Tyco Enhanced Sediment Removal Plan Approach

Prepared for

Tyco Fire Products LP Facility

September 2011

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Executive Summary

Pursuant to a meeting between Tyco Fire Products LP (formerly known as Ansul Incorporated) and the U.S. Environmental Protection Agency (USEPA) on August 16, 2011, Tyco is submitting this document to provide additional technical information describing a proposed Enhanced Sediment Removal Plan (ESRP). As discussed with USEPA, most of the ESRP is identical to the USEPA-approved Sediment Removal Work Plan (SRWP) including:

- All soft sediments with arsenic concentrations greater than or equal to 50 milligrams per kilogram (mg/kg) will be removed.
- Semi-consolidated materials with arsenic concentrations greater than or equal to 50 mg/kg in the previously dredged portion of the navigational channel and along the western and southern portions of the Turning Basin will be removed.
- Monitored natural recovery (MNR) will be implemented in the area where sediments have been removed to document anticipated further reductions in sediment arsenic concentrations to achieve USEPA's target concentration of 20 mg/kg.

Table ES-1 provides a summary comparison of the proposed ESRP to the SRWP.

The ESRP differs from the SRWP in that an engineered chemical isolation layer, designed following USEPA cap design guidance, will be placed over approximately 6.2 acres of the site, instead of removing semi-consolidated materials within this area. The proposed chemical isolation layer will be protective and will provide an equivalent or higher level of overall environmental benefit compared with the USEPA-approved SWRP. Moreover, the proposed ESRP is fully consistent with the requirements of the Administrative Order on Consent (AOC), and provides equivalent or improved performance when compared to the evaluation factors considered in the Statement of Basis. The ESRP is consistent with USEPA's National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR Part 300 (the "NCP") and USEPA's national contaminated sediment policy, as embodied in the Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, OSWER 9355.0-85, December 2005 (the "Guidance") and various other USEPA policy and technical documents.

The enhancements provided by the implementation of the ESRP include:

- Providing an effective exposure barrier over semi-consolidated materials with arsenic concentrations greater than or equal to 50 mg/kg in areas outside the previously dredged area.
- Immediately restoring this portion of the project area to background conditions and meeting the media cleanup standard for arsenic of less than 20 mg/kg.
- Eliminating the need to stabilize/reconstruct the existing sheet pile wall at the 8th Street Slip, thereby eliminating the associated potential for release of or exposure to the contaminated materials contained within the cofferdam area.

Consistent with paragraph VI.11.f of the AOC, Tyco's ESRP protects human health and the environment, is legally implementable, and achieves an equivalent or higher level of protection to that of the SRWP. The following paragraphs summarize how the ESRP meets these requirements with references to the supporting technical details presented in subsequent sections of this document shown parenthetically:

- The chemical isolation layer protects human health and the environment by immediately preventing direct contact with impacted semi-consolidated materials, significantly reducing diffusive flux of the soluble arsenic (Section 4), and by eliminating the potential for the resuspension of arsenic-impacted sediment and the release of arsenic associated with dredging.

  The sorption capacity of a chemical isolation layer comprised of 18 inches of native sediment or its equivalent (Section 4.3) will effectively prevent releases of arsenic from exceeding chronic water quality standards. Consistent with USEPA's cap design guidance, accounting for natural sedimentation processes that effectively reduce arsenic concentrations in surface sediments, and also conservatively using the highest measured concentrations of total arsenic concentrations at the site, the chemical isolation layer will essentially provide permanent protection. Thus, while also minimizing dredging-related resuspension and releases from these semi-consolidated sediments.

- Use of the chemical isolation layer is legally implementable and consistent with both the Guidance and the current state of practice.
  - Placement of the chemical isolation layer does not require a statutory amendment to deauthorize a portion of the federal navigation channel nor will it impact the current uses of the Turning Basin.[1]
  - Use of risk management principles to evaluate and select a combination remedy, such as that proposed in the ESRP, which includes a site-specific appropriate mix of dredging, containment, and MNR, is consistent with the Guidance and current best management practices for contaminated sediment sites.

- The level of protection to ecological and human receptors provided by the chemical isolation layer is equivalent to or greater than the removal of semi-consolidated materials described in the SRWP, as follows:
  - Protectiveness within the area of the chemical isolation layer of the ESRP will immediately achieve, and in fact is expected to be lower than, the long-term performance requirement of 20 mg/kg because the material used in the isolation layer will represent sediment background conditions within the river (Section 4).
  - The exposure barrier provided by the chemical isolation layer, which is immediately effective, will become more effective over time, as natural sedimentation processes are expected to increase the thickness of the sorptive material over the semi-consolidated sediments. This will provide an immediate and increasing level of

[1] U.S. Army Corps of Engineers (USACE) authorization to place the chemical isolation layer can be accomplished administratively, coupled with Tyco's agreement to remove this layer in the event the full-authorized depth is deemed necessary by USACE. See Section 3.2.1 for additional details.

protection for both human and ecological receptors in the area of the chemical isolation layer.

– To demonstrate that the chemical isolation layer is protective and functioning as intended, Tyco will develop a monitoring plan, as discussed in Section 5, in addition to the natural recovery monitoring and submit this for USEPA approval. As with the MNR approach, a contingency plan will be developed if monitoring over the specified period indicates the chemical isolation layer is not achieving its performance standards.

To further demonstrate that Tyco's proposal is equivalent in performance to the approach conditionally approved by USEPA on June 1, 2011, Table ES-2 compares the ESRP to the SRWP using the evaluation factors USEPA cited in the Statement of Basis.

The SRWP is technically and economically impracticable because the ESRP is an equally, if not more, protective remedy that is also more cost effective than the SRWP remedy. Per the NCP, the ESRP is more cost effective because its "costs are proportional to its overall effectiveness" whereas the SRWP's costs ($37,600,000) are significantly greater than the ESRP's costs ($23,300,000), but its overall effectiveness is not greater. This represents a 53 percent increase in the project cost for no corresponding increase in risk reduction. Moreover, the NCP directs that the "remedial action selected shall be cost effective" (40 CFR §300.430(f)(1)(ii)(D)). Additionally, an "important risk management function generally is to compare and contrast the costs and benefits of various remedies" (USEPA 2005, 7-1). Thus, applying the NCP and the risk management principles embodied in the Guidance, the ESRP should be considered the preferred remedy and the SRWP is impracticable compared to the ESRP.

As part of the ESRP, Tyco also proposes that conventional dredging be used in the area proposed for expanded dry excavation.

- Dry excavation of the South Channel as originally proposed can be implemented effectively because of the shallow water conditions, easily contained area, shallow nature of the impacts (restricted to soft sediments only), and the extensive debris located in the area. However, expansion of the dry excavation area, as proposed by USEPA, is less implementable because it is technically more challenging to install the sheet piling and will require additional sheet piling to isolate the area along the island. This requirement is estimated to add between $500,000 and $800,000 to the cost of the project, and will address only 56,000 cubic yards of material representing 11 percent of the arsenic mass, which may be removed by dry excavation in this area, the remainder would require dredging to remove. Thus, for little environmental benefit in the form of a potential reduction in the resuspension and release of arsenic, the expansion of the dry excavation area would pose significantly greater technical challenges and increase costs.
- Consistent with the performance-based approach outlined in the AOC (which focuses on the results achieved and allows Tyco flexibility in implementation), Tyco requests the opportunity to propose alternate construction methods as part of the final dredging design that will achieve the same, or a higher level of protectiveness as the work required to expand the dry excavation area.

Tyco remains committed to meeting the November 1, 2013, construction completion date as required by the AOC, and none of the changes proposed herein will compromise meeting that target.

TABLE ES-1
Remedy Comparison

Remedy	Enhanced Remedy	USEPA SRWP in June 2010 Approval Letter	Comparison
Soft Sediment Removed (cubic yards)	89,700	89,700	Same – all soft sediments containing concentrations of arsenic greater than 50 mg/kg are removed.
Semi-consolidated Material Removed (cubic yards)	12,887	144,376	ESRP removes semi-consolidated material in the majority of the Turning Basin area consistent with the SRWP. A portion of the materials will be addressed through chemical isolation layer placement within the Turning Basin (eastern portion) and adjacent to the 8th Street Slip and wetlands
Semi-consolidated Material Addressed through Chemical Isolation Layer Placement (cubic yards)	131,489	0	ESRP's chemical isolation layer placed over a portion of the semi-consolidated material.
Area of Soft Sediment Removed (Acres)	19.3	19.3	Same – all soft sediments containing concentrations of arsenic greater than 50 mg/kg are removed.
Area of Semi-consolidated Material Removed (Acres)	2.9	9.1	ESRP manages the other acres of semi-consolidated material containing concentrations of arsenic greater than 50 mg/kg by placing a chemical isolation layer over that portion of the semi-consolidated material.
Area of Semi-consolidated Material Addressed through Chemical Isolation Layer Placement (Acres)	6.2	0	ESRP manages the other acres of semi-consolidated material containing concentrations of arsenic greater than 50 mg/kg by placing a chemical isolation layer placed over that portion of the semi-consolidated material.
Percent of Total Arsenic Targeted for Removal – Project Total	53	100**	ESRP leaves some semi-consolidated material containing concentrations of arsenic greater than 50 mg/kg.
Percent of Total Arsenic Managed – Project Total (%)	100	100	Same amount managed to provide equivalent long-term protection.
Estimated Cost (including contingency)	$23,300,000	$37,600,000	ESRP is more cost effective than the SRWP.

** - does not include generated residuals

TABLE ES-2
Comparison of SRWP and ESRP

Statement of Basis Evaluation Criteria	SRWP	ESRP
Protect Human Health and the Environment	Relies on technology and construction techniques to manage environmental impacts during dredging.	Reduced removal area will reduce potential for resuspension of solids and releases of arsenic, reduces volume of water to be treated and potential for other environmental exposures associated with dredging. Placement of chemical isolation layer along the 8th Street Slip sheet pile wall area retains wall stability, continues to provide a barrier to groundwater migration and, in those areas where the chemical isolation layer is placed, provides a surface that meets or is lower than the ultimate arsenic goal of 20 mg/kg.
Attain Media Cleanup Standards	Arsenic cleanup level of 20 mg/kg will be reached through MNR over time.	The material in the chemical isolation layer will meet all media cleanup standards immediately.
Comply with Any Applicable Standards for Management of Wastes	Waste generated during remediation will be properly characterized, managed and disposed.	Installation of the chemical isolation layer will reduce the amount of waste generated by approximately 56 percent. All remediation waste that is generated will be properly characterized, managed and disposed as indicated in the SRWP.
Control Sources and Releases	Relies on technology and construction techniques to manage environmental impacts during dredging.	Placement of the chemical isolation layer will physically isolate contaminated sediments, effectively control potential releases of arsenic to surface water and will reduce the releases associated with dredging.
Long-term Reliability and Effectiveness	Dredging can be successfully applied to sites. If MNR is not demonstrated to be effective, then a contingency plan will be required.	The chemical isolation layer will be effective at controlling releases and the results of modeling indicate that the chemical isolation layer has an estimated conservative service life of approximately 750 years once natural recovery processes are considered. Performance monitoring of the chemical isolation layer will be included in the O&M plan (see Section 5), and if data show that the overall remedy performance standards are not met, then a contingency plan will be provided.
Reduction in the Toxicity, Mobility or Volume of Waste	The SRWP provides for removal of approximately 234,000 cubic yards of contaminated sediment, or approximately 192,500 pounds of arsenic.	The ESRP removes 53 percent of the arsenic mass specified in the SRWP. The chemical isolation layer will immobilize arsenic in the underlying sediments and render it unavailable to ecological receptors.
Short-term Effectiveness	Relies on technology and construction techniques to manage environmental impacts during dredging.	The short-term effectiveness of the chemical isolation layer is high, because it will provide an immediate improvement in surface water quality following construction and will provide 6.2 acres of clean sediment bed material. In addition, the ESRP will result in a reduced release of arsenic during construction compared to the SRWP because less material will be dredged.

TABLE ES-2
Comparison of SRWP and ESRP

Statement of Basis Evaluation Criteria	SRWP	ESRP
Implementability	In addition to the permits, controls and monitoring plans required to successfully implement the SRWP, additional work will be required to stabilize the existing sheet pile wall to allow removal of semi-consolidated sediments at the toe.	Implementation of the chemical isolation layer can be done without additional controls or monitoring beyond those needed for the dredging. Authorization or permit may be obtained from the U.S. Army Corps of Engineers allowing placement of the chemical isolation layer in the navigational channel area. Further, placement of the chemical isolation layer will allow the existing sheet pile wall to remain undisturbed – eliminating that technically challenging element of the SRWP.
Construction Completion Date	November 1, 2013	November 1, 2013
Estimated Cost (including contingency)	$37,600,000	$23,300,000

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Acronyms and Abbreviations

µg/L	micrograms per liter
AMRSRP	Alternative Menominee River Sediment Removal Plan
AOC	Administrative Order on Consent
BMP	best management practice
bss	below the sediment surface
cm/yr	centimeters per year
ESRP	Enhanced Sediment Removal Plan
facility	Tyco Fire Products LP, Marinette, Wisconsin
Guidance	Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, USEPA, OSWER 9355.0-85, December 2005
L/kg	liters per kilogram
lb/ft^2	pounds per square foot
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNR	monitored natural recovery
MOA	Memorandum of Agreement
NCP	National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR Part 300
RCRA	Resource Conservation and Recovery Act
site	Tyco Fire Products LP, Marinette, Wisconsin
SRWP	Sediment Removal Work Plan
TCLP	toxicity characteristic leaching procedure
TSS	total suspended solids
Tyco	Tyco Fire Products LP
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WDNR	Wisconsin Department of Natural Resources
WQC	water quality criteria

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SECTION 1

1 Introduction

This document was prepared at the request of the U.S. Environmental Protection Agency (USEPA) to compare and contrast the Sediment Removal Work Plan (SRWP) as approved by USEPA on June 1, 2011, with Tyco Fire Products LP's (Tyco, formerly known as Ansul Incorporated) proposed Enhanced Sediment Removal Plan (ESRP). In fact, most of the components of the SRWP and the ESRP approaches are identical. A project completed following either the SRWP or the ESRP will remove by dredging most of the arsenic contained in the impacted soft sediment and semi-consolidated silts and sands (also referred to herein as semi-consolidated materials). The main difference between the two approaches is that the ESRP uses a chemical isolation layer to eliminate the risk from a select portion of the semi-consolidated material instead of removing all the material by dredging. Key points of the ESRP approach are as follows:

- Equally or more protective of human health and the environment as the SRWP
- Consistent with Administrative Order on Consent (AOC) requirements and the Statement of Basis
- Eliminates risk of 8th Street Slip sheet pile wall compromise or failure resulting from removal of semi-consolidated materials, which are adjacent to and supporting the wall
- More cost effective than relying solely on dredging with a greater degree of immediate net environmental benefit because of the accelerated recovery of the waterbody because of the presence of the chemical isolation layer

1.1 Project Background

The Tyco site is an active manufacturing facility in the City of Marinette in northeastern Wisconsin, adjacent to the south shore of the Menominee River (herein referred to as the facility or site; Figure 1). The property is bordered by the Menominee River to the north; the 6th Street Slip and City of Marinette property to the east; Water Street, City of Marinette property, Marinette School District property, and residential properties to the south; and Stanton Street and Marinette Marine Corporation to the west.

