (Table 4).

5.3 Field Operations

5.3.1 Mobilization and Demobilization

Before initiating fieldwork, the following preparatory activities will be completed.

- Obtain and transport the identified field supplies to the site (for example, personal protective equipment [PPE], sample containers, preservatives, sample forms, and other related items) and field monitoring equipment

- Set up temporary investigation-derived waste (IDW) storage equipment on the sampling vessel

- Mobilize subcontractor, supplies, and materials

- Confirm that analyses are scheduled through the contracted laboratory
- Confirm that field equipment is in proper working order and has received appropriate QC checks

Equipment and tools will be properly decontaminated before they are demobilized from the area. No site restoration activities are anticipated to be necessary.

5.3.2 Location Positioning/Mapping

Sample locations will be measured in the field using a GPS unit capable of horizontal accuracy of ±3 feet. Target locations will be provided to the dive team. The location of sample buoys placed during diver sample collection will be recorded and used to position the drilling barge to within ±10 feet of the diver sample location. Field operating procedures (FOPs) for GPS are provided in FOP-1 of the 2015 BWGMPU (CH2M 2015a).

5.3.3 Surveying

Vertical profile locations will be referenced horizontally to the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1983. Established benchmarks will be used to survey each vertical profile location to a minimum horizontal tolerance of 3 feet and a vertical tolerance of 0.1 foot. Coordinates (x, y) and elevations (z) (in North American Vertical Datum of 1988 and IGLD 1985) of the benchmarks used for surveying activities will be recorded in the same coordinate system and datum as the sample locations. Sediment surface elevation will be determined by surveying the water elevation using surveyed staff gauges. Water depth measurements will be collected using a weighted tape or survey rod. To derive the sediment surface elevation, the water depth measurement will be subtracted from the surveyed water elevation.

5.3.4 Field Equipment Decontamination

Nondisposable sampling equipment will be decontaminated on arrival at the site and before each use. Dedicated, single‑use sampling equipment will be used during sample collection and processing where possible. Portions of the sampling device that will be used at the stations will be decontaminated between stations.

5.3.5 Investigation-Derived Waste

IDW will consist of excess sediment, soil, and liquids generated during investigation and decontamination activities, as well as PPE. IDW will be segregated by waste type and stored in 55-gallon drums. Each drum will be labeled and staged in a secure location. After classification, the drums will be shipped offsite for disposal at an approved facility. Liquids may alternatively be treated at the onsite groundwater collection and treatment system.

5.4 Sample Management

This section describes the procedures to be implemented so environmental samples are properly containerized, preserved, shipped, and otherwise handled in a manner that will maintain sample integrity. The techniques will result in representative samples and reduce the possibility of sample contamination from external sources.

5.4.1 Sample Nomenclature

A sample nomenclature system will be used to identify each sample, including quality assurance (QA)/QC samples. The sample identifier will be unique for each sample. The unique sample identifier will be used for tracking each sample within the chain-of-custody, database, and subsequent reports. Each sample, regardless of analytical protocol, also will be assigned a site-specific identifier, including a sample depth for subsurface sediment samples that will be included on the sample label, traffic report, and chain-of-custody record.

The site-specific identifier is based on the following system:

- **Sample Type—**The first two letters indicate the type of sample location as follows:
  - SD = Sediment sample.
  - SW = Surface water sample
  - SO = Soil sample
  - GW = Groundwater sample
  - GT = Geotechnical sample
  - WD = IDW characterization sample. An example of the first IDW characterization sample is WD-001, followed by WD-002.
  - EB = Equipment blank sample. An example of the first EB sample is EB001, followed by EB002.
- **Sample Number**—The vertical profile locations will be numbered sequentially, as depicted on Figure 2. The sample also will be appended with a dash and the year of collection to differentiate between sampling events.
  - An example sediment sample location is SD102-2019.
- **Sample Depth**—The depth from which the sample was collected will be added to the station location at the end after a dash and with a forward slash (/) between the start and end depths:
  - The 0- to 0.5-foot interval at the previous sediment location example would be indicated as SD102-2019-0.0/0.5.
- **QA/QC Identifier—**Field QA/QC samples will be identified using the following QA/QC identifiers:
  - Duplicate samples will be identified with the same station location as the parent sample and appended with a dash and D (for field duplicate), to the end.

5.4.2 Quality Assurance and Quality Control Samples

Laboratory tasks are described in the approved *Quality Assurance Project Plan* (QAPP; Earth Tech, Inc. 2006) and applicable QAPP addendums (CH2M 2010a, 2012a, 2012b, 2013) Field sampling precision and bias will be evaluated by collecting the QA/QC samples as described below, per the QAPP and QAPP addendums. Interpretation of laboratory tasks and their success or failure will be accomplished using data validation procedures outlined in the approved QAPP.

Field Duplicates

Field duplicate samples will be used to measure the heterogeneity of the sample matrix and the precision of the field sampling and analytical process. Duplicate samples will be collected from locations throughout the sampling area and from various depths at a frequency of 10% to assess sample variability. Field duplicates will be collected for each sample matrix and submitted for the same analytical parameters as the primary samples. Field duplicates will not be collected for geotechnical samples.

Equipment Blanks

Equipment blanks will be collected and analyzed to determine whether the decontamination procedure has been adequately performed and whether cross-contamination of samples occurred from the equipment or residual decontamination solutions. One equipment blank will be collected on each day of sampling per piece of nondedicated equipment used during field activities and analyzed for the same parameters as the environmental samples.

Matrix Spike and Matrix Spike Duplicate

Laboratories will use matrix spike (MS) and matrix spike duplicate (MSD) samples to assess the precision and accuracy of sample analysis. The laboratories will fortify MS/MSD samples in accordance with the specifications of the analytical methods. Sample containers will be filled and stored in the same manner as field duplicate samples. The frequency for collecting MS/MSD samples will be at least 5% for each sample matrix.

Temperature Blanks

A temperature blank will be included in each cooler to allow the laboratory receiving the shipment of samples to determine if the samples have been maintained at the proper temperature. Temperature blanks will consist of an unpreserved sample container filled with distilled water. One temperature blank will accompany each sample cooler being shipped to the laboratory.

5.4.3 Sample Handling

Sample handling, packaging, and shipping procedures are described in Appendix F of the approved QAPP (Earth Tech 2006).

5.4.4 Equipment

The drilling equipment, boat, GPS, and consumables associated with sample collection (for example, core tubes and caps) will be provided by a qualified contractor and will be used in accordance with their standard operating procedures. Diving services will be provided by the Jacobs' scientific diving team, and equipment used by this team will be used in accordance with their standard operating procedures.

5.5 Safety Plan

The contractors implementing the elements of this work plan have not been selected. Project-specific health and safety plans (HASPs) will be developed by the contractor, Jacobs, or Tyco for each element. The HASPs will be consistent with Tyco's generic HASP for the site and address potential health and safety issues associated with the proposed work. The HASPs will contain precautions that site personnel must take regarding equipment associated with the work and required tasks in the event of system failures. HASPs will be updated when new activities are defined and pursued.