The facility consists of approximately 63 acres, including a manufacturing area on the western part of the property and an undeveloped area to the east, referred to as the "wetlands area." A fence surrounds both parts of the facility, and access is restricted.

For ease of reference, the portion of the Menominee River that is the focus of this remedial action has been divided into seven areas as shown on Figure 1. These areas include:

- Main Channel – generally defined as the area north of the site and is the location of the primary navigation channel within the river

- Turning Basin – generally defined as the area bounded to the south and west by Tyco property; the east by the approximate limits of the previously dredged navigation channel; and to the north by the Main Channel of the Menominee River
- Transition Area 1 – shallow water area located east of the Turning Basin that is bounded on the north and south by islands and Waupaca Foundry property to the east
- Transition Area 2 – shallow water area located east of the Turning Basin and to the west by the South Channel of the Menominee River
- Transition Area 3 – relatively shallow water area located directly north of undeveloped Tyco property referred to as the wetlands
- 6th Street Slip – former logging slip located adjacent to the City of Marinette public boat launch area
- South Channel – shallow water channel of the Menominee River bounded to the north by Waupaca Foundry property, to the south by City of Marinette property, and to the east by Ogden Street

The facility has been the subject of numerous investigations starting in 1974. The investigations evaluated the soils and groundwater at the site and sediment, semi-consolidated materials, pore water, and surface water in the adjacent Menominee River. The primary investigation activities concluded in 2009 with the signing of the AOC between Tyco and USEPA on February 26, 2009. The AOC focused on implementation of site remediation activities including those to address onsite soil and groundwater, as well as and soft sediments and semi-consolidated materials in the Menominee River.

Tyco commenced remedial actions at the site in 2009. Initial work included the installation of a slurry wall along the western, southern, and eastern boundaries of the manufacturing area, the placement of covers over several areas containing elevated concentrations of arsenic in surficial soils, and augmentation of the existing phyto-pumping plots. During 2010, Tyco completed the installation of a sheet pile wall along the riverfront of the facility that tied into the previously installed slurry wall and completed the containment of site groundwater[2]. In addition, Tyco installed a groundwater extraction and treatment system to remove and treat groundwater to prevent flooding of the plant site. Lastly, Tyco completed an extensive investigation within the Menominee River to assess the extent of arsenic impacts in the soft sediments and semi-consolidated material.

In December 2010, Tyco submitted the SRWP and the Alternative Menominee River Sediment Removal Plan (AMRSRP). USEPA approved with modifications the SRWP in June 2011. The SRWP included the removal of all soft sediment and semi-consolidated material in the river with arsenic concentrations greater than or equal to 50 milligrams per kilogram (mg/kg). In addition, USEPA's approval letter suggested the expansion of the dry excavation area that was proposed in the AMRSRP.

[2] The sheet pile wall is distinct from the 8th Street Slip sheet pile wall that was installed in the late 1990s.

1.2 Project Objectives

Most of the components of the SRWP and ESRP approaches are identical – the main difference between the two approaches is that the ESRP uses a chemical isolation layer to eliminate the risk from a portion of the semi-consolidated material with concentrations of arsenic greater than 50 mg/kg in areas outside of the previously dredged area instead of removing the material by dredging.

The placement of a chemical isolation layer over the semi-consolidated material with concentrations of arsenic greater than 50 mg/kg in the areas outside of the previously dredged area will meet the following objectives:

- Provide a sorptive barrier between the impacted semi-consolidated material and benthic organisms
- Be as protective of human health and the environment in the long term as removal of the semi-consolidated material by isolating the impacted semi-consolidated materials
- Be more protective in the short-term by reducing dredging-related impacts such as resuspension and release

1.3 Summary of Enhanced Sediment Removal Plan Approach

The ESRP approach is outlined in the following sections, including a comparison of the components that are identical and those that vary from the SRWP, and are further summarized in Table 1.

TABLE 1
Remedy Comparison

Remedy	Enhanced Remedy	USEPA SRWP in June 2010 Approval Letter	Comparison
Soft Sediment Removed (cubic yards)	89,700	89,700	Same – all soft sediments containing concentrations of arsenic greater than 50 mg/kg are removed.
Semi-consolidated Material Removed (cubic yards)	12,887	144,376	ESRP removes semi-consolidated material in the majority of the Turning Basin area consistent with the SRWP. A portion of the materials will be addressed through chemical isolation layer placement within the Turning Basin (eastern portion) and adjacent to the 8th Street Slip and wetlands
Semi-consolidated Material Addressed through Chemical Isolation Layer Placement (cubic yards)	131,489	0	ESRP's chemical isolation layer placed over a portion of the semi-consolidated material.
Area of Soft Sediment Removed (Acres)	19.3	19.3	Same – all soft sediments containing concentrations of arsenic greater than 50 mg/kg are removed.
Area of Semi-consolidated Material Removed (Acres)	2.9	9.1	ESRP manages the other acres of semi-consolidated material containing concentrations of arsenic greater than 50 mg/kg by placing a chemical isolation layer over that portion of the semi-consolidated material.
Area of Semi-consolidated Material Addressed through Chemical Isolation Layer Placement (Acres)	6.2	0	ESRP manages the other acres of semi-consolidated material containing concentrations of arsenic greater than 50 mg/kg by placing a chemical isolation layer placed over that portion of the semi-consolidated material.
Percent of Total Arsenic Targeted for Removal – Project Total	53	100**	ESRP leaves some semi-consolidated material containing concentrations of arsenic greater than 50 mg/kg.
Percent of Total Arsenic Managed – Project Total (%)	100	100	Same amount managed to provide equivalent long-term protection.
Estimated Cost (including contingency)	$23,300,000	$37,600,000	ESRP is more cost effective than the SRWP.

** - does not include generated residuals

Consistent with the Guidance, Tyco will implement a combination remedy including dredging, treatment, disposal, placement of a chemical isolation layer, and monitored natural recovery , which will consist of four primary phases. The elements involved in each phase are provided below.

1.3.1 Sequencing

Phase I (Mechanical Dredging of Impacted Soft Sediment)

Phase I of the ESRP (Mechanical Dredging of Impacted Soft Sediment) is identical to the approved SRWP except the ESRP also conducts dredging of soft sediment rather than conducting dry excavation of soft sediment in the area that the SRWP, as modified by USEPA, called the expanded portion of the dry excavation area. The soft sediment that contains total arsenic concentrations greater than or equal to 50 mg/kg will be mechanically dredged using an environmental clamshell bucket and treated onsite. Figure 2 shows the location of soft sediments to be removed during Phase I. The treatment process will reduce the concentration of leachable arsenic in the sediment such that it passes the toxicity characteristic leaching procedure (TCLP) test with less than 5 milligrams per liter (mg/L) of total arsenic. The treated soft sediment will be disposed offsite at a Resource Conservation and Recovery Act (RCRA) Subtitle D (nonhazardous) landfill.

Phase II (Dredging of and Placement of a Chemical Isolation Layer over the Semi-Consolidated Material)

Phase II of the ESRP (Dredging of and Placement of a Chemical Isolation Layer over the Semi-Consolidated Material) is identical to the SRWP in the previously dredged area of the navigational channel in the Turning Basin and the southern and western portion of the Turning Basin area outside the navigational channel. In these areas, the semi-consolidated material that contains total arsenic concentrations greater than or equal to 50 mg/kg will be mechanically dredged. Figure 3 shows the location of semi-consolidated materials to be removed during Phase II. The mechanical dredging will utilize an environmental clamshell bucket to the extent practical. However, it is anticipated that most of the dredging of the semi-consolidated material will require a standard clamshell bucket because the material's cohesive strength, as documented by the high blow counts obtained during sampling activities, makes using an environmental bucket technically impractical.

Based on initial treatability testing, it is anticipated that a stabilization process will be needed for a portion of the semi-consolidated material to pass the TCLP test for total arsenic. The semi-consolidated material will be disposed offsite at a RCRA Subtitle D landfill.

In addition, Phase II of the ESRP will include placement of a chemical isolation layer over the semi-consolidated material that contains total arsenic concentrations greater than or equal to 50 mg/kg that is outside the historically dredged area of the Turning Basin. Figure 3 shows the location of the proposed chemical isolation layer to be placed during Phase II. The chemical isolation layer will consist of material similar in chemical characteristics, such as sorptive capacity, to non-impacted soft sediment and with sufficient thickness that the layer will provide an environmentally protective barrier between the impacted semi-consolidated material and benthic organisms. The chemical isolation layer will be armored to provide long-term protection of the sorptive layer from bioturbation and forces such as propeller wash. A conceptual isolation layer and armoring approach is presented in Section 4.6.

Phase III (Dry Excavation of Soft Sediment from the South Channel)

Phase III of the ESRP (Dry Excavation of Soft Sediment from the South Channel) is identical to the SRWP within the South Channel. Sheet piling will be installed to hydraulically isolate the South Channel, and water inside the temporary enclosure will be pumped out. Figure 2 shows the location of the sheet pile and the area to be excavated during Phase III. Conventional excavation equipment (backhoes and articulated haulers) will be used to stabilize the soft sediment in situ, excavate it, and transport it back to the facility for treatment and disposal offsite at a RCRA Subtitle D landfill.

Phase IV (O&M of Chemical Isolation Layer and Monitoring Natural Recovery)

Phase IV consists of operations, maintenance and monitoring of the chemical isolation layer, as well as monitoring as part of the monitored natural recovery (MNR) component of the combination remedy.

Chemical Isolation Layer Operations, Maintenance, and Monitoring

The monitoring activities for the chemical isolation layer are presented in Section 5. A detailed operation and maintenance plan is due to the agency as part of the design and specifications submittal.

Monitored Natural Recovery

Soft sediment and semi-consolidated material containing arsenic at concentrations between 20 and 50 mg/kg will be left in place. The area will be monitored for natural recovery for a period of 10 years to determine whether the ultimate goal of reducing total arsenic concentrations to 20 mg/kg or less has been met.

A plan for MNR will be described in detail under a separate submittal due to the agency by November 1, 2012.

SECTION 2

2 Soft Sediment Removal

2.1 Existing Conditions

In addition to characterizing the current conditions throughout the areas of soft sediment contamination, the 2010 sediment investigation represented the first time a comprehensive evaluation of the underlying semi-consolidated sands and silts and glacial till had been performed as it involved the widespread collection and analysis of continuous samples of sediments and soils to depths of up to 34 feet below the sediment surface (bss). In total, 78 cores were advanced and 722 samples were collected for arsenic analysis. A total of 335 samples were collected from the soft sediments. The results of this most recent investigation were presented in the Sediment Removal Work Plan (CH2M HILL 2010).

The 2010 sediment investigation analytical data were used to define the lateral and vertical extent of the arsenic-impacted soft sediment greater than 20 mg/kg. The distribution of arsenic within the soft sediments and the volume and mass of these impacted materials in addition to the mass of arsenic estimated to be associated with them is important to evaluating the effectiveness of a chemical isolation layer, and is summarized in the following subsections.

2.1.1 Contaminant Distribution

The observed thicknesses of soft sediments ranges from less than 0.5 foot in the Main Channel of the Menominee River to as much as 8 feet along the northwestern end of Transition Area 1 (identified on Figure 1) and at the mouth of the 6th Street Slip. The lateral distribution of the highest concentration of arsenic detected within the soft sediments is illustrated on Figure 4.

The highest concentrations of arsenic observed within the soft sediment are located within the central portions of the Turning Basin and towards the Main Channel of the Menominee River where the thicknesses of these deposits range from 1 to 5 feet and total arsenic concentrations up to 19,600 mg/kg were observed in samples. In general, concentrations in the Turning Basin area are an order of magnitude greater than observed elsewhere and are an order of magnitude greater than what has been measured in the most impacted intervals of the underlying semi-consolidated materials.

Farther to the southeast between the Turning Basin and the Transition Areas there is a large area of non-impacted soft sediments (total arsenic concentrations less than 20 mg/kg) before elevated concentrations are observed immediately adjacent to the shoreline straddling the border between Transition Areas 2 and 3. Here the thickness of soft sediments is approximately 5 feet and contains up to 5,030 mg/kg of arsenic which was observed at core location SD527 between 3.5 and 4 feet bss.

Soft sediment concentrations of total arsenic beyond the Turning Basin and adjacent to the shoreline between Transition Areas 2 and 3 generally are below 200 mg/kg. The next highest total arsenic concentration (227 mg/kg) has been observed within the 6th Street Slip in the top 4 feet of soft sediment. Farther into the slip, the total arsenic concentrations in the top 4 feet of the soft sediment decline and below 4 feet the arsenic concentrations are less than 50 mg/kg. The northeastern portion of Transition Area 2 and the South Channel have still lower concentrations of arsenic that generally do not exceed 100 mg/kg and where impacts above 50 mg/kg are found only in the top 2 feet of soft sediment.

2.1.2 Area, Volume and Mass

A total of approximately 89,700 cubic yards of soft sediments with arsenic concentrations greater than or equal to 50 mg/kg are located over approximately 19.3 acres within the Menominee River project area. The soft sediments to be removed contain approximately 83,000 pounds of arsenic, representing 43 percent of the total arsenic mass to be addressed during remediation. Figure 5 shows the volume and mass of arsenic present in the soft sediments in each area of the project site.

2.2 Proposed Approach

2.2.1 Description

The removal of soft sediment in the approved SRWP and the proposed ESRP both meet the AOC requirement to remove all soft sediment with arsenic concentrations greater than or equal to 50 mg/kg. The approach to removal of the soft sediments are identical in both plans, except that the ESRP does not propose to expand dry excavation beyond the South Channel area as suggested in the approved with modifications SRWP. Soft sediments requiring removal in all areas except the South Channel will be mechanically dredged using an environmental clamshell bucket and treated onsite. Soft sediment removal in the South Channel will be conducted by dry excavation and treatment onsite.

Additional details on the mechanical dredging approach for soft sediment removal in the ESRP approach are as follows:

- Mechanical dredging of approximately 77,700 cubic yards of soft sediment impacted with arsenic greater than or equal to 50 mg/kg using an environmental bucket, following best management practices (BMPs), and loading the sediment into watertight scows
- Transporting loaded scows to the mooring area adjacent to the facility
- Pumping free water off the dredged material to the temporary water treatment system
- Offloading dredged material from the scows
- Treating and stabilizing the impacted dredged material with suitable reagents to reduce leachable arsenic, eliminate free water, and provide moderate strength gain
- Allowing sufficient time for reagents added to sediment to react to meet landfill acceptance criteria
- Conducting sampling and analysis to verify compliance with disposal criteria
- Placing the stabilized sediment into trucks
- Covering the truck bed and decontaminating the exterior of the trucks

- Transporting the sediment to a RCRA Subtitle D landfill
- Collecting and treating wastewater through the temporary water treatment system
- Performing ongoing monitoring activities, including turbidity monitoring in the river, and monitoring of arsenic and suspended solids concentrations in the influent to and effluent from the water treatment system
- Performing a bathymetric survey to document the post-removal subsurface elevations
- Performing sampling of post-dredge surface to document removal

Dry Excavation

Dry excavation of soft sediment in the South Channel is identical in the ESRP to that proposed in the SRWP. A cofferdam (sheet piling) will be installed at the western end of the South Channel; additional sheet piling may be required on the east end of the South Channel depending on river water levels. Water inside the temporarily contained area will be pumped out. Conventional excavation equipment (backhoes and articulated haulers) will be used to stabilize the soft sediment in situ, excavate it, and transport it back to the facility for treatment and disposal offsite at a RCRA Subtitle D landfill.

Dry excavation of the soft sediments was selected as the remedial approach for the soft sediments in the South Channel for the following reasons:

- The South Channel appears to be easily isolated through installation of a temporary cofferdam located near the 6th Street Slip area. Cranes positioned on dry land likely could install this cofferdam. The proposed location of the cofferdam is shown on Figure 6.
- Debris, such as wood scraps and metal shavings that are remnants of historical milling operations in the area, is abundant on the bottom of the channel. This debris makes wet dredging with an environmental clamshell bucket difficult and inefficient.
- Water depths in the South Channel typically range from less than 1 foot to approximately 2 feet. These depths are generally too shallow to float dredging equipment into the channel
- Based on existing data, only the soft sediments appear to be impacted in the South Channel. These soft sediments are generally less than 2 feet thick.

Expansion of the dry excavation area as outlined in the approved with modifications SRWP (Figure 6) has not been included in the ESRP for the following technical and economic reasons:

- The modified SRWP proposes that the sheet piling be installed between the 8th Street Slip cofferdam and an island in the river and from the island to land owned by ThyssenKrupp (Waupaca Foundry). During project-related activities, this island at times has been submerged and is largely covered with wetland-type grasses. The instability of the island subsoils would prevent it from successfully serving as a portion of the hydraulic barrier during dry excavation activities. Therefore, it would be necessary to install sheet pile along the entire length of the island at an additional cost ranging from $500,000 to $800,000.

- Unlike the cofferdam proposed for the South Channel area, the sheet pile would require installation by a barge-mounted crane under very challenging conditions. The area near the island requiring sheet piling would be extremely difficult to access because of the presence of additional islands within the area and the relatively shallow water depths within this area (approximately 2 to 3 feet).
- The expanded dry excavation area contains soft sediments and semi-consolidated material that exceed the 50 mg/kg cleanup goal. The impacted semi-consolidated material extends to a depth of approximately 27 feet. As a result, removal of semi-consolidated materials would be limited because of structural failure concerns similar to those associated with the 8th Street Slip area; that is, only a relatively small volume (approximately 56,000 cubic yards and 11 percent of the total arsenic mass) of semi-consolidated material could actually be removed through dry excavation. The remainder of the semi-consolidated material would require removal through dredging. Figures 7 and 7a show the location of a cross-section through the expanded dry excavation sheet pile and highlight the material that must remain in place during dry excavation to maintain wall stability. The SRWP calls for a cofferdam alignment through an area of semi-consolidated materials that lie on top of a bedrock layer that precludes the deeper (that is, more stable and resistant to adjacent excavation) installation of the sheet pile.

Additional details on the dry excavation approach of the ESRP are as follows:

- Mobilizing equipment necessary specifically for Phase III activities
- Pumping free water on top of the sediment to the river until total suspended solids (TSS) exceeds 80 mg/L in the discharged water
- Pumping remaining free water within the sediment to the onsite temporary water treatment system
- Installing well points to facilitate additional dewatering below the top of sediment and pumping this water to the onsite temporary water treatment system
- Stabilizing approximately 12,000 cubic yards of soft sediment impacted with arsenic greater than 50 mg/kg in situ using an excavator, excavating the stabilized sediment, and loading the sediment into articulated trucks to transport the material back to the stabilization area on the facility (some stabilization reagents might be added to the soft sediment before it is transported to the facility in order to dry it out)
- Treating and stabilizing the impacted dredged material with suitable reagents to reduce leachable arsenic, eliminate free water, and provide moderate strength gain
- Allowing sufficient time for reagents added to sediment to react to meet landfill acceptance criteria
- Conducting sampling and analysis to verify compliance with disposal criteria

- Placing the stabilized sediment into trucks
- Covering the truck bed and decontaminating the exterior of the trucks
- Transporting the sediment to a RCRA Subtitle D landfill
- Collecting and treating wastewater through the temporary water treatment system
- Performing ongoing monitoring activities, including turbidity monitoring in the river, monitoring of arsenic and suspended solids concentrations in the influent to and effluent from the water treatment system, and monitoring of fugitive dust emissions from the stabilization activities
- Performing confirmation sampling to document that materials with arsenic concentrations exceeding 50 mg/kg have been removed
- Performing a survey to document the post-Phase III subsurface conditions
- Removing sheet piling and the berm required to provide access for sheet pile installation and removal equipment

2.2.2 Protectiveness

All the soft sediment with arsenic concentrations greater than or equal to 50 mg/kg will be removed under either the ESRP or the SRWP.

2.2.3 Short-Term and Long-Term Effectiveness

Both the ESRP and the SRWP conduct dry excavation of soft sediments in the South Channel, which eliminates the resuspension and release of arsenic to surface water in that area. Both the ESRP and SRWP remove soft sediment in the Turning Basin by mechanical dredging. To reduce the resuspension and release of arsenic during that dredging, BMPs will be implemented.

The long-term effectiveness of both the ESRP and the SRWP are identical as they both remove the impacted soft sediment.

2.2.4 Implementability

The ESRP is more implementable and cost effective than the SRWP. The approved with modifications SRWP poses significant technical challenges that result from the proposed expansion of the dry excavation area. These include issues related to installing the extra sheet piling and dewatering the proposed dry excavation area. Specifically, installation of sheet piling in the expanded dry excavation area would be more challenging and costly to implement successfully because of the shallow water levels and need for increased sheet pile placement along emergent wetland areas.

2.2.5 Cost

The SRWP's expansion of the dry excavation area requires significantly more sheet piling and water treatment than the ESRP. Therefore, the SRWP is estimated to cost $500,000 to $800,000 more than the ESRP to install the extra sheet piling and to provide the additional water treatment.

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SECTION 3

3 Semi-Consolidated Material

The SRWP specifies the removal of all semi-consolidated material containing arsenic concentrations greater than or equal to 50 mg/kg. The AOC also allows for the semi-consolidated material to be addressed in an alternate manner. The ESRP approach involves removing a portion of the semi-consolidated materials with arsenic concentrations greater than 50 mg/kg and placing a chemical isolation layer and armoring over the rest.

The ERSP is identical to the SRWP in the previously dredged area of the navigational channel in the Turning Basin and the southern and western portion of the Turning Basin area outside the navigational channel. In these areas, the semi-consolidated material that contains total arsenic concentrations greater than or equal to 50 mg/kg will be mechanically dredged. An environmental clamshell bucket will be used where possible in the upper, less compacted layers of the semi-consolidated material, but it is anticipated that mechanical dredging will largely be performed using a standard clamshell bucket because of the relatively high cohesive nature of the semi-consolidated material as evidenced by the high blow counts recorded during the sampling of this material.

The ESRP includes placement of a chemical isolation layer over the semi-consolidated material that contains total arsenic concentrations greater than or equal to 50 mg/kg that is outside the historically dredged portion of the Turning Basin. This includes semi-consolidated material located in the eastern portion of the Turning Basin, near the 8th Street Slip cofferdam, and near the shoreline of the wetlands area. Figure 7 shows the location of both the dredged and the chemical isolation layer areas. Figures 7a and 7b show the profile of the soft sediments and semi-consolidated material to be removed and the semi-consolidated material to be covered by the chemical isolation layer

The chemical isolation layer will consist of material similar in chemical characteristics to non-impacted soft sediment and with sufficient thickness that the layer will provide an environmentally protective barrier between the impacted semi-consolidated material and benthic organisms. The chemical isolation layer will be armored as necessary to provide long-term protection of the layer from bioturbation and forces associated with propeller wash, and flooding, and seiche events. Details regarding the chemical isolation layer are provided in Sections 4 and 5.

3.1 Existing Conditions

The 2010 sediment investigation analytical data were used to define the lateral and vertical extent of the arsenic-impacted semi-consolidated materials greater than 20 mg/kg. The distribution of arsenic within the semi-consolidated materials and the volume and mass of these impacted materials in addition to the mass of arsenic estimated to be associated with them is summarized in the following subsections.

3.1.1 Contaminant Distribution

Semi-consolidated materials have been observed at depths below the sub-bottom ranging from 0 feet along the shoreline in the Turning Basin and within the Main Channel of the river to approximately 5 feet south of the Turning Basin. The greatest thicknesses of these deposits are found beneath the soft-sediments within the Transition Areas where they have been observed down to depths of over 30 feet and at thicknesses of up to almost 27 feet. To the north in the direction of the Turning Basin and the Main Channel, the semi-consolidated deposits thin and generally are present at thickness of 2 to 5 feet.

The lateral distribution of the highest concentration of arsenic detected within these semi-consolidated material deposits from each of the 2010 sediment cores is illustrated on Figure 7. The highest concentrations of arsenic observed within the semi-consolidated sands and silts are located within the thinner and sometimes discontinuous deposits of this material in the central portions of the Turning Basin. With the exception of some near shore areas, the impacts here extend throughout the entire thickness of the deposits that range from 3 to 5 feet in thickness. Samples collected from the semi-consolidated sands and silts within the Turning Basin have shown concentrations of arsenic as high as 2,870 mg/kg and on average are greater than 600 mg/kg.

To the southeast of the Turning Basin, concentrations within the semi-consolidated material deposits remain elevated in deeper intervals that are generally 10 to 15 feet below the current sediment surface and approximately 5 feet below the top of these deposits. Although still elevated, at 1,410 mg/kg, the highest concentrations of arsenic measured here is half of what has been observed in the Turning Basin, and is at a depth of 11 feet below the base of the soft sediment versus 2.5 feet. The average concentration of arsenic measured within the interval of semi-consolidated materials 5 to 10 feet below the base of the soft sediment is approximately 274 mg/kg. Lower average concentrations of 105 and 156 mg/kg are observed in the overlying (0- to 5-foot) and underlying (10- to 15-foot) intervals, respectively.

Arsenic concentrations above 50 mg/kg within the semi-consolidated materials are found only in near shore areas farther south. The southern extent of these impacts reaches as far as core SD562 (to the north of the mouth of the 6th Street Slip) where only one of the 22 continuous samples collected from these deposits exceeded 50 mg/kg at a concentration of 65.6 mg/kg.

Profiles of existing conditions that show arsenic concentrations over depth and the associated stratigraphy have been generated for both the Turning Basin and areas outside the Turning Basin (Figure 8). These profiles illustrate the general distribution of arsenic within the semi-consolidated deposits where arsenic concentrations greater than 50 mg/kg are present and show conditions within the overlying soft sediments associated with each area.