General topics included in the HASPs will include site location and scope of work, health and safety risk analysis, field team organization and responsibilities, PPE, site control measures, decontamination procedures, emergency response plan, employee training, and medical monitoring. HASPs will be kept onsite during all field activities, and a copy will be maintained in the project files.

6. Proposed Analytic Approach

This section summarizes the proposed analytic approach, which also is summarized in Step 5 of Table 2.

6.1 Evaluate (to extent possible) Whether Dredge Residuals are Present

The presence of dredge residuals at each location will be determined by analyzing the riverbed slope, diver observations, and soil core observations. Photographs taken by divers will be evaluated for the steepness of riverbed and nature of sediment deposits to determine if dredge residuals may have settled at the deepest areas. In addition, the arsenic concentrations observed in the soil cores will be compared to historical arsenic concentrations in SCM and soft sediments; elevated levels in the cores may indicate possible dredge residuals.

6.2 Evaluate Vertical Groundwater Transport Pathway

To evaluate the vertical groundwater transport pathway, previously collected vertical gradient data (as presented in the annual barrier wall groundwater monitoring reports) combined with hydraulic conductivity values determined during this investigation, will be used to calculate potential vertical groundwater migration rates using Darcy's Law. If the vertical arsenic concentration profiles in glacial till groundwater or soils indicate uniform (or increasing) arsenic concentrations with depth, advective vertical transport might be occurring from the underlying bedrock. Pore water concentrations in the soft sediment will be calculated from bulk sediment arsenic concentrations using the previously developed site-specific Freundlich isotherm (CH2M 2012c) and compared to underlying groundwater concentrations.

6.3 Evaluate Potential Diffusion-Related Transport

Fick's Law and vertical arsenic concentration profiles will be used to evaluate potential diffusive flux, both from glacial till/dredge residuals to soft sediments/pore water, and from pore water to surface water. Within the vertical arsenic concentration profiles, observations of the highest arsenic concentrations at the top of the glacial till may indicate remnant impacts from pre-dredging arsenic migration. Because diffusion occurs from areas of high concentration to low concentration, arsenic may diffuse upward into the overlying soft sediments, pore water, and surface water. Fick's Law will be used to determine diffusive flux based on these concentration gradients.

6.4 Evaluate Surface Water Concentrations

Arsenic concentrations of surface water samples will be compared to Wisconsin surface water criteria to determine if the Menominee River displays elevated levels. Per Wisconsin Administrative Code NR 105.05 Tables 1 and 5, the acute value for warm water is 339.8 micrograms per liter (µg/L) as arsenite (arsenic III), and the chronic value is 152.2 µg/L as arsenic III.

Surface water concentrations also will be compared spatially with calculated pore water concentrations. This will indicate whether vertical transport of groundwater, if occurring, is affecting surface water concentrations above regulatory criteria.

6.5 Evaluate Potential Future Concentration Trends in Soft Sediment

The CapSim model (Shen et al. 2018) is a transient one-dimensional model that can simulate sediment and pore water concentrations through time at different depths. The model can simulate groundwater upwelling (including advection, diffusion, and sorption), deposition of new sediment, effects of a sediment cover, contaminant degradation, and bioturbation. The model has previously been used at the site, including in a draft MNR work plan (CH2M 2012c)[4], to simulate the potential range of future arsenic

[4] This work plan was not finalized, as Tyco and the Agencies agreed to conduct the Legacy Act dredging project.

concentrations in sediments. Key inputs include the starting arsenic concentration, sediment deposition rates, site-specific sediment-porewater partitioning relationship, and groundwater upwelling velocities.

CapSim simulations will be run for the Turning Basin area to predict the future range of arsenic concentrations in this area in reference to the 20 mg/kg cleanup goal. Data from the 2018 and 2019 river investigations will be used to refine input parameters, including sediment deposition rate, vertical groundwater upwelling rate, and current arsenic concentration profiles. Soft sediment thicknesses, especially in areas with sand cover placed in 2015, will be used to calculate post-dredging sedimentation rates. Higher rates of sedimentation are expected to result in more rapid burial of the impacted glacial till and thus lower arsenic concentrations in the upper 6 inches of soft sediments. Vertical groundwater upwelling rates will be calculated using previously measured vertical hydraulic gradients and the hydraulic conductivities measured during this investigation. Arsenic concentration profiles from this investigation also will be used. A Monte Carlo approach, wherein key parameters are randomly varied within a reasonable range of values, is anticipated to provide a range of future arsenic concentrations.

7. Reporting and Schedule

7.1 Fieldwork Schedule

Fieldwork is anticipated to be conducted in summer or early fall 2019.

7.2 Initial Summary Presentation to Regulatory Agencies

If requested, after fieldwork and initial evaluations are completed, an initial summary presentation of results may be provided to the Agencies before submitting the technical memorandum.

7.3 Technical Memorandum

A technical memorandum will be submitted to the Agencies by March 1, 2020. The anticipated report structure includes:

1. Introduction
2. Background (Conceptual Site Model)
3. Objectives
4. Field Implementation
5. Field Observations, Changes, and Challenges (if needed)
6. Results (tables/figures/geology)
7. Evaluation and Updates to Conceptual Site Model
8. Evaluation of Monitoring Natural Recovery Rates in Turning Basin
9. Conclusions and Recommendations

8. References

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Tables

Table 1. Post-Dredging Arsenic Surface-Weighted Average Concentrations

Arsenic Migration Pathways Evaluation Work Plan

Tyco Fire Products LP Facility, Marinette, Wisconsin

Sub-Area		Area (ft^2)	No. of Data Points/ Polygons	Range of Concentrations (mg/kg)	No. >20 mg/kg	Surface Sediment SWAC (mg/kg)
Turning Basin	No Cover	165,839	25	<2.3 - 380	5	95.0
	Cover	95,309	4	<2.8 - 11	0	8.0
	Combined	261,148	29	<2.3 - 380	5	63.2
Main Channel	No Cover	339,833	21	<2.2 - 54	5	11.6
	Cover	15,006	1	2.6	0	2.6
	Combined	354,839	22	<2.2 - 54	5	11.2
Transition Area 1	No Cover	246,817	18	<2.35 - 20.7	1	14.0
Transition Area 2	No Cover	278,478	66	<1.5 - 210	3	7.6
	Cover	9,058	2	1.7 - 2.5	0	2.1
	Combined	287,536	68	<1.5 - 210	3	7.5
Transition Area 3	No Cover	67,468	30	<1.19 - 217	4	12.6
6th Street Slip	No Cover	35,286	12	<1.37 - 217	1	8.1
South Channel	No Cover	434,683	70	<1.31 - 65	6	9.5
Site-Wide	No Cover	0	0	<1.19 - 380	0	19.5
	Cover	0	0	1.7 - 11	0	6.9
Combined		0	0	<1.19 - 380	0	**18.6**

ft^2 - square feet

mg/kg - milligrams per kilogram

SWAC - surface-weighted average concentration

Table 2. Project Quality Objectives
Arsenic Migration Pathways Evaluation Work Plan
Tyco Fire Products LP Facility, Marinette, Wisconsin