3.1.2 Area and Volume

Approximately 144,400 cubic yards of semi-consolidated materials with arsenic concentrations greater than or equal to 50 mg/kg are located over approximately 9.1 acres within the Menominee River project area. Impacted soft sediments currently overlie the majority of these semi-consolidated materials. Figure 5 shows the volume and mass of arsenic present in the soft sediments in each area of the project site.

3.2 Proposed Approach

3.2.1 Turning Basin Area

Semi-consolidated material containing arsenic concentrations greater than or equal to 50 mg/kg will be removed from the base of the previously dredged portion of the navigational channel. As a result, portions of the navigational channel will be deeper than the authorized depth of 21 feet below the low water level (577.5 feet above mean sea level). In addition, semi-consolidated material along the western and southern portion of the Turning Basin will be removed to meet the AOC requirement of 50 mg/kg. The removal of the material from the base of the navigational channel and the western and southern portions of the Turning Basin are identical to the removal approach presented in the SRWP. A general profile of conditions following the proposed dredging activities within the Turning Basin is illustrated on Figure 8. Figure 8 also compares the post-dredging conditions proposed as part of the ESRP to existing conditions and illustrates how the proposed approach is identical to the SWRP within the portion of the Turning Basin previously dredged by the U.S. Army Corps of Engineers (USACE).

The eastern portion of the navigational channel that has never been dredged will not be dredged, but will be covered with a chemical isolation layer and armored to protect from bioturbation and propeller wash and other events, such as flooding and seiche.

Preliminary discussions suggest that USACE is receptive to Tyco’s proposal to install a chemical isolation layer for remediation purposes in a small portion of the historically undredged portion of the Turning Basin if memorialized in a Memorandum of Agreement (MOA) such as the MOA for the Lockheed Shipyard in Seattle Washington. The MOA would require Tyco to dredge the chemical isolation areas to the navigational channel authorized depth in the future, if USACE determines necessary.

Additional details on semi-consolidated material removal in the ESRP approach are as follows:

- Mechanical dredging of approximately 12,900 cubic yards of semi-consolidated material impacted with arsenic greater than or equal to 50 mg/kg using an environmental bucket to the extent practical followed by removal using a standard clamshell bucket, following BMPs, and loading the sediment into watertight scows
- Transporting loaded scows to the mooring area adjacent to the facility
- Pumping free water off the dredged material to the temporary water treatment system
- Offloading dredged material from the scows
- Treating and stabilizing the impacted dredged material with suitable reagents to reduce leachable arsenic, eliminate free water, and provide moderate strength gain
- Allowing sufficient time for reagents added to material to react to meet landfill acceptance criteria

- Conducting sampling and analysis to verify compliance with disposal criteria
- Placing the treated materials into trucks
- Covering the truck bed and decontaminating the exterior of the trucks
- Transporting the material to a RCRA Subtitle D landfill
- Collecting and treating wastewater through the temporary water treatment system
- Performing ongoing monitoring activities, including turbidity monitoring in the river, and monitoring of arsenic and suspended solids concentrations in the influent to and effluent from the water treatment system
- Performing confirmation sampling to document that materials with arsenic concentrations exceeding 50 mg/kg have been removed
- Performing a bathymetric survey to document the post-removal subsurface elevations

Navigation Considerations

The Turning Basin is part of a federally authorized navigational channel with an authorized channel depth of 21 feet below the low water data (577.5 feet above sea level). The navigational channel is used by industry for maneuvering ships within the river. Industrial users include Marinette Marine in Marinette, Wisconsin and K&K Integrated Logistics in Menominee, Michigan. Recreational boaters and anglers also use the navigational channel.

Dredging restrictions have been imposed within the navigational channel because of the elevated arsenic concentrations in the soft sediments that have deposited within the Turning Basin since the last navigational dredging event. As a result, the Turning Basin currently does not meet the authorized depth requirements. In addition, it is important to note, that a portion of the Turning Basin located along the eastern portion has never been dredged. Figure 9 is a map showing the elevation of the current configuration of the Turning Basin.

To develop the proposed approach, navigational considerations included use by industries located along the river (including Marinette Marine Corporation and K&K Integrated Logistics) and USACE navigational channel authorization. Details of the available information are presented below.

Marinette Marine Corporation Use of the Turning Basin

Tyco conducted discussions with Marinette Marine Corporation representatives on July 29, 2011, to develop a further understanding of use and operational limitations related to the current and potential future configuration of the Turning Basin. Specific topics included:

- Current and potential future Turning Basin configuration
- Operational use of the Turning Basin
- Anchoring restrictions
- General propulsion operations

A summary of the specific topics is provided below.

Current and Future Configuration

Marinette Marine Corporation has not encountered issues with the current configuration of the Turning Basin related to operations. However, Marinette Marine Corporation has noted that during some operations, soft sediment is resuspended.

Operational Use of the Turning Basin by Marinette Marine Corporation

Marinette Marine Corporation generally uses the Turning Basin during two evolutions associated with ship construction. The first use of the Turning Basin typically occurs immediately following the launch of a new ship. Tugs will tow the ship to the Turning Basin and perform a "Y" turn in the Turning Basin and Main Channel of the Menominee River, then return the ship to the facility for additional outfitting.

The second evolution is during sea trials conducted in Lake Michigan, which usually last for 7 to 14 days. As required by contract, Marinette Marine Corporation ships pass under the Ogden Street bridge bow forward. As a result, the Turning Basin is used to properly turn the ship for docking and further outfitting or modification. During this evolution, the ship operates under its own power.

The current configuration of the Turning Basis has in no way hindered operational use of the Turning Basin by Marinette Marine Corporation. Therefore, no additional dredging is warranted for current navigational purposes. Although soft sediment often is resuspended during the evolutions, to Marinette Marine Corporation representative's knowledge, no ships have ever run aground on the semi-consolidated material beneath the soft sediments in the Turning Basin.

Anchoring Restrictions

As part of the evaluation of remedial actions to be conducted in the Menominee River, the question has been raised of whether a permanent restriction on anchoring may be required to prevent damage to the area containing the chemical isolation layer. USEPA requested input from Marinette Marine Corporation on impact to operations if "EPA establishes legal restrictions to boat traffic that may include no trenching or anchoring in areas where caps are allowed…"

Based on our discussion, Marinette Marine Corporation conducts required anchoring evolutions as part of the sea trials in Lake Michigan, generally at predetermined depths. Anchoring in the Turning Basin during launching or sea trials is not a standard practice and has rarely, if ever, occurred.

However, the safety of the ship and crew are of the utmost importance and should an emergency arise during use of the Turning Basin, anchoring may be required to protect the ship and crew. Any emergency anchoring situation will be addressed through the operation and maintenance plan requiring communication with Tyco to allow Tyco to inspect and repair any damage to the isolation layer or its armoring. The institutional controls currently applicable to the study area would in all likelihood be continued for the area addressed by the chemical isolation layer.

General Propulsion Operations

During rotating the ship after launching, tug propeller propulsion is used to safely maneuver the ship. In addition, ships, like the Littoral Combat Ship currently being constructed, utilize a water jet propulsion system. Both systems are designed to generate significant propulsion during operations.

During launch operations, tugs may be required to use significant propulsion to maneuver the ship. As noted above, soft sediment has been resuspended during these operations under current conditions. Under post-dredging conditions, these soft sediments will be removed and resuspension will be eliminated. Normal sea trial evolutions do not require high levels of propulsion during use of the Turning Basin.

While propulsion cannot be restricted in the Turning Basin to maintain safe operations of ships during evolutions, the final design of the isolation layer will include sufficient armoring to maintain protectiveness.

K&K Integrated Logistics Use of the Turning Basin

A telephone conversation with a K&K Integrated Logistics representative was conducted on August 26, 2011, to obtain an understanding of use and limitations related K&K Integrated Logistics operations. K&K Integrated Logistics indicated the operations are not hindered by the current configuration of the Turning Basin. Ships, generally less than 400 feet in length, with a draft of 6 to 7 meters, perform 180-degree turns (spins) in the Turning Basin. No anchoring is conducted and maneuvering is very controlled and precise in the Turning Basin.

USACE Approach

Because the current configuration of the Turning Basin poses no limitations to operations, and a mechanism is in place to obtain a permit/authorization from USACE, Tyco proposes that no dredging be performed in the eastern portion of the Turning Basin that historically has never been dredged. This area, referred to herein as "the wedge" will not be removed as part of the ESRP; however, a chemical isolation layer with sufficient armoring will be placed over the area.

Removal of Material

The ESRP proposes to remove all soft sediments in the navigational channel with arsenic concentrations equal to or greater than 50 mg/kg. This achieves the AOC requirement. Semi-consolidated material in the previously dredged portion of the Turning Basin that contain arsenic concentrations greater than or equal to 50 mg/kg also will be removed to achieve the AOC requirement. As a result, a large portion of the navigational channel will be dredged to a depth greater than the authorized channel requirement (556.5 feet above mean sea level). Figure 10 identifies the anticipated resulting elevation in the Turning Basin following removal of materials. The eastern portion of the Turning Basin that has not been previously dredged will be covered by the chemical isolation layer and protective armoring.

3.2.2 Outside Turning Basin Area

This area is comprised of the eastern portion of the Turning Basin area outside the navigational channel, the area adjacent to the 8th Street Slip, and the area along the wetlands to the east of the 8th Street Slip. The ESRP plan differs in this area from the SRWP. The SRWP includes removal of all semi-consolidated material that contains arsenic concentrations greater than or equal to 50 mg/kg. The ESRP does not propose to remove any semi-consolidated material from this area but instead proposes the placement of a chemical isolation layer over the semi-consolidated materials following removal of the soft sediment. This approach does not jeopardize the integrity of the 8th Street Slip cofferdam and is equally (if not more) as protective to the environment as removal in accordance with the SRWP. A general profile of conditions following the proposed soft sediment dredging and capping activities in areas along the eastern edge of the Turning Basin and farther east is illustrated on Figure 8. Figure 8 also compares the post-dredging and capping conditions here to the existing conditions as well as to the approach set forth in the SRWP for this area.

The chemical isolation layer will cover an area of 6.2 acres in the area outside the navigational channel, along the 8th Street Slip and wetlands area. The chemical isolation layer will be armored to protect against bioturbation, propeller wash, and forces associated with flooding and seiche events. No loss of water depth is anticipated in this area. The performance of the isolation layer is discussed in Section 4.

8th Street Slip Wall Stability

Wall Purpose and Construction Components

As presented in the SRWP and discussed in the USEPA June 1, 2011, approval document, removing impacted semi-consolidated material adjacent to the sheet pile wall was determined to be technically impractical, because removing the material to the depth required to achieve removal of all material with concentrations greater than 50 mg/kg would result in failure of the sheet pile wall. As such, approximately 5,000 cubic yards of semi-consolidated material would not be removed. The SRWP included a discussion and figures highlighting the concern. Figure 11 shows the location of the semi-consolidated materials of concern adjacent to the sheet pile wall.

As shown on Figure 11, the area of concern related to structural failure is located adjacent to the 8th Street Slip cofferdam, not the recently installed sheet pile wall. The 8th Street Slip cofferdam was installed in the late 1990s as a part of the interim action completed in the 8th Street Slip. At the time, USEPA required that Tyco stop the migration of surface water and soft sediments into the river from the 8th Street Slip. The cofferdam was installed solely for containing the surface water and soft sediment in the slip until such time that groundwater could be contained in the area and soft sediments removed. Therefore, the cofferdam sheet pile was only installed to a depth necessary for stability to contain surface water; not installed to bedrock as has been conducted at the remainder of the site.

A secondary sheet pile wall was installed inside the cofferdam to the depth of bedrock, again, solely for containing groundwater in the area. The focus of subsequent remedial action in this area was the soft sediment, semi-consolidated materials were not considered for removal at that time. As such, the sheet pile installed in this area does not have tiebacks or other structures that would stabilize the wall to allow for semi-consolidated material removal to the depths required. To implement the SRWP in this area, the construction of an expensive structure to reinforce the sheet pile wall before dredging adjacent to the 8th Street Slip area is required. In contrast, the ESRP places a chemical isolation layer over the semi-consolidated material and maintains the structural integrity of the 8th Street Slip sheet pile wall. A schematic cross-section of the area is included as Figures 11a.

It is important to note that impacted semi-consolidated materials are present between the inner sheet pile wall and the cofferdam. These materials currently are covered by asphalt because of capping the 8th Street Slip area; however, under the SRWP the impacted materials would be exposed in the subsurface following removal of semi-consolidated material adjacent to the cofferdam. The only way to address these materials would be by removing the cofferdam to allow access; however, the same stability issue described for the cofferdam also would be associated with the inner sheet pile wall.

3.3 Protectiveness

All of the semi-consolidated materials containing concentrations of arsenic greater than or equal to 50 mg/kg will be managed under either the ESRP or the SRWP, and therefore, are protective of human health and the environment. Under both the ESRP and SRWP, semi-consolidated materials containing concentrations of arsenic greater than or equal to 50 mg/kg located in previously dredged areas of the Turning Basin will be dredged. In areas outside the previously dredged areas of the Turning Basin, under the ESRP, semi-consolidated materials containing concentrations of arsenic greater than or equal to 50 mg/kg will be managed through placement of a chemical isolation layer composed of a sorptive layer and, in areas potentially exposed to forces associated with propellers, floods, or seiches, an armor layer over the sorptive layer. This chemical isolation layer is expected to effectively permanently sequester arsenic and will be monitored to verify its effectiveness. That is, it is expected that the chemical isolation layer will permanently prevent the flux of arsenic in concentrations exceeding the State of Wisconsin Water Quality chronic criterion to the bioactive zone when natural sedimentation is considered.

Use of the chemical isolation layer to manage in place the impacted semi-consolidated materials is consistent with the Guidance, which notes that "deeper contaminated sediment that is not currently bioavailable or bioaccessible, and that analyses have shown to be stable to a reasonable degree, do not necessarily contribute to site risks" Guidance at 7-3. By managing the impacted semi-consolidated materials with a chemical isolation layer, these semi-consolidated materials will be stable and will not contribute to site risks. Thus, leaving them in place will be protective and consistent with USEPA's national contaminated sediment policy.

3.4 Short-Term and Long-Term Effectiveness

The ESRP is more short-term effective than the SRWP because the ESRP dredges less semi-consolidated material in this area. Less dredging reduces resuspension of semi-consolidated material and, thus, water quality impacts will be reduced when compared to the SRWP approach. The ESRP also is more effective in the long-term than the SRWP, because the chemical isolation layer will accelerate the recovery of the waterbody.

3.5 Implementability

The ESRP is more implementable than the SRWP because the ESRP does not jeopardize the integrity of the 8th Street Slip cofferdam. The ESRP avoids the structural integrity issues by managing in place the impacted semi-consolidated materials, which are critical to the support of the cofferdam, with a chemical isolation layer. The SRWP's proposed engineering solution to prevent the release of impacted materials behind the 8th Street Slip cofferdam during dredging is technically very challenging. Thus, the ESRP's use of the chemical isolation layer is more implementable than the SRWP's use of dredging, and it is more cost effective.

3.6 Cost

The cost of implementation of the ESRP is approximately $14,300,000 less than the cost to implement the SRWP in this area.

4 Chemical Isolation Layer

The ESRP will manage in place the semi-consolidated materials containing arsenic concentrations exceeding 50 mg/kg with a protective engineered chemical isolation layer designed according to USEPA and USACE cap design guidance (Palermo et al. 1998). These sediments are located between 1 and 28 feet below the current sediment surface along the eastern edge of the Turning Basin, within near shore areas adjacent to the 8th Street Slip, and the wetlands area. Given the potentially mobile nature of sediment accumulations in this location, and considering probable environmental impacts associated with dredging-related arsenic releases as discussed previously, placement of a protective chemical isolation layer is appropriate for these areas.

Consistent with USEPA and USACE guidance, the preliminary design of the chemical isolation layer was evaluated by Dr. Danny Reible of the University of Texas. A copy of Dr Reible's work is included in Appendix A. This evaluation was based upon the following assumptions:

- All soft sediments with arsenic concentrations greater than or equal to 50 mg/kg will be removed.
- Semi-consolidated materials in excess of 50 mg/kg in the previously dredged areas of the Turning Basin will be dredged, removing both the highest concentrations of arsenic and maintaining navigation depths in the active portion of the Turning Basin.
- Sediment concentration profiles in the soft sediments and underlying semi-consolidated sediments are adequately represented by the sediment data collected in 2010.
- Sediment-pore water partitioning is approximated by measurements of bulk solids arsenic and filtered pore water concentrations in 2003 core samples.
- Onshore remedial efforts will effectively eliminate any potential groundwater upwelling in the near shore sediments leaving diffusion as the primary arsenic transport mechanism.

The dredging of the soft sediments and semi-consolidated materials to the authorized navigation depths, will remove most of the arsenic mass present in these areas. Semi-consolidated sediments containing arsenic at concentrations greater than 50 mg/kg will remain outside of the navigation areas. The protectiveness of the chemical isolation layer placed to effectively contain this remaining arsenic also considered river flooding events and potential sediment movement caused by propeller/ jet pump wash produced by vessels within the Turning Basin. This evaluation does not represent a final isolation layer design but instead evaluates the potential protectiveness of such a layer and identifies the key characteristics, such as thickness and sorption capacity, to ensure that such a layer will be protective.

4.1 Proposed Isolation Layer Location and Semi-Consolidated Material Conditions

The extent of semi-consolidated materials containing arsenic concentrations greater than 50 mg/kg that will be left in place and managed with a chemical isolation layer is shown on Figure 7.

With the exception of the area around SD513, where the semi-consolidated material currently is found at approximately 0.5 feet bss, the depth of the semi-consolidated materials throughout the area proposed for the chemical isolation layer is approximately 4 to 5 feet bss. Extending to depths of approximately 30 feet bss, impacted semi-consolidated material has been observed at thicknesses of up to 25 feet down to the surface of the glacial till.

In general, concentrations within these materials are greatest in the 10- to 15-foot bss depth interval where a maximum concentration of 1,410 mg/kg was observed and the average of all samples throughout this interval is 274 mg/kg. Above and below this interval, in the 5- to 10-foot and 15- to 20-foot intervals, the maximum observed concentrations within the semi-consolidated materials are 524 and 692 mg/kg, respectively. The average arsenic concentration is 105 mg/kg between 5 and 10 feet bss, and 156 mg/kg between 15 and 20 feet bss. Below a depth of 20 feet, isolated occurrences of elevated arsenic concentrations as high as 1,310 mg/kg have been observed; however, concentrations decline below 25 feet as the semi-consolidated materials contain less arsenic and/or the glacial till is encountered. A general profile of existing conditions that illustrates the observed arsenic concentrations over depth and the associated stratigraphy within the area where a chemical isolation layer is proposed is provided on Figure 7a.

4.2 Protectiveness

A chemical isolation layer will be placed across the area illustrated on Figure 7 to ensure long-term protection consistent with USEPA and USACE cap design guidance, and to ensure equal or greater protectiveness to that which would be achieved through removal in this area. As discussed in more detail in Appendix A, the chemical isolation layer will limit the upward migration of arsenic by providing a sorption barrier that will effectively sequester the mobile arsenic fraction before its reaching the shallow overlying biologically active zone. Ultimately, the chemical isolation layer will prevent the exposure of ecological receptors to concentrations of arsenic exceeding the applicable Wisconsin water quality criteria (WQC) (acute or chronic toxicity) that could result from the remaining arsenic within the semi-consolidated materials at concentrations above 50 mg/kg.

4.3 Effectiveness of the Isolation Layer

To ensure that the long-term protectiveness described above can be achieved, an evaluation of the chemical isolation layer's ability to effectively contain the remaining arsenic was performed consistent with USEPA and USACE cap design guidance. This analysis, detailed in Appendix A, focused on modeling the migration of arsenic from semi-consolidated materials where an isolation layer will be placed on top of the material exposed by the proposed dredging. The sorptive component of the modeled chemical isolation layer is clean, soft sediment from the site. Although relatively mobile organic arsenic species are present at the site, site-specific data demonstrate that the arsenic has a strong affinity for sorption to these sediments, ensuring the protectiveness of the proposed chemical isolation layer engineered cap in this setting.

This modeling effort was performed by Dr. Reible and is summarized below. A technical memorandum detailing the assumptions, methods, and conclusions associated with this work is provided as Appendix A. In addition to the modeling efforts, a preliminary design-level assessment was performed for the isolation layer and its overlying armoring components' stability in the face of hydrodynamic forces associated with flooding events and boating activity to further ensure the protectiveness of the isolation layer.

4.3.1 Performance Modeling

Modeling of a hypothetical chemical isolation layer that accounts for the observed distribution of arsenic relative to the proposed soft sediment dredging, and the observed sediment-pore water partitioning for arsenic at the site was performed. This work evaluated the feasibility of preventing exceedances of the Wisconsin WQC within the shallow biologically active zone pore water through placement of a chemical isolation layer.

Post-Dredge Conditions

The existing 2010 sediment core data were evaluated to assess the concentrations of total arsenic that will remain at depths below the proposed isolation layer. Based on this data evaluation, a profile of total arsenic concentrations over depth that will remain at the site was developed and is depicted on Figure 8. Based upon measured sediment concentrations at the site, a conservative (preliminary design-level) profile of arsenic was then developed for the chemical isolation modeling, assuming upper-bound bulk arsenic concentrations of 560 mg/kg and 1,410 mg/kg in the upper 5 feet below the proposed isolation layer and to the layer between 5 and 10 feet below the proposed isolation layer, respectively. Unlike the profiles shown on Figure 8, this "limiting" profile assigns the highest arsenic concentrations measured in each of the intervals to ensure the protectiveness of the chemical isolation layer throughout the site. Actual concentrations through the remaining sediment profile following semi-consolidated material removal are expected to be less.

Partitioning

To estimate the mobile (or dissolved) fraction of arsenic associated with sediment intervals within the limiting profile, 31 samples from 19 cores collected in 2003 with measurements of arsenic concentrations in bulk solids and in filtered pore water were used to determine sediment-pore water partitioning coefficients. The measured partition coefficients of the arsenic in these samples ranged from 0.83 liters per kilogram (L/kg) (at high sediment arsenic concentrations) to 1,222 L/kg (at low sediment arsenic concentrations). In general, the conditions at the site are such that the arsenic is relatively soluble and mobile compared with many other sediment arsenic sites. These non-linear data were fit to a Freundlich isotherm to extrapolate this relationship to additional data and estimate the dissolved fraction associated with the remaining semi-consolidated materials to be managed with a chemical isolation layer. On average, the fitted isotherm overpredicts the pore water concentration of arsenic in the 2003 dataset by approximately 34 percent, thus overpredicting arsenic availability and mobility and providing an additional level of conservatism to the isolation layer modeling and design.

Using the site-specific, non-linear isotherm, the pore water concentrations were estimated for the three layers modeled below the proposed isolation layer (Table 2).

TABLE 2
Pore Water Concentration Estimates

$0-5$ ft	560 mg / kg	54.1 mg / L (54,100 μg / L)
$5-10$ ft	1410 mg / kg	239 mg / L (239,000 μg / L)
>10 ft	1410 mg/ kg	239 mg/ L (239,000 μg/ L)

Simulations

The modeling simulations presented in Appendix A examined a number of scenarios that involved placement of chemical isolation layers of varying thicknesses and materials, as well as where no isolation layer would be placed and varying concentrations of subsurface sediment arsenic remaining from 20 to 50 mg/kg in the 0- to 5-foot depth contained below the chemical isolation layer. Chemical isolation modeling scenarios were undertaken assuming diffusion was the primary transport mechanism and that no natural attenuation mechanisms were present. This assumption of diffusion as the primary transport mechanism is consistent with the groundwater cutoff features of the upland remedy; however, the sensitivity of the modeling results to this assumption also was evaluated by Dr. Reible, the results of which are discussed below in the Model Sensitivity section. Sensitivity analyses also included an assessment of varying sediment/ pore water portioning and select natural attenuation mechanisms. Other model parameters were based upon site-specific data or established estimation approaches (Table 1 of Appendix A).

Each modeling simulation predicted the time at which concentrations of arsenic at the base of the biologically active zone would exceed the Wisconsin WQC of 339.8 micrograms per liter (µg/L) (acute) and 152.2 µg/L (chronic).

As discussed in detail in Appendix A, a number of isolation layer simulations were evaluated to determine if a chemical isolation layer comprised of material with at least the sorption capacity of the existing sediments would provide the protectiveness required, and to develop the appropriate preliminary design specifications for the isolation layer, consistent with USEPA and USACE cap design guidance. As an isolation layer consisting of river sediments alone would not likely withstand peak hydrodynamic forces in the river, including potential propeller wash from vessels operating in the site area, a layer of armoring material was included in the preliminary isolation layer design. Isolation layers with the following components were evaluated:

- Armoring layers
  - 12 inch armor layer composed of cobble-sized materials
- Sorptive Isolation layer
  - 24 inches of sand or
  - 12 to 24 inches of river sediment

Results

Results of the isolation layer effectiveness modeling are summarized in Table 3. Because of the mobility of the arsenic present at the site, an isolation layer consisting solely of sand will not be effective at preventing longer-term exceedances of the Wisconsin chronic and acute WQC. However, an isolation layer constructed of river sediment obtained from areas of the river (such as to maintain navigational channel depths), can provide a highly effective isolation layer. As shown in Table 3, a sediment isolation layer with a thickness of 12 inches would sequester the release of mobile forms of arsenic, such that pore water arsenic levels of potential concern (that is, greater than surface water criteria concentrations) would not occur for at least 100 years, consistent with USEPA and USACE cap design guidance to ensure long-term protectiveness. The conservative modeling approach summarized in Appendix A does not account for natural sedimentation and other attenuation processes that would further control the release of arsenic through the isolation layer, which over this extended period would allow for the recovery of the remaining semi-consolidated materials and contribute further protectiveness.

TABLE 3
Summary of Base Case Isolation Layer Modeling Results

Isolation Layer Description	Thickness (inches)	Flux at Exceedance of Chronic Criteria ($mg/m^2/yr$)	Time until Exceedance of Chronic Criteria Assuming No Natural Attenuation (years)	Time until Exceedance of Acute Criteria Assuming No Natural Attenuation (years)
Sand	24	4	0.9	1.1
Soft Sediment	12	3.1	132	141
	18	2.3	247	264
	24	1.3	531	572

Placing a chemical isolation layer over the remaining semi-consolidated materials with arsenic concentrations above 50 mg/kg can be protective if it is constructed from a material that exhibits at least as much sorption as the existing native sediments in the site area. An effective chemical isolation layer thickness of 18 inches would result in a remedy that would be protective in excess of 745 years, considering the positive effects of the natural attenuation processes, such as the deposition of clean sediment. Once the expected natural attenuation processes are taken into account, as is customary in performing the evaluation specified in the USACE capping guidance, this 745 year projection would be considered permanent.

Model Sensitivity

The sensitivity of the model was examined relative to a number of parameters including the effects of natural attenuation, sediment-pore water partitioning (sorption), and the possibility of groundwater upwelling resulting from the incomplete elimination of hydraulic gradients beneath the river as part of the upland remedy. The results of the additional sensitivity analysis are summarized in Table 4.