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
State the Problem	**Identify the Study Goals**	**Identify Information Inputs**	**Define the Study Boundaries**	**Develop the Analytic Approach**	**Specify the Performance or Acceptance Criteria**	**Develop the Plan for Obtaining Data**
Previous and ongoing remedial efforts limit the potential migration of arsenic-impacted soils and groundwater from the site to soils, soft sediment, and pore water under the Menominee River, and surface water of the Menominee River. Dredging was conducted from 2012 to 2014 with the goal of removing all soft sediments and SCM above the glacial till layer, that exhibited arsenic concentrations greater than 20 mg/kg. Glacial till with arsenic concentrations greater than 20 mg/kg remained in place (up to 1,130 mg/kg). Where river depths were sufficient (that is, 2 feet below the Federally Authorized Navigational Depth), a sand cover mixed with activated carbon was placed to isolate remaining arsenic-impacted soils from surface waters, resulting in the establishment of a new "clean" benthic layer for restoration. Historical salt piles were removed, soils were covered, and a vertical barrier wall was installed to limit migration of arsenic-impacted groundwater to the river. While monitoring activities are conducted to evaluate the vertical barrier wall effectiveness, remnant arsenic impacts to bedrock groundwater are known to be present beneath the river. Based on 2018 post-remedy sediment sampling, soft sediments and underlying materials with arsenic concentrations above 20 mg/kg remain in the Menominee River bottom adjacent to the Tyco facility. Calculation of post-dredging arsenic SWAC indicates the average sitewide arsenic concentration in the upper 6 inches of SCM and soft sediment is less than the 20 mg/kg cleanup goal. SWACs calculated for sub-areas of the river indicate that only the Turning Basin exhibits average arsenic concentrations greater than 20 mg/kg. Although the sitewide SWAC meets the cleanup goal, the average arsenic concentration is greater than 20 mg/kg in soft sediments within areas of the Turning Basin where sand cover could not be placed due to federal navigation channel requirements and glacial till was known to contain concentrations greater than 20 mg/kg. Based on the request of the agencies to evaluate the arsenic migration pathways, the 2018 sediment sampling results, and to evaluate whether the Site will continue to meet the cleanup goal, Tyco will update the conceptual site model by evaluating the potential for vertical transport (by advection and/or diffusion) of arsenic-impacted groundwater through the glacial till to soft sediments, pore water, and surface water in the Turning Basin area of the Menominee River, as well as the potential presence of dredge residuals that may be affecting these media.	The goals of the study are to update the conceptual site model by evaluating: • Whether arsenic-impacted dredge residuals are present and potential effects on soft sediment, pore water, and surface water arsenic concentrations. • Whether vertical advective transport is occurring and potential effects on soft sediment, pore water, and surface water arsenic concentrations. • Effect (if any) of diffusion from arsenic-impacted remnant glacial till, SCM, and/or dredge residuals on soft sediment, pore water and surface water arsenic concentrations. • Whether vertical transport of groundwater, if occurring, is affecting surface water quality above regulatory criteria. • Whether arsenic migration processes are likely to result in decreasing arsenic concentrations in the upper 6 inches of soft sediment in the Turning Basin.	<u>Existing Data:</u> • Pre-dredging and post-dredging bathymetric maps showing sand cover locations and likely areas of preferential sediment deposition • Previously collected pre-dredging and post-dredging soil, sediment, groundwater, pore water, and surface water data • Stratigraphic information from previous sampling • Vertical gradient information from historical vibrating wire piezometer and paired monitoring well data and previous groundwater modeling • Previously developed site-specific Freundlich isotherm relating pore water concentrations to soft sediment concentrations <u>Data to be Collected during this Investigation:</u> • Stratigraphic information from newly collected sediment/soil cores, including stratigraphic logging of cores as soft sediment, dredge residuals, glacial till, and SCM • Hydraulic conductivity, bulk density, and grain-size measurements from undisturbed soil cores • Estimated groundwater velocity in native materials, calculated using Darcy's Law • Calculated time for vertical migration of groundwater from bedrock/till interface to soft sediment/river bottom • Total arsenic and TOC concentration data from soil cores sampled every 6 inches from river bottom to top of bedrock (vertical profile) • Total and dissolved arsenic concentrations in groundwater above bedrock collected every 2 feet • Estimates of total and dissolved arsenic concentrations in porewater every 6 inches using the previously developed Freundlich isotherm and new soft sediment data • Vertical profiles of soil and sediment concentrations • Vertical profiles of groundwater, pore water, and surface water concentrations • Total and dissolved arsenic concentrations in surface water • Estimated soft sediment concentrations if primary process is diffusion, using Fick's Laws and underlying native material concentrations • Post-dredging sedimentation rates in the Turning Basin	The horizontal boundary of the study is the Turning Basin and nearby Transition Area of the Menominee River, where the highest historical arsenic impacts were present, including those in glacial till within the Turning Basin that remain. This area also generally corresponds to those areas where soft sediment concentrations of greater than 20 mg/kg arsenic were observed in 2018. The vertical boundary is the top of bedrock, which generally ranges from 2 to 8 feet below the river-sediment interface in the Turning Basin. The temporal boundary is data collected from 1998 (pre-remedies) and later.	1a. If observed materials below soft sediment consist of SCM with concentrations in excess of 20 mg/kg (native or reworked) in areas reported to be dredged to glacial till (or to SCM with concentrations < 20 mg/kg), then it will be inferred that these materials are dredge residuals. 1b. If vertical concentrations profiles indicate soft sediment concentrations are higher than concentrations in underlying SCM or glacial till, then it will be inferred that redeposition of dredge spoils may be the source of arsenic concentrations observed in soft sediment 1c. If observed materials below soft sediment consist of undisturbed native glacial till, then it will be inferred that these materials are not dredge residuals. 2a. If groundwater velocity (calculated using Darcy's Law) indicates groundwater could not have migrated from the till/bedrock boundary to soft sediment since most recent dredging, then it will be concluded that recent vertical advective transport from bedrock is not currently affecting observed soft sediment, pore water, and surface water concentrations. 2b. If groundwater velocity (calculated using Darcy's Law) indicates groundwater could have migrated from the till/bedrock boundary to soft sediment since most recent dredging, and vertical soil and groundwater concentration profiles are consistent with vertical transport, then it will be concluded that vertical transport may be affecting observed soft sediment, pore water, and surface water concentrations. 3a. If diffusion calculations using Fick's Laws and observed groundwater and soil concentrations in uppermost materials below soft sediment (native materials or dredge residuals) are consistent with observed soft sediment, pore water, and/or surface water concentrations, then it will be inferred that diffusion from underlying native materials may be an important arsenic migration mechanism. 3b. If calculations using Fick's Laws and observed concentrations in uppermost native materials are not consistent with observed soft sediment concentrations, then it will be inferred that diffusion is not an important arsenic migration mechanism. 4a. If total and dissolved arsenic concentrations in surface water collected within approximately 1 foot of the sediment surface are greater than acute (339.8 µg/L) and chronic arsenic (152.2 µg/L) surface water criteria for warm water (Wisconsin Administrative Code NR 105.05 Tables 1 and 5), then it will be inferred that vertical transport processes may be adversely affecting surface water concentrations. 4b. If total and dissolved arsenic concentrations in surface water are less than acute (339.8 µg/L) and chronic arsenic (152.2 µg/L) surface water criteria for warm water (Wisconsin Administrative Code NR 105.05 Tables 1 and 5), then it will be inferred that vertical transport processes are not adversely impacting surface water. 5a. If predictive modeling indicates arsenic concentrations in the upper 6 inches of soft sediment (or less than 6 inches if insufficient sedimentation has occurred) in the Turning Basin are likely to decrease, then it will be inferred that the current remedial approach will continue to be protective. 5b. If predictive modeling indicates arsenic concentrations in the upper 6 inches of soft sediment (or less than 6 inches if insufficient sedimentation has occurred) in the Turning basin are likely to increase, then additional evaluation of remedy protectiveness may be necessary	Measurement errors will be controlled by using appropriate sampling methods, following established SOPs and the work plan. For reproducibility and comparability of analytical data, standard EPA-approved analytical methods will be used when available. Samples will be analyzed by accredited laboratories. Field duplicates and other quality assurance/quality control samples will be collected and analyzed to evaluate data reproducibility	The sampling design and rationale are discussed in detail in the Work Plan. Co-located cores (consisting of till, SCM, and/or soft sediment), groundwater, and surface water sampling will occur in 2019 at up to six locations. Sediment/soil cores will be collected at each location to bedrock and subsampled at 0.5-foot intervals. Groundwater samples will be collected from native materials above the bedrock at 2-foot intervals. Surface water samples will be collected approximately 6 inches above the river bottom. Sediment thicknesses will be measured at up to 15 locations. Surface water and sediment samples and sediment thickness measurements will be collected by scientific divers, while groundwater and soil cores will be obtained using a barge-mounted drilling rig. Soft sediment-only samples will be collected at two additional locations. The soil/sediment subsamples will be analyzed for TOC by Lloyd Kahn, percent moisture, and total arsenic by appropriate EPA methods consistent with past data collection on the site. The groundwater samples will be analyzed for total and dissolved arsenic and TOC and surface water samples will be analyzed for total and dissolved arsenic. At up to three locations, 2-foot undisturbed cores from the glacial till will be laboratory analyzed for hydraulic conductivity, bulk density, and grain-size. Field quality control samples will be collected at required frequencies. Analytical data will be validated.

mg/kg = milligrams per kilogram
SCM = semi-consolidated materials
SWAC = surface-weighted average concentration
TOC = total organic carbon
µg/L = micrograms per liter
SOP = standard operating procedure
EPA = U.S. Environmental Protection Agency

Table 3. Proposed Vertical Profiling Locations
Arsenic Migration Pathways Evaluation Work Plan
Tyco Fire Products LP Facility, Marinette, Wisconsin

Proposed Vertical Profile Location	Nearest 2018 Sediment Location	River Area	2018 Soft Sediment Arsenic Conc. (mg/kg)	2018 Soil Arsenic Conc. (maximum, mg/kg)	Surficial Glacial Till Conc. and Year (mg/kg)	Sand Cover?	Objectives				Notes
							Dredge Residual Presence	Vertical Transport	Surface Water Conditions	Sediment	
VP-101	SD-09	Turning Basin	380	3,900	310 (2018)	No	X	X	X	X	2018 soft sediment highest concentration location
VP-102	South of SD-09	Turning Basin	Not tested	Not tested	310 (2018)	No	X	X	X	X	Provide additional information on Turning Basin conditions near SD-09
VP-103	SD-12	Turning Basin	3.2	Not tested	139 (2010)	Yes		X	X	X	Also evaluate sand cover effectiveness; 139 mg/kg in nearest historical till sample
VP-104	SD-10	Turning Basin	9.0	Not tested	310 (2010)	Yes		X	X	X	Also evaluate sand cover effectiveness; 47 mg/kg in sand cover; 310 mg/kg in nearest historical till sample
VP-105	SD-05B	Turning Basin	85	Not tested	<1.11 (2014)	No	X	X	X	X	At bottom of dredged slope, possible dredge spoil redeposition; 1.7 mg/kg in nearest historical till sample
VP-106	SD-18	Transition Area	210	Not tested	<2.33 (2014)	No	X	X	X		Possible dredge residuals; less than 2.33 mg/kg in nearest historical till sample
SD-107	West of SD-09	Turning Basin	Not tested	Not tested	2.6 (2010)	No				X	Refine extents of soft sediment arsenic concentrations greater than 20 mg/kg in Turning Basin
SD-108	East of SD-09	Turning Basin	Not tested	Not tested	111 (2010)	No				X	Refine extents of soft sediment arsenic concentrations greater than 20 mg/kg in Turning Basin

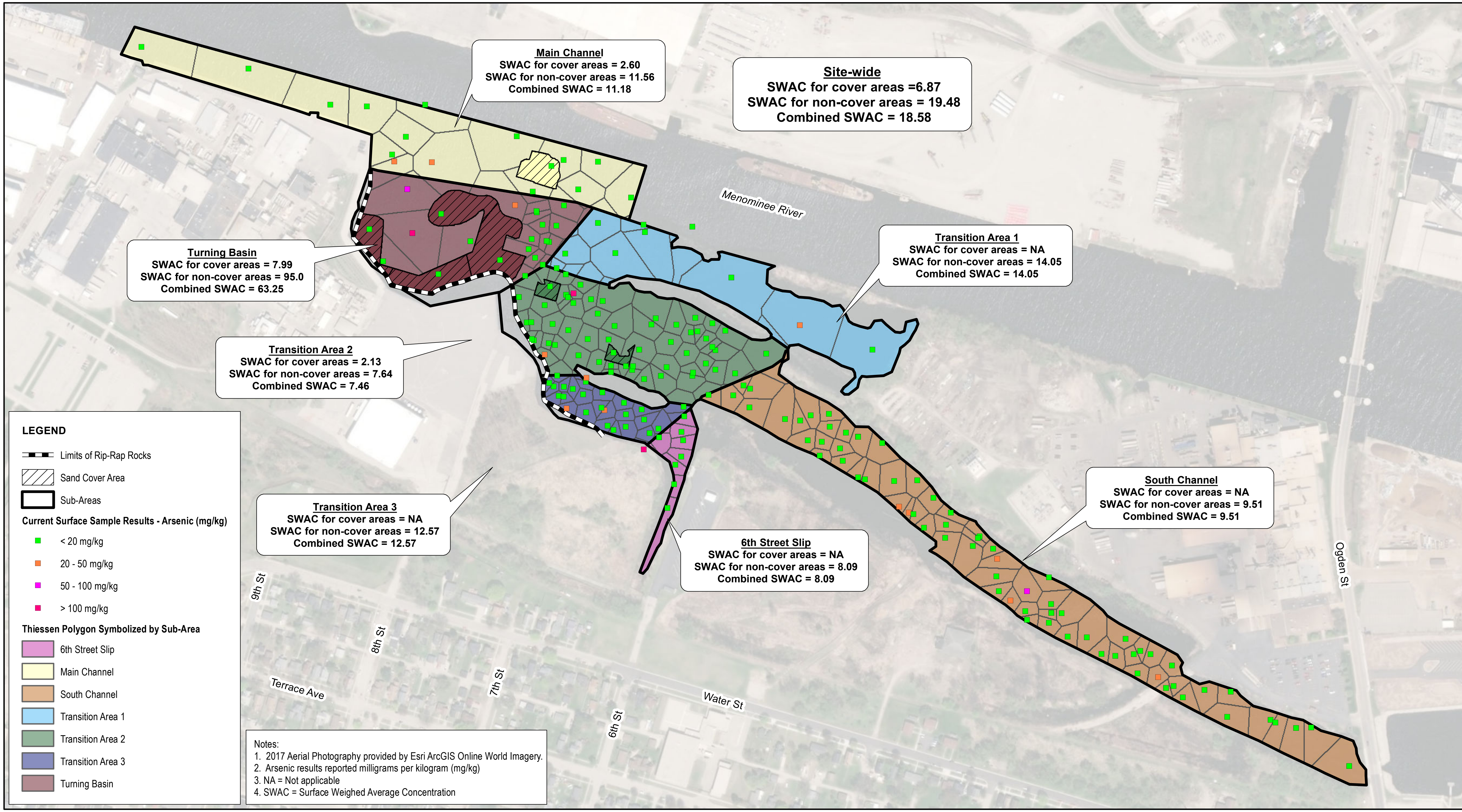
Conc. = concentration
mg/kg = milligrams per kilogram