TABLE 4
Summary of Modeling Sensitivity Analysis Results

Description Modification from Base Case (18-inch layer, no upwelling, best fit sorption)	Flux at Exceedance of Chronic Criteria ($mg/m^2/yr$)	Time until Exceedance of Chronic Criteria Assuming No Natural Attenuation (years)	Time until Exceedance of Acute Criteria Assuming No Natural Attenuation (years)
Base Case	2.3	247	264
Base Case w/deposition of sediment filling half of armor pore space*	5.7	745	817
Base Case + 2 cm/yr	7.7	147	150
Base Case + 10 cm/yr	55	57	57
Base Case + High Sorption	1.3	524	585
Base Case + Low Sorption	4.4	111	116
24” Sediment + Low Sorption	2.4	238	249

The effect of natural attenuation was assessed by considering the deposition of clean sediment in the armoring pore space where half of the armor pore space was assumed to accumulate deposited sediments over the course of 100 years. As shown in Table 4, this clean sediment deposition significantly increased the period over which an 18–inch-thick isolation layer was expected to be protective to approximately 750 years. This calculation illustrates how the chemical isolation layer can provide containment until natural containment/attenuation processes become dominant and ensure the remedy remains protective indefinitely.

The sensitivity of the isolation layer design to groundwater upwelling was assessed by increasing vertical Darcy velocities to 2 and 10 centimeters per year (cm/yr). These simulations evaluate the possibility of incomplete elimination of upward groundwater flow beneath those areas where impacted semi-consolidated materials will remain in place. These advective flows reduced the time the isolation layer would be expected to be protective in the absence of natural attenuation to 147 years at 2 cm/yr and 57 years at 10 cm/yr. Again, as shown in Table 4 for the modified base case scenario, the natural accumulation of sediments within the pore space of the armoring layer would be expected to provide further containment beyond these already significant periods.

Using the calculated error range associated with the site-specific sorption isotherm, additional model runs were performed using low and high sorption scenarios for the base case. Results showed that, even with the assumption of low sorption and with no accommodation of the effects of natural attenuation, an 18-inch isolation layer would be protective for well beyond 100 years, and will achieve suitable long-term protection consistent with USEPA and USACE cap design guidance.

Conclusions

A chemical isolation layer, which is at least as sorbent as the existing native sediments in the site area, placed over semi-consolidated materials as proposed in the ESRP will prevent long-term arsenic concentrations within the biologically active zone from exceeding both the chronic and acute Wisconsin WQC. An effective chemical isolation layer thickness of 18 inches would result in an essentially permanent remedy, particularly once expected natural attenuation processes such as deposition of clean sediment are taken into account. The actual material employed as an isolation material could be natural sediments obtained from adjacent channel areas or a manufactured material with sorption characteristics that equal or exceed those of native sediments. Additional study could be performed during remedial design to optimize the performance of the isolation layer to further improve the effectiveness of the cap.

Maximum effectiveness can be achieved by ensuring that the isolation layer remains in place (for example, through appropriate armor design; see below) and by maintaining the effectiveness of adjacent upland hydraulic controls.

It should be emphasized that the evaluation presented herein is based upon the highest observed arsenic concentrations from the most impacted cores in the sediment below the isolation layer and uses a sorption isotherm that over predicts pore water concentrations and arsenic availability and mobility; that is, the chemical isolation layer as proposed in the ESRP would provide an even greater degree of protectiveness than predicted by this preliminary modeling evaluation.

4.3.2 Stability Evaluation

Flood Resilience Evaluation

To ensure the long-term integrity of the proposed chemical isolation layer, a preliminary design analysis was performed to develop specifications for the overlying armor layer that will resist flood-induced shear stresses and propeller wash forces, consistent with USEPA and USACE cap design guidance (Palermo et al. 1998). The analysis used conservative assumptions to determine a rock size resistant to movement. The following data were used in the flood resilience analysis:

- HEC-2 data of Menominee River supplemented with 2008 bathymetry survey from USACE converted to HEC-RAS hydraulic model
- Flood Insurance Study, City of Marinette, Wisconsin 1977
  - Peak flow rates for 100-year and 500-year return period storm
- NOAA Green Bay lake elevation
  - 15 years of data (1996-present), NOAA station 9087079

Several layers of conservatism were built into the analysis.

- Considered sensitivity of both FEMA 100- and 500-year return period flood flows in a HEC-RAS hydraulic model developed from HEC-2 data.
- Downstream boundary conditions in Lake Michigan (Green Bay) were lowered to 3 feet below the lowest lake level recorded in the last 15 years. A lower downstream boundary condition provides for potentially greater flood induced disturbance. Table 5 illustrates the lake level fluctuations from 15 years of data at NOAA station 9087079. Using these conservative assumptions, the lake level used for the resilience evaluation was

approximately 7 feet below the USACE low water datum for the navigational channel on the Menominee River and approximately 7.5 feet lower than the average Lake Michigan level over the last 15 years.

TABLE 5
Lake Levels at NOAA Station 9087079 Green Bay , Lake Michigan

Lake Condition	Lake Level (ft)
Maximum	583.37
Average	578.16
Minimum (assumed seiche effect)	573.47
Resilience Evaluation Minimum (3 feet below observed low in last 15 years)	570.47

- The highest shear stress computed for any location in the river in the vicinity of dredging was used to develop the armor layer specification. The cross-section in the project area that experienced the highest shear stress was cross-section 1.02, which corresponds to a location with a relatively narrower river width located just upstream of the Turning Basin.

The resulting shear stress from the resilience evaluation assuming varying low lake level elevations is shown in Table 6.

TABLE 6
Shear Stress Calculation

Shear Stress Scenario	100-year Flow, 15-Year Low Lake Level	500-year Flow, 15-Year Low Lake Level	100-year Flow, Resilience Evaluation Minimum Lake Level	500-year Flow, Resilience Evaluation Minimum Lake Level
Density of water (lb/ft^3):	62.4	62.4	62.4	62.4
Slope of energy line (ft/ft):	0.00032	0.00040	0.00041	0.00048
Peak Water Surface Elevation (ft IGLD85):	576.99	578.41	575.86	577.53
Lowest River Bottom Elevation (ft IGLD85):	548.80	548.80	548.80	548.80
Water Depth (ft):	28.19	29.61	27.06	28.73
Shear Stress (lb/ft^2):	0.563	0.739	0.692	0.861

This peak bottom shear stress range was then compared to published values of the stable (permissible) grain size that would resist initiation of sediment movement under different shear stresses. Table 7 contains a summary of shear stress with associated stable stone size that would ensure stability of the cap for long-term protectiveness. The sensitivity analysis results indicated a stone size of 2 or 3 inches would meet the shear stress requirements. To be conservative, a stone size of 3 inches would be required.

The multiple levels of conservatism built into the assumptions used in the analysis combine to provide a high level of confidence that flood induced disturbance should not occur in the chemical isolation layer when the overlying armor layer is comprised of a median (D50) stone size of approximately 3 inches or greater (that is, capable of withstanding a shear stress of 1.00 lb/ft^2) through interpolation of Table 7). Based on this criterion, 4- to 6-inch cobble-sized armor stone would be more than sufficient to ensure the long-term protectiveness of the chemical isolation area. The final armor layer specifications would be refined as part of detailed design.

TABLE 7
Permissible Shear Stress for Stone

Stone Size in Inches (D50)	Permissible shear stress (lb/ft^2)
1	0.33
2	0.67
6	2
9	3
12	4
15	5

Source: Adapted from FHWA, HEC-15, April 1983 pages 17 and 37

4.3.3 Resilience to Potential Vessel Propeller/Jet Pump Wash

Cap armoring designed for relatively large vessels operating in the Lower Fox River's federal navigation channel and Turning Basin (Tetra Tech EC, Inc., et al. 2009) can be used as the basis for a conceptual cap armor design for this project. Based on these more detailed design evaluations at the nearby Fox River site, the 4- to 6-inch armor stone specification that would resist peak flood-induced shear stresses as summarized above also would be protective of potential peak propeller wash forces for relatively large vessels that may operate in the site area. Again, the final armor layer specifications would be refined as part of detailed design of the chemical isolation layer, consistent with USEPA and USACE cap design guidance.

4.4 Implementability

This component of the ESRP is equally as implementable as the SRWP. Both approaches use readily available equipment to implement the work. Furthermore, the materials that will be required for construction of the chemical isolation layer can be obtained from other areas within the river or can be manufactured material of equal or greater sorption value.

4.5 Conceptual Design

This section presents a conceptual design for a chemical isolation layer in the area where semi-consolidated materials containing arsenic concentrations exceeding 50 mg/kg will remain in place. This design has been developed with the goal of providing a high level of protection to the Menominee River and its receptors that is, at a minimum, as protective as the SRWP. This goal is achieved through careful consideration of the lateral and vertical distribution of semi-consolidated materials containing arsenic concentrations greater than 50 mg/kg that will remain following the dredging component of the ESRP and the results of the chemical isolation layer modeling and stability evaluations discussed in Section 4.3.1.

The lateral extent of the proposed chemical isolation layer cap is illustrated on Figure 7 and encompasses all semi-consolidated materials containing arsenic concentrations greater than 50 mg/kg that will remain following dredging. Figure 7a presents a cross-section running from north to southeast that transects this area parallel to the shoreline and illustrates where soft sediment and semi-consolidated materials will be dredged in addition to the position of the proposed chemical isolation layer.

Based on the chemical isolation layer modeling and isolation layer stability evaluations, the proposed isolation layer will be approximately 42 inches (3.5 feet) thick and will consist of the following components:

- 18–inch-thick sorptive layer composed of clean river sediment
- 9–inch-thick filter layer of sand (6-inch minimum thickness) and gravel (3-inch minimum thickness)
- 12–inch-thick armor layer composed of 6- inch-diameter cobble

SECTION 5

5 Chemical Isolation Layer Monitoring Approach

5.1 Introduction and Objectives

The preliminary design of the chemical isolation layer includes 18 inches of a clean, soft sediment layer and approximately 21 inches of a filter/armor layer for long-term stability. The details of the conceptual design are described in the previous section of this document and are shown on Figure 12. An evaluation was performed to assess the protectiveness of this chemical isolation layer to effectively contain the arsenic remaining in the semi-consolidated materials outside the historically dredged portion of the Turning Basin. The environmental monitoring will involve both short-term activities for placement of layers and long-term activities to ensure its physical integrity and protectiveness over time. The main objectives of the monitoring are listed below:

- Document the placement and initial thickness of each of the separate sorptive, filter, and armor layers
- Ensure water quality criteria during placement of the isolation layer
- Monitor the integrity of armor layer and surface sediment chemical concentrations of arsenic over time to verify the long-term protectiveness of the chemical isolation layer

The strategy for monitoring is to perform more frequent monitoring during the first few years after placement of the chemical isolation layer and then to reduce the frequency of monitoring over time as appropriate.

5.2 Monitoring Approach

5.2.1 Monitoring During Placement

Hydrographic surveys and other widely accepted methods (for example, coring and buckets) for monitoring placement of the sorptive, filtering, and armoring layers will be used to verify proper construction of the chemical isolation layer. Turbidity also will be monitored to meet the water quality criteria during placement of the layers.

5.2.2 Initial Post-Construction Monitoring

Construction quality assurance surveys, including coring and bathymetry, will be performed shortly after the placement of each layer to document proper construction of each layer. The initial post-construction survey(s) will verify that each layer's specifications and construction criteria have been met, including both the aerial coverage and thickness. If the initial post-construction monitoring shows that the specifications and construction criteria have not been met, then the layers shall be augmented to meet the design. A post-construction high definition multi-beam bathymetry survey will be used as a baseline to monitor the initial few years of consolidation beneath the armor layer and as a baseline of the isolation layer's integrity over time. The extent of consolidation will depend on time elapsed after placement, the thickness of the isolation layer, thickness of soft sediments beneath the isolation layer, and consolidation properties of the isolation layer and soft sediment. In addition, representative chemical sampling for arsenic at the top of the sorptive layer will be undertaken before adding the armor layer to establish baseline conditions and to confirm that this layer meets the arsenic remedial goal.

5.2.3 Long-Term Monitoring

The overall objective of this monitoring plan is to ensure the long-term integrity and protectiveness of the chemical isolation layer. To achieve that objective, two primary components of monitoring are incorporated:

- Physical integrity monitoring
- Chemical monitoring

Each of these monitoring elements is discussed separately below.

Physical Integrity Monitoring

To ensure the integrity of the armor and sorptive layers, a measured reduction in elevation of greater than 6 inches relative to the post-construction as-built (baseline) survey will trigger further evaluation to ensure that the armor layer remains intact. Some elevation changes may be experienced because of settlement of the chemical isolation layer over time. The precision of differential bathymetric surveys between various years is limited to approximately 6 inches. Thus, follow-on chemical isolation layer inspections will be performed in contiguous cap areas with more than 6 inches of differential reduction relative to as-built elevations. Physical inspections will be performed during the same monitoring year as the bathymetric survey to characterize the presence of the armor layer. If follow-on visual inspection verifies that the armor layer is in place, physical integrity of the chemical isolation layer will be verified. If the armor layer is not verified by the inspection, the area will be identified on a map and USEPA will be notified that further investigation will be necessary.

Chemical Monitoring

For this site, arsenic is the appropriate focus for verifying the protectiveness of the chemical isolation layer. To ensure the chemical isolation layer is protective on an ongoing basis, recently deposited sediment collected on the surface will be sampled and analyzed for arsenic. Maximizing sample quality will require the presence of sufficient recently deposited sediment over the coarse-grained aggregate used for armoring to be sampled. If sufficient sediment is not present, an alternative sampling approach will be proposed for USEPA approval. If surface sediments remain (and are projected to remain) below 20 mg/kg, chemical isolation layer protectiveness will be verified. If the surface sediments exceed 20 mg/kg, USEPA will be notified that further work will be planned to address these findings.

SECTION 6

6 Revised Cost Estimate

The total estimated cost to implement the ESRP's estimated to cost $23,300,000 (including contingency), including remedial design, construction management, and contingencies. Appendix B provides a breakdown of estimated costs for specific line items. The total estimated cost to implement the SRWP as approved by USEPA is estimated at $37,600,000.

The following assumptions were made when developing these costs:

- Only dredging or chemical isolation of materials with arsenic concentrations greater than 50 mg/kg will be performed.
- MNR for materials with arsenic concentrations less than 50 mg/kg will occur to below 20 mg/kg within a 10-year period.
- Specific stabilization reagents and percentages are based on results of treatability studies performed in 2010. Additional treatability studies will be performed to further refine the reagent mixing percentages.
- All contaminated soft sediment will be removed under both scenarios.
- Contingency was added to cover variations in characteristics of dredged materials, water generation volume, and stabilization mixing percentages.
- For the ESRP scenario:
  - All of the contaminated semi-consolidated sands and silts not located within a previously dredged portion of the federal navigation channel will be addressed through the placement of a chemical isolation layer and armoring.
  - Contaminated semi-consolidated sands and silts located within the previously dredged portion of the federal navigation channel will be dredged.
  - Dry excavation will occur in the south channel only.
- For the SRWP scenario:
  - All contaminated semi-consolidated sands and silts will be removed through either mechanical dredging or dry excavation.
  - The dry excavation area has been expanded as required in the USEPA-approval letter dated June 1, 2011.
  - A new sheet pile wall will be constructed along the exterior of the former 8th Street slip to allow excavation of approximately 5,000 cubic yards of contaminated semi-consolidated sands and silts that would cause failure of the existing wall.

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SECTION 7

7 Project Schedule

A preliminary project schedule for the proposed ESRP activities is included as Figure 13. This schedule supersedes the schedule provided in the SRWP. The following is a general summary of the overall project schedule with critical milestones and assumptions discussed (refer to Figure 13 for details):

- Preparation of design documents to start in September 2011 and assumes USEPA has approved the ESRP approach.
- Water quality variance request submitted to the Wisconsin Department of Natural Resources (WDNR) on November 15, 2011. WDNR review time is assumed to be 60 days, it is not clear what the actual review time will be since WDNR has approved few, if any, of these variance requests in the past. In addition, the WDNR process includes opportunity for public review comment and possible legal challenges to WDNR decisions by the public.
- Pre-final design/project manual and operations and maintenance plan submitted to USEPA on January 23, 2012 and assumes a USEPA review time of 30 days and finalization of the project manual by February 29, 2012.
- Dredge permit application and other permitting/agreement/variance request tasks will be submitted at the same time as the pre-final design/project manual to the appropriate agencies. It is assumed the dredging permit, as well as the RCRA onsite treatment variance will require 180 days for agency review.
- Procurement planned for March through April 2012.
- Mobilization is anticipated to start at the end of July 2012, with dredging activities staring at the end beginning of September 2012.
- 2012 dredging activities include removal of approximately 75,000 cubic yards of soft sediments. It is assumed that dredging will be allowed through the end of October 2012.
- MNR plan due to USEPA on November 1, 2012.
- Interim demobilization in November 2012 through the winter with interim mobilization to the site in spring 2013.
- 2013 dredging activities include dredging remaining soft sediment (3,000 cubic yards) and semi-consolidated sands and silts (approximately 13,000 cubic yards), dry dredging of the South Channel and placement of the chemical isolation layer. It is assumed that dredging activities can start May 15, 2013.
- Final site restoration and demobilization is planned to be completed by early September 2013.
- Sediment construction completion report due to USEPA on March 1, 2014.

7.1 Other Schedule Considerations

It will be necessary to schedule activities to accommodate the current commercial and industrial uses of the Menominee River. The dredging schedule will be coordinated with USEPA, WDNR, and the U.S. Fish and Wildlife Service to minimize potential disturbance of fish spawning during the spring (assume May 15 start date) and fall seasons (assume complete by end of October). The dredging contractor will be responsible to coordinate with local industrial facilities to accommodate the arrival and departure of commercial ships delivering raw materials and with the local agencies as necessary.

SECTION 8

8 Conclusion

The ESRP’s combination remedy for the soft sediment and semi-consolidated materials containing concentrations of arsenic greater than or equal to 50 mg/kg, which includes dredging, dry excavation, placement of a chemical isolation layer, and MNR, is consistent with the NCP and the risk management principles embodied in the Guidance. Specifically, the NCP and the Guidance focus on selecting and implementing a cost-effective remedy that will achieve long-term protection while minimizing short-term impacts. At many sites, this site included, a “combination of sediment approaches” is the “most effective way to manage the risk.” As discussed above, the combination of sediment management approaches in the ESRP will cost-effectively provide long-term protection of human health and ecological receptors while at the same time minimizing short-term impacts.

Moreover, the SRWP is technically and economically impracticable because the ESRP is an equally, if not more, protective remedy that is also more cost effective than the SRWP remedy. Per the NCP, the ESRP is more cost effective because its “costs are proportional to its overall effectiveness” whereas the SRWP’s estimated costs, including contingency ($37,600,000) are significantly greater than the ESRP’s estimated costs, including contingency ($23,300,000), but its overall effectiveness is not greater. This represents a 53 percent increase in the project cost for no corresponding increase in risk reduction. The NCP directs that the “remedial action selected shall be cost effective.” Additionally, an “important risk management function generally is to compare and contrast the costs and benefits of various remedies.” Thus, applying the NCP and the risk management principles embodied in the Guidance, the ESRP should be considered the preferred remedy and the SRWP is impracticable compared to the ESRP.

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SECTION 9

9 References

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Figures

Figure 1
Site Location Map
Tyco Fire Products LP Facility
Marinette, WI

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Figure 2
Area of Soft Sediment Removal
Tyco Fire Products LP Facility
Marinette, WI

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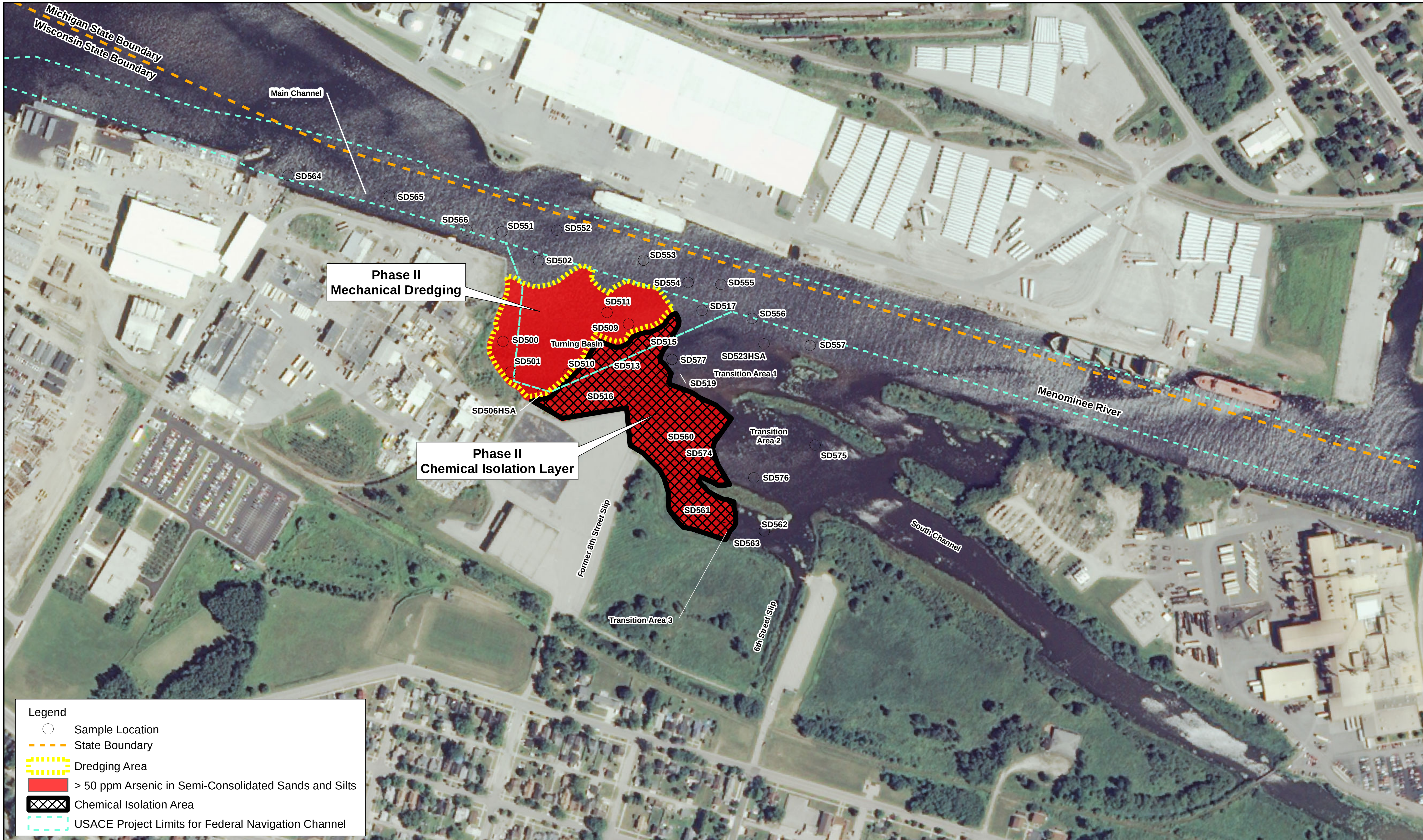

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Figure 3
Semi-Consolidated Sands and Silts Dredging
and Chemical Isolation Areas
Tyco Fire Products LP Facility
Marinette, WI

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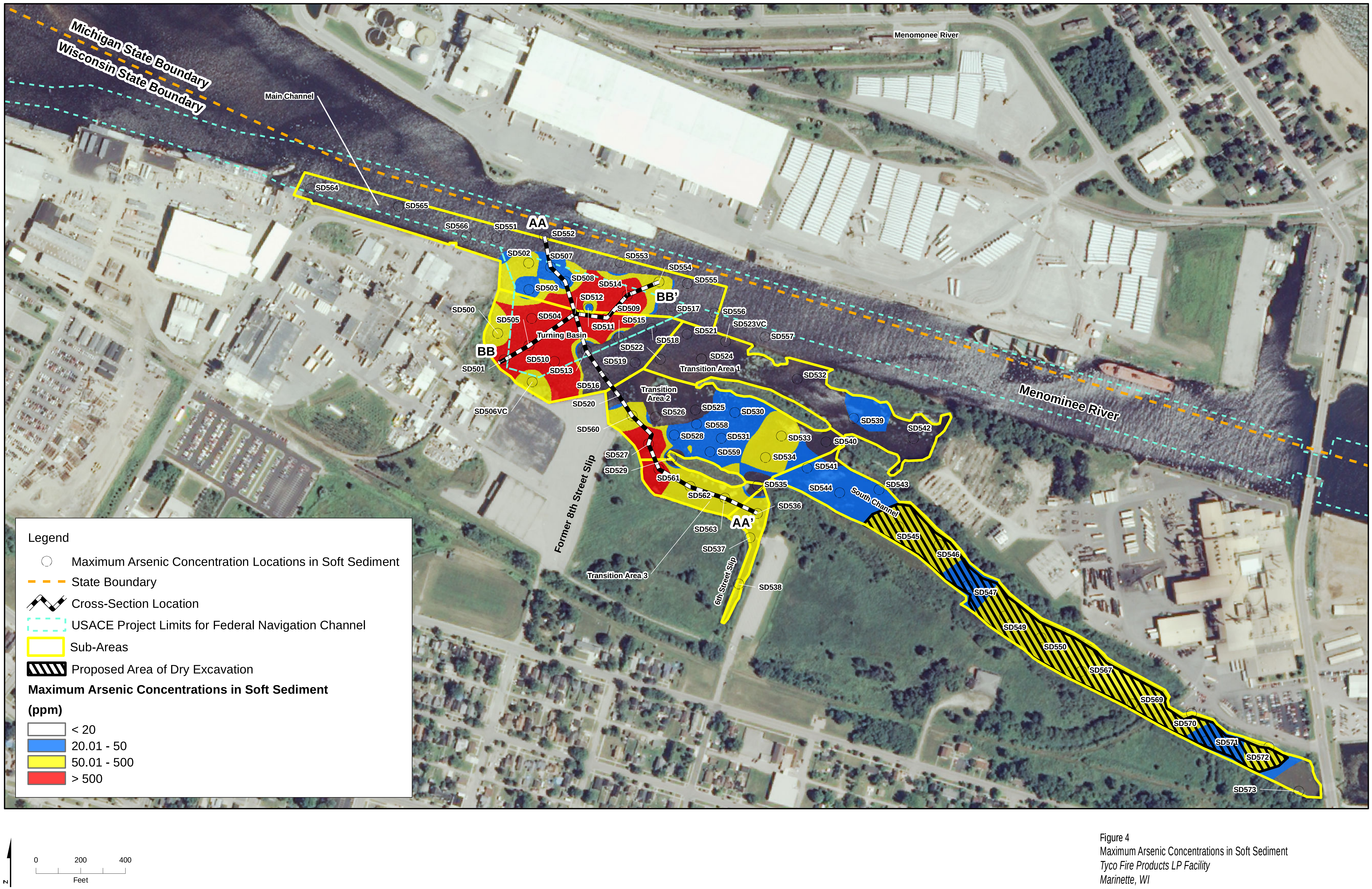