Table 4. Summary of Sample Locations, Sampling Intervals, and Scheduled Analyses
Arsenic Migration Pathways Evaluation Work Plan
Tyco Fire Products LP Facility, Marinette, Wisconsin

Profile Location	Sample Name	Sampling Media	Northing	Easting	Sampling Method	Sampling Interval		*Analyses*								
							Analysis	Arsenic (EPA 6020A)	Total Arsenic (EPA 200.8)	Dissolved Arsenic (EPA 200.8)	Percent Moisture (2540G)	Total Organic Carbon (EPA Lloyd Kahn)	Total Organic Carbon (SM 5310C)	Bulk Density (ASTM D2937)	Grain Size (ASTM D422)	Hydraulic Conductivity (TBD)
							Sample Bottle/Preservative	4 oz. glass	250 mL Plastic	Field filtered-250 mL Plastic	4 oz. glass	2 oz. glass	40 mL vial	16 oz. glass jar	16 oz. glass jar	2' Plastic Sleeve
							Preservative	None	HNO3	HNO3	None	None	HCl or H2SO4	None	None	None
VP-101	SW-101-2019-SD/ED	Surface Water	470033	2585129	**Diver-manual**	**6 to 12" above soft sediment**			X	X						
	SD-101-2019-SD/ED	Soft Sediment			**Diver-manual**	**Every 6"**		X			X	X				
	SS-101-2019-SD/ED	Soil/Sand Cover			Drilling	Every 6"			X		X	X				
	GW-101-2019-SD/ED	Groundwater			Drilling	Every 2'		X		X			X			
	SS-101-2019-SD/ED	Soil			Drilling-Denison Sampler	One 2' interval								X	X	X
VP-102	SW-102-2019-SD/ED	Surface Water	469990	2585081	**Diver-manual**	**6 to 12" above soft sediment**			X	X						
	SD-102-2019-SD/ED	Soft Sediment			**Diver-manual**	**Every 6"**		X			X	X		X	X	
	SS-102-2019-SD/ED	Soil/Sand Cover			Drilling	Every 6"			X		X	X				
	GW-102-2019-SD/ED	Groundwater			Drilling	Every 2'		X		X			X			
VP-103	SW-103-2019-SD/ED	Surface Water	469936	2585032	**Diver-manual**	**6 to 12" above soft sediment**			X	X						
	SD-103-2019-SD/ED	Soft Sediment			**Diver-manual**	**Every 6"**		X			X	X				
	SS-103-2019-SD/ED	Soil/Sand Cover			Drilling	Every 6"			X		X	X				
	GW-103-2019-SD/ED	Groundwater			Drilling	Every 2'		X		X			X			
	SS-103-2019-SD/ED	Soil			Drilling-Denison Sampler	One 2' interval								X	X	X
VP-104	SW-104-2019-SD/ED	Surface Water	470117	2585245	**Diver-manual**	**6 to 12" above soft sediment**			X	X						
	SD-104-2019-SD/ED	Soft Sediment			**Diver-manual**	**Every 6"**		X			X	X				
	SS-104-2019-SD/ED	Soil/Sand Cover			Drilling	Every 6"			X		X	X				
	GW-104-2019-SD/ED	Groundwater			Drilling	Every 2'		X		X			X			
VP-105	SW-105-2019-SD/ED	Surface Water	470297	2585054	**Diver-manual**	**6 to 12" above soft sediment**			X	X						
	SD-105-2019-SD/ED	Soft Sediment			**Diver-manual**	**Every 6"**		X			X	X		X	X	
	SS-105-2019-SD/ED	Soil/Sand Cover			Drilling	Every 6"			X		X	X				
	GW-105-2019-SD/ED	Groundwater			Drilling	Every 2'		X		X			X			
	SS-105-2019-SD/ED	Soil			Drilling-Denison Sampler	One 2' interval								X	X	X
VP-106	SW-106-2019-SD/ED	Surface Water	469832	2585736	**Diver-manual**	**6 to 12" above soft sediment**			X	X						
	SD-106-2019-SD/ED	Soft Sediment			**Diver-manual**	**Every 6"**		X			X	X				
	SS-106-2019-SD/ED	Soil/Sand Cover			Drilling	Every 6"			X		X	X				
	GW-106-2019-SD/ED	Groundwater			Drilling	Every 2'		X		X			X			
SD-107	SD-19-2019-SD/ED	Soft Sediment	470143	2585104	**Diver-manual**	**Every 6"**		X			X	X				
SD-108	SD-20-2019-SD/ED	Soft Sediment	469975	2585231	**Diver-manual**	**Every 6"**		X			X	X				

SD- Start Depth
ED - End Depth
TBD - to be determined
Coordinate System: NAD 1983 State Plane Wisconsin Central FIPS 4802 Feet

Figures



N

0 350 700

Approximate scale in feet

Figure 1a. Arsenic Surface-Weighted Average Concentrations, Upper 6 inches of Soft Sediment/SCM

Tyco Fire Products LP Facility

Marinette, WI

\\LAKEFRONT\PROJ\TYCO\MAPFILES\2019\POREWATERWORKPLAN\FIGURE 1 - ARSENIC SWAC CONCENTRATIONS, UPPER 6 IN OF SS_11X17.MXD JHANSEN1 6/21/2019 1:37:40 PM

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0 150 300
Approximate scale in feet

Figure 1b. Arsenic Surface-Weighted Average Concentrations, Upper 6 inches of Soft Sediment/SCM
Tyco Fire Products LP Facility
Marinette, WI

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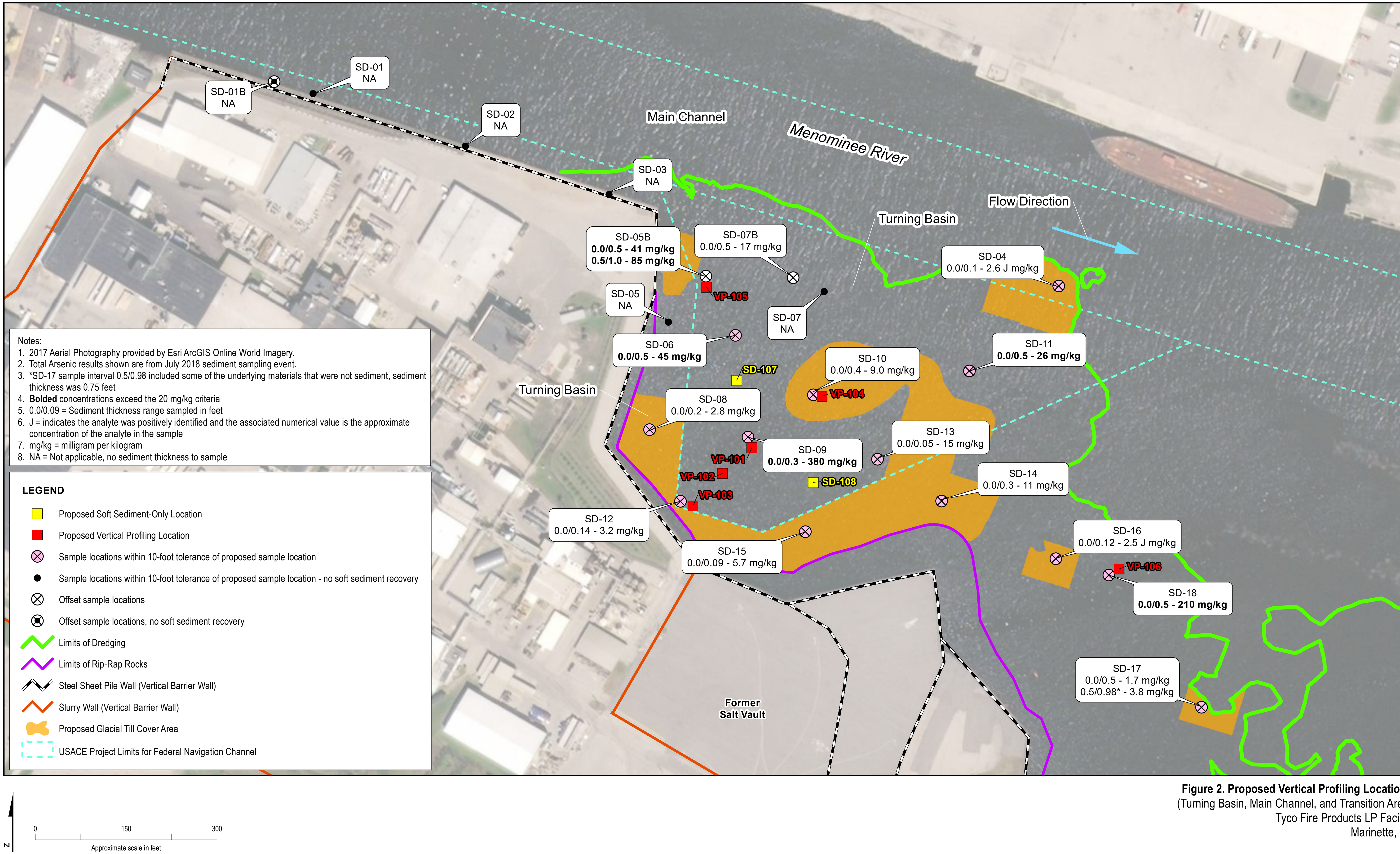
\\LAKEFRONT\PROJ\TYCO\MAPFILES\2019\POREWATERWORKPLAN\FIGURE 1 - ARSENIC SWAC CONCENTRATIONS, UPPER 6 IN OF SS.MXD JHANSEN1 6/20/2019 4:28:13 PM



Notes:
1. 2017 Aerial Photography provided by Esri ArcGIS Online World Imagery.
2. Total Arsenic results shown are from July 2018 sediment sampling event.
3. *SD-17 sample interval 0.5/0.98 included some of the underlying materials that were not sediment, sediment thickness was 0.75 feet
4. **Bolded** concentrations exceed the 20 mg/kg criteria
5. 0.0/0.09 = Sediment thickness range sampled in feet
6. J = indicates the analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample
7. mg/kg = milligram per kilogram
8. NA = Not applicable, no sediment thickness to sample

LEGEND

- Proposed Soft Sediment-Only Location
- Proposed Vertical Profiling Location
- Sample locations within 10-foot tolerance of proposed sample location
- Sample locations within 10-foot tolerance of proposed sample location - no soft sediment recovery
- Offset sample locations
- Offset sample locations, no soft sediment recovery
- Limits of Dredging
- Limits of Rip-Rap Rocks
- Steel Sheet Pile Wall (Vertical Barrier Wall)
- Slurry Wall (Vertical Barrier Wall)
- Proposed Glacial Till Cover Area
- USACE Project Limits for Federal Navigation Channel

Figure 2. Proposed Vertical Profiling Locations
(Turning Basin, Main Channel, and Transition Area)
Tyco Fire Products LP Facility
Marinette, WI

\\LAKEFRONT\PROJ\TYCO\MAPFILES\2019\POREWATERWORKPLAN\FIGURE 2 - PROPOSED VERTICAL PROFILING LOCATIONS.MXD JHANSEN1 6/18/2019 1:56:58 PM

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Appendix A
Summary of Current Arsenic Surface Concentrations

Appendix A – Summary of Current Arsenic Surface Concentrations

This appendix provides additional information on arsenic surficial concentrations remaining in the areas evaluated as part of the Menominee River sediment removal project adjacent to the Tyco Fire Products LP (Tyco) facility. Figures A-1 and A-2 depict all post-dredging arsenic concentrations at and near the post-dredge surface. To provide additional context, samples of glacial till and SCM that represented the final dredge surfaces but that do not currently represent surface conditions due to the subsequent placement of sand cover or rip-rap following dredging have also been included (shown with a clear or gray appearance on the figure to indicate it is no longer representative of surface conditions). The data sets used to develop figures A-1 and A-2, include the following:

- 2010 Sediment Investigation—Predredge samples used in areas not dredged or dredged to glacial till, samples staring with SD5## (CH2M HILL 2010)
- 2012 to 2013 Administrative Order on Consent (AOC) Sediment Removal Project (dredged to 50 milligrams per kilogram [mg/kg])—Confirmation samples in areas that were not redredged during the Legacy Act project starting with a letter or double letter and a number and sometimes have a dash with a number such as M11-2 or BB02 and VBW### (CH2M HILL 2014)
- 2014 Legacy Act Sediment Removal Project (dredged to 20 mg/kg)—Confirmation samples starting with L##-A, -B, -C or -D (CH2M HILL 2015b)
- 2018 Sediment Sampling—Samples starting with SD0## (Jacobs 2018a and 2018b)

As indicated above data depicted on these figures include glacial till concentrations (glacial till was specifically excluded in the AOC and did not require dredging), including glacial till that subsequently had sand cover placed on top of it, as well as glacial till that could not be covered by sand due to Federal Navigation Channel depth restrictions. Some sample locations have arsenic concentrations greater than 20 mg/kg. A review of the results indicates the following reasons for the observed individual arsenic concentrations greater than 20 mg/kg:

- Glacial Till—Glacial till material that was not required to be dredged, as stipulated in the Administrative Order on Consent. In locations where the river bottom elevation was 2 feet below the federal navigational channel elevation of 556.5 feet International Great Lakes Datum (IGLD) of 1985 (that is, sand could only be placed if the river bottom elevation was below 554.5 feet), a 12-inch sand cover was placed over exposed glacial till exhibiting concentrations greater than 20 mg/kg. Glacial till areas above this elevation remained exposed due to the restriction imposed by U.S. Army Corps of Engineers.
- 2018 Soft Sediment—the exact mechanism by which the sediment exceeds 20 mg/kg is to be further evaluated as part of the 2019 fieldwork. Concentrations are suspected to be the result of one of the following:
  - Glacial Till—Impacted glacial till that may have adversely affected overlying soft sediment.
  - Dredge Residuals—As with any sediment removal project, dredge residuals may include impacted materials that were inadvertently left in place. Inherent to any confirmation sampling approach, including the approved dredge management unit (DMU) approach used at the site, it is not uncommon to find concentrations above the cleanup goal at locations not specifically targeted as part of post-dredge confirmation sampling. Other dredge residual sources could include redeposition of suspended impacted materials during and shortly after dredging, or downslope transport of dredge residuals along steeper riverbed slopes that formed post-dredging (due to deepening of the dredged areas).
  - Sampling Method—Ponar sampling method that may have incorporated underlying impacted glacial till or dredge residuals.
- Riprap Placement After 2012/2013 Dredging—Sediments were dredged to 50 mg/kg in 2012 and 2013 as required by the Administrative Order on Consent. Riprap was placed at the end of the project to provide support for the sheet pile wall where the sediment and semi-consolidated materials (SCM) were removed. Subsequently, Tyco, the Wisconsin Department of Natural Resources, and the U.S. Environmental Protection Agency (EPA) moved forward with the Legacy Act dredging project in 2014;

areas adjacent to where the riprap was placed could not be removed to prevent de-stabilizing the riprap; therefore, any of these materials containing arsenic concentrations between 20 to 50 mg/kg remain in place. Like the glacial till sample locations that were buried with sand cover, post 2013 dredging sample locations that were subsequently covered with riprap are also shown with a clear or gray appearance on the figure to indicate they are no longer representative of surface conditions.

- Dredging Limitations—The equipment could not dig any deeper at L14-A. EPA approved stopping in this area, even though the 20-mg/kg cleanup goal was not met and placing sand cover over the exposed SCM.

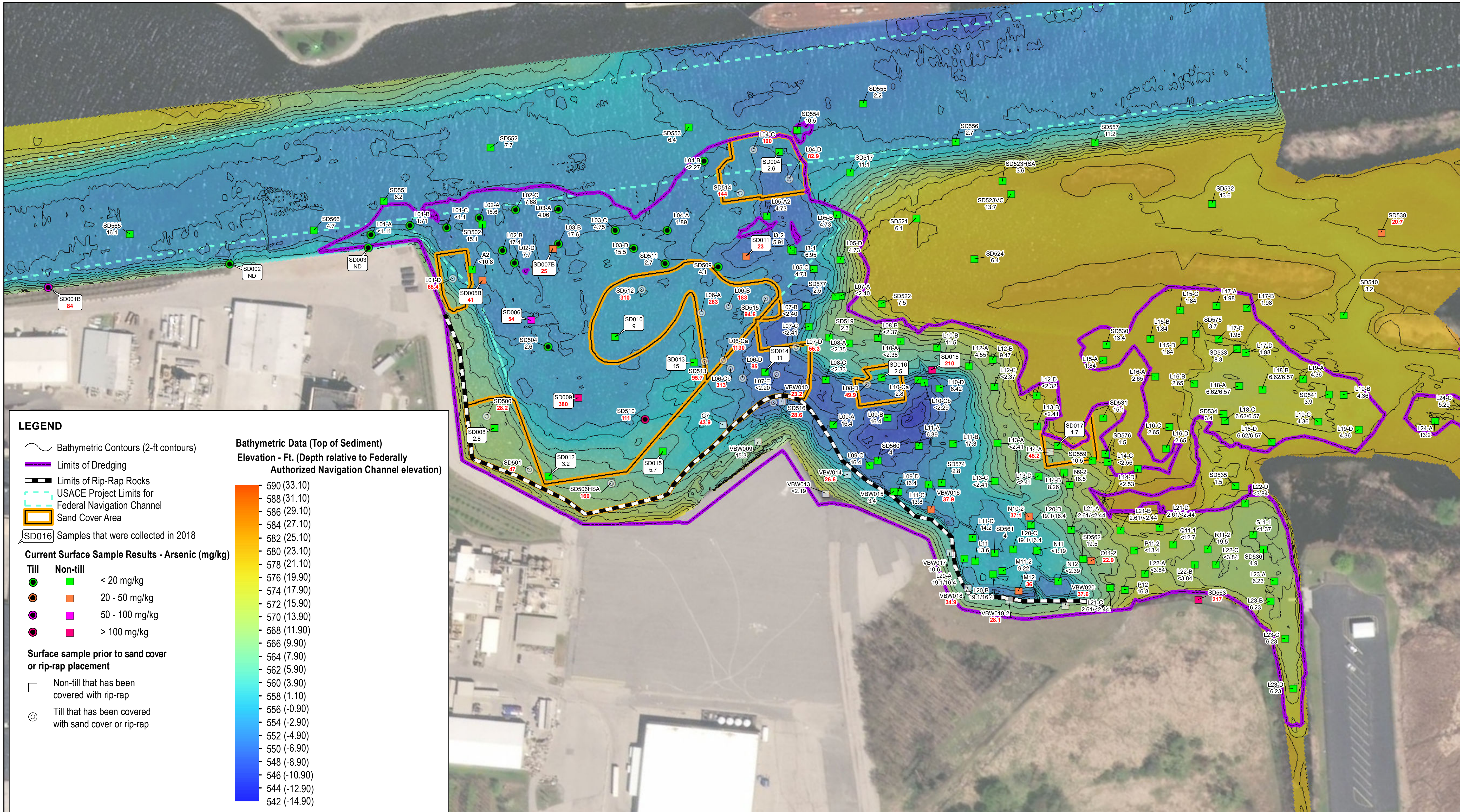
- Outside Combined (2012-2014) Dredge Area—Field survey results indicate a location did not fall within 2012/2013 or 2014 dredging footprint. There are three locations from the 2010 sediment investigation where this is the case. These locations were either isolated, not easily accessible, and/or could be related to survey accuracy between events.

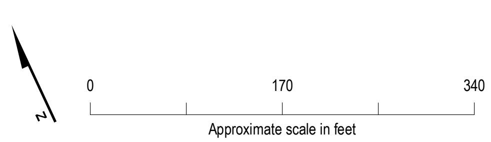
- Outside Legacy Act Project Dredge Area—Field survey results indicate seven confirmation locations were within the 2012/2013 dredge footprint (dredged to 50 mg/kg), but were either on the boundary of or outside of the Legacy Act project dredging footprint. These seven locations had concentrations between 20 and 50 mg/kg and were either not easily accessible (due to utilities or other river dynamics/features) and/or could be related to survey accuracy between events.

Locations exceeding 20 mg/kg are summarized in Table A-1 by the known or suspected reason(s) for the concentration. The 2019 arsenic migration pathway evaluation investigation will provide additional data about dredge residual presence and the arsenic migration pathways for the 2018 sediment results.

Table A-1. Surficial and Near-Surficial Locations with Greater than 20 mg/kg Arsenic

Reason for Concentration > 20 mg/kg	Locations
Glacial Till Location – not covered	SD510, SD001B (no sediment in this area, in Main Channel)
Glacial Till Location – sand cover	L01-D, SD500, SD501, SD506HSA, L06-Cb, L06-D, L06-Ca, SD513, SD515, L06-A, L06-B, SD512, L07-D, L04-C, L04-D, SD514, and L08-D
2018 Sediment over uncovered impacted till, dredge residuals, and/or Ponar sampling method	SD011, SD007B, SD006, and SD009
2018 Sediment – Likely Dredge Residuals	SD018 (also ponar sample) and SD005B (also underlain by impacted till)
Riprap – Could not be dredged due to riprap placed to stabilize vertical barrier wall after dredging to 50 mg/kg	VBW014, VBW010 (also partially glacial till), SD516 (also glacial till), VBW016, VBW018, VBW019-2, VBW020, M12, and G7 (also has cover over SCM)
Could not be dredged to full depth – exposed SCM with sand cover	L14-A
Outside Combined (2012-2014) Dredge Area	SD550, SD539, and SD563 (on land at time of dredging)
Outside Legacy Act Project Dredge Area	N10-2, O11-2, TT02, LL01, JJ01-1, EE02-01, and EE02-02





Notes:

1. Bathymetric surface and Federally Authorized Navigation Channel elevation are using the North American Vertical Datum of 1988 (NAVD 88).
2. Bathymetry represents conditions post-dredging and post-sand cover.
3. Arsenic results reported in milligrams per kilogram (mg/kg)

Figure A-1. Post Dredge Surface and Near Surface Arsenic Concentrations

Tyco Fire Products LP Facility

Marinette, WI

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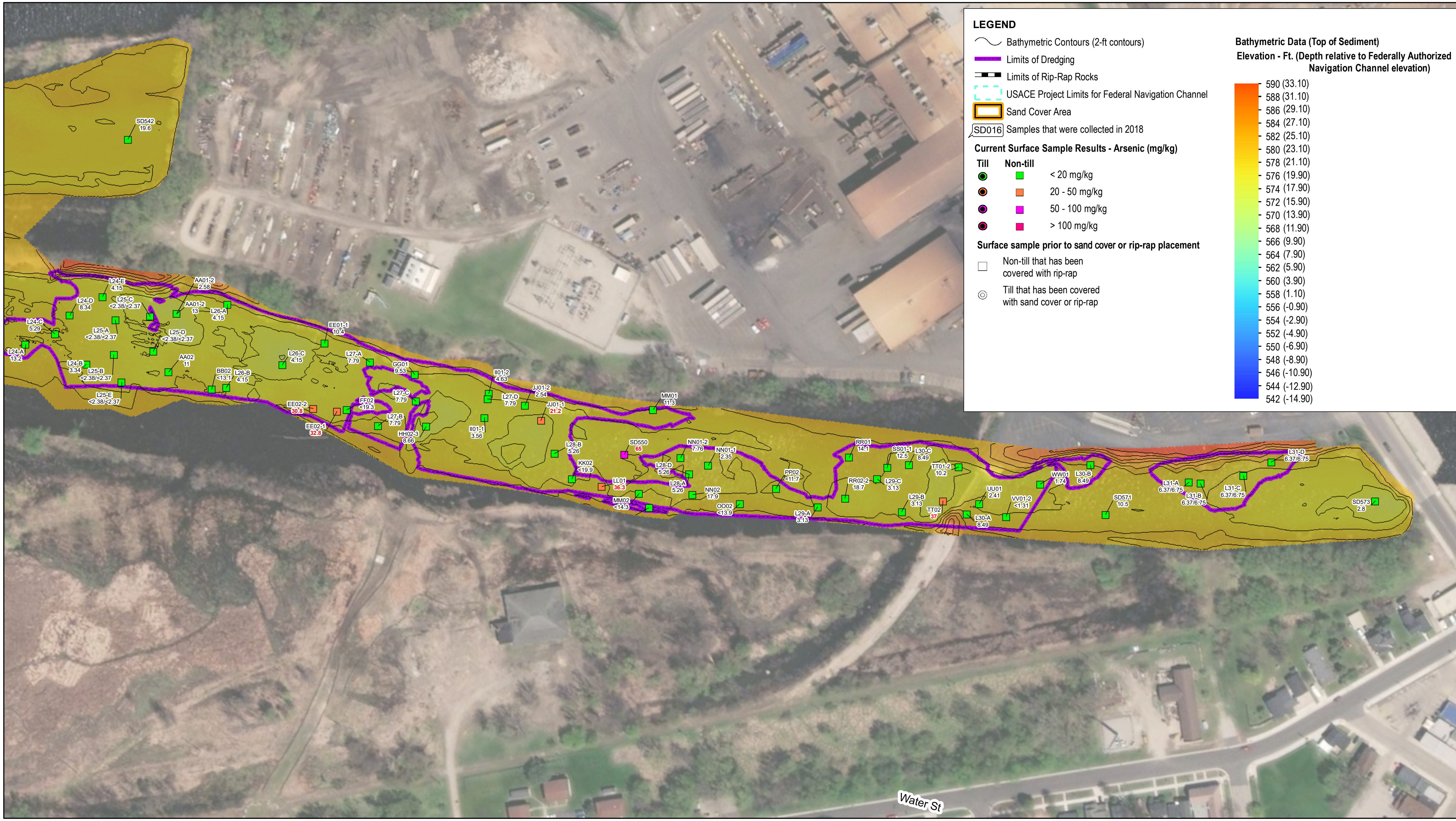
\\LAKEFRONT\PROJ\TYCO\MAPFILES\2018\SEDIMENTDATA\FIGURE A-1 - POST DREDGE SURFACE ARSENIC CONCENTRATIONS.MXD, DATE SAVED: 6/20/2019 4:20:54 PM, USER NAME: JHANSEN1



Notes:

1. Bathymetric surface and Federally Authorized Navigation Channel elevation are using the North American Vertical Datum of 1988 (NAVD 88).
2. Bathymetry represents conditions post-dredging and post-sand cover.
3. Arsenic results reported in milligrams per kilogram (mg/kg)

Figure A-2. Post Dredge Surface and Near Surface Arsenic Concentrations
Tyco Fire Products LP Facility
Marinette, WI

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\\LAKEFRONT\PROJ\TYCO\MAPFILES\2018\SEDIMENTDATA\FIGURE 2 - POST DREDGE SURFACE ARSENIC CONCENTRATIONS.MXD, DATE SAVED: 4/29/2019 12:46:00 PM, USER NAME: JHANSEN1