Figure 4
Maximum Arsenic Concentrations in Soft Sediment
Tyco Fire Products LP Facility
Marinette, WI

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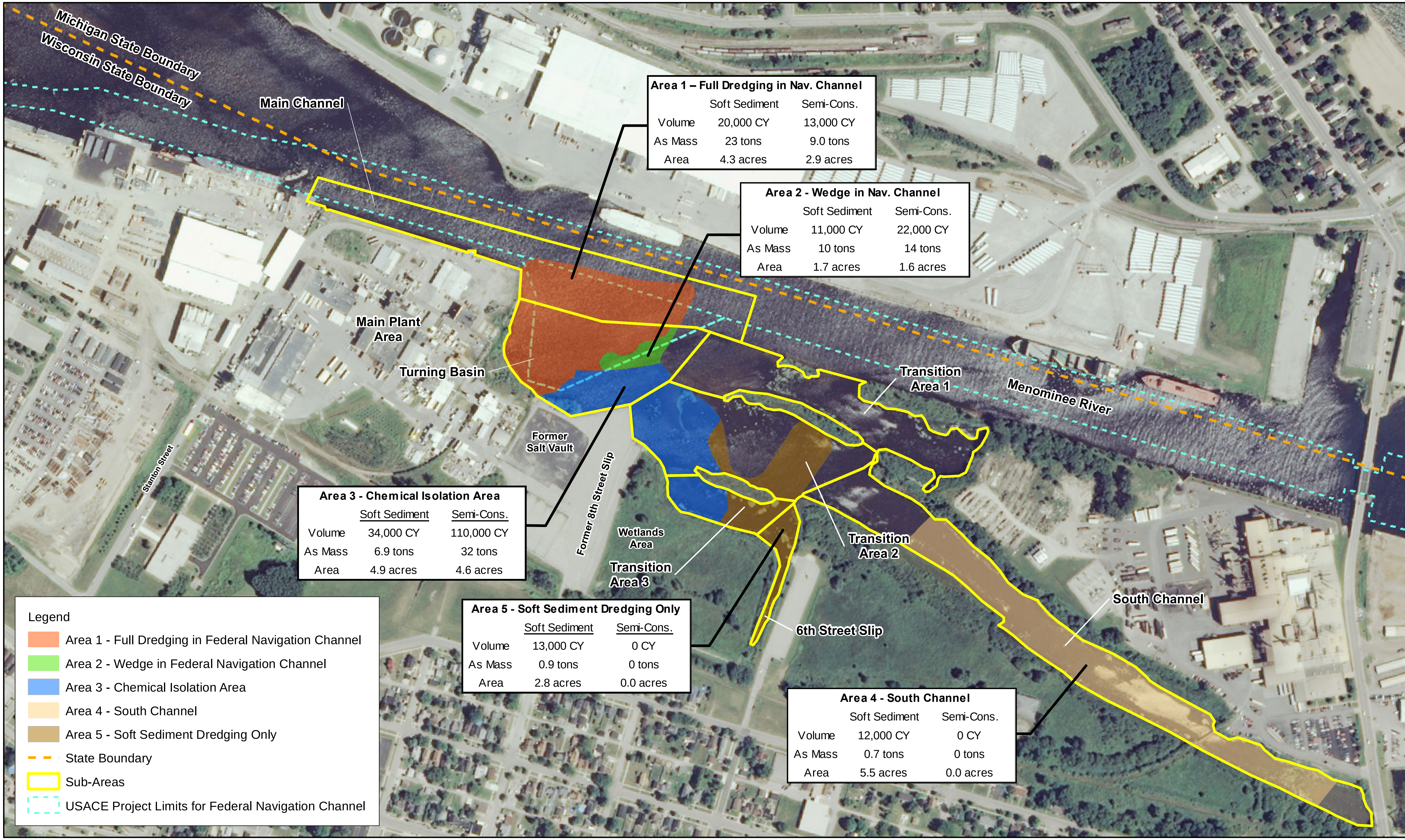

Area 1 – Full Dredging in Nav. Channel

	Soft Sediment	Semi-Cons.
Volume	20,000 CY	13,000 CY
As Mass	23 tons	9.0 tons
Area	4.3 acres	2.9 acres

Area 2 - Wedge in Nav. Channel

	Soft Sediment	Semi-Cons.
Volume	11,000 CY	22,000 CY
As Mass	10 tons	14 tons
Area	1.7 acres	1.6 acres

Area 3 - Chemical Isolation Area

	Soft Sediment	Semi-Cons.
Volume	34,000 CY	110,000 CY
As Mass	6.9 tons	32 tons
Area	4.9 acres	4.6 acres

Area 5 - Soft Sediment Dredging Only

	Soft Sediment	Semi-Cons.
Volume	13,000 CY	0 CY
As Mass	0.9 tons	0 tons
Area	2.8 acres	0.0 acres

Area 4 - South Channel

	Soft Sediment	Semi-Cons.
Volume	12,000 CY	0 CY
As Mass	0.7 tons	0 tons
Area	5.5 acres	0.0 acres

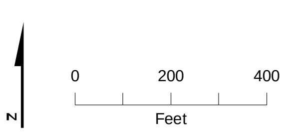

Figure 5
Quantities in Each Dredge Area
Tyco Fire Products LP Facility
Marinette, WI

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Figure 6
Original and EPA Proposed Sheet Piling for Dry Excavation
Tyco Fire Products LP Facility
Marinette, WI

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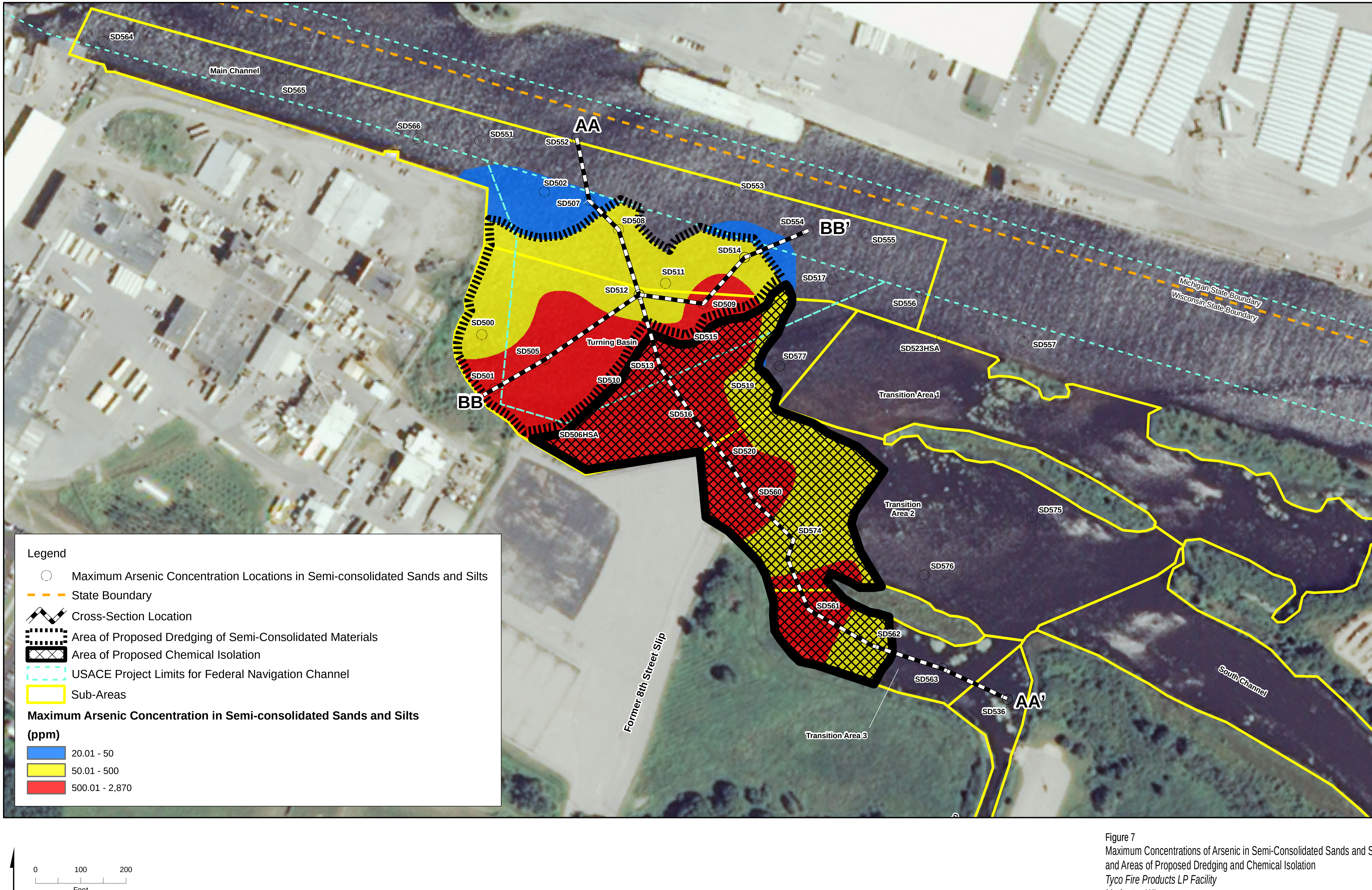

Figure 7
Maximum Concentrations of Arsenic in Semi-Consolidated Sands and Silts and Areas of Proposed Dredging and Chemical Isolation
Tyco Fire Products LP Facility
Marinette, WI

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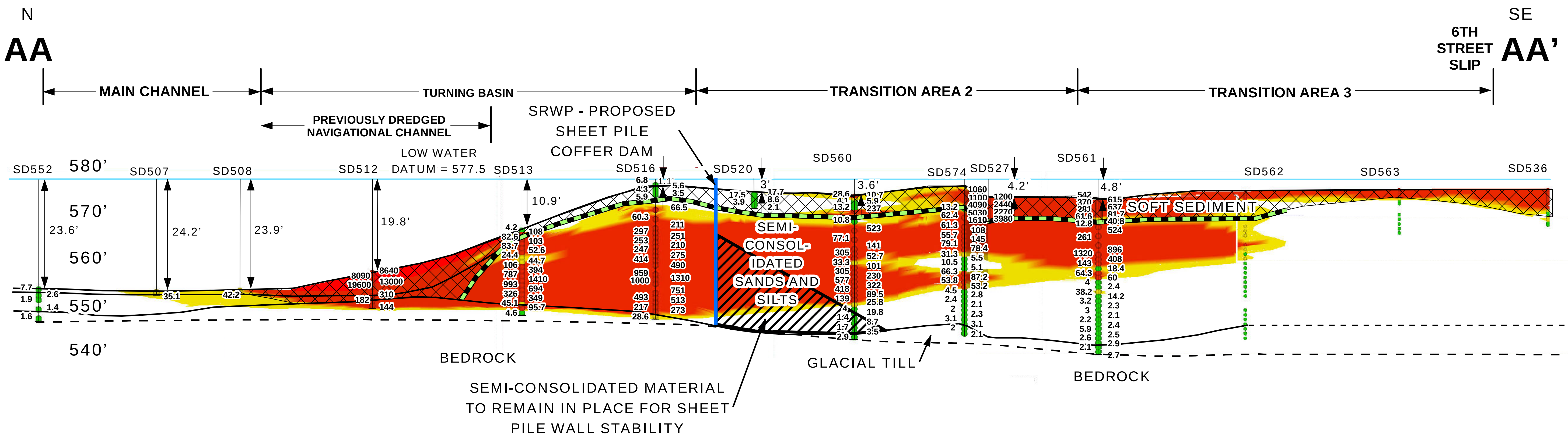

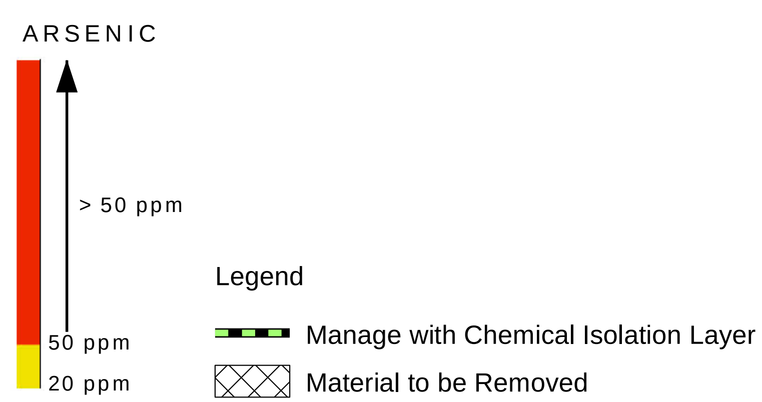

NOTES:
1. FIGURES 4 AND 8 SHOWS THE CROSS-SECTION LOCATION
2. VERTICAL DATUM IS NAVD88-FT
3. ARSENIC CONCENTRATION IN PARTS PER MILLION
4. 19.8' - WATER DEPTH AT SAMPLE LOCATION REFERENCED TO LOW WATER DATUM
5. ELEVATIONS AND WATER DEPTH IN FEET
6. BEDROCK DEPICTION IS APPROXIMATE
7. GREEN HIGHLIGHTED SAMPLE POINTS ARE RESULTS BELOW 20 PPM
8. THE 3-DIMENSIONAL SOFTWARE EXTRAPOLATES BETWEEN DATA POINTS; AS SUCH, THE INTERPRETATION OF CONCENTRATIONS AND LITHOLOGY BETWEEN DATA POINTS ARE APPROXIMATE

Figure 7A
Cross-Section AA-AA'
Profile of Turning Basin and Nearshore Transition Areas
Existing Conditions and Enhanced Remedy
Tyco Fire Products LP Facility
Marinette, WI

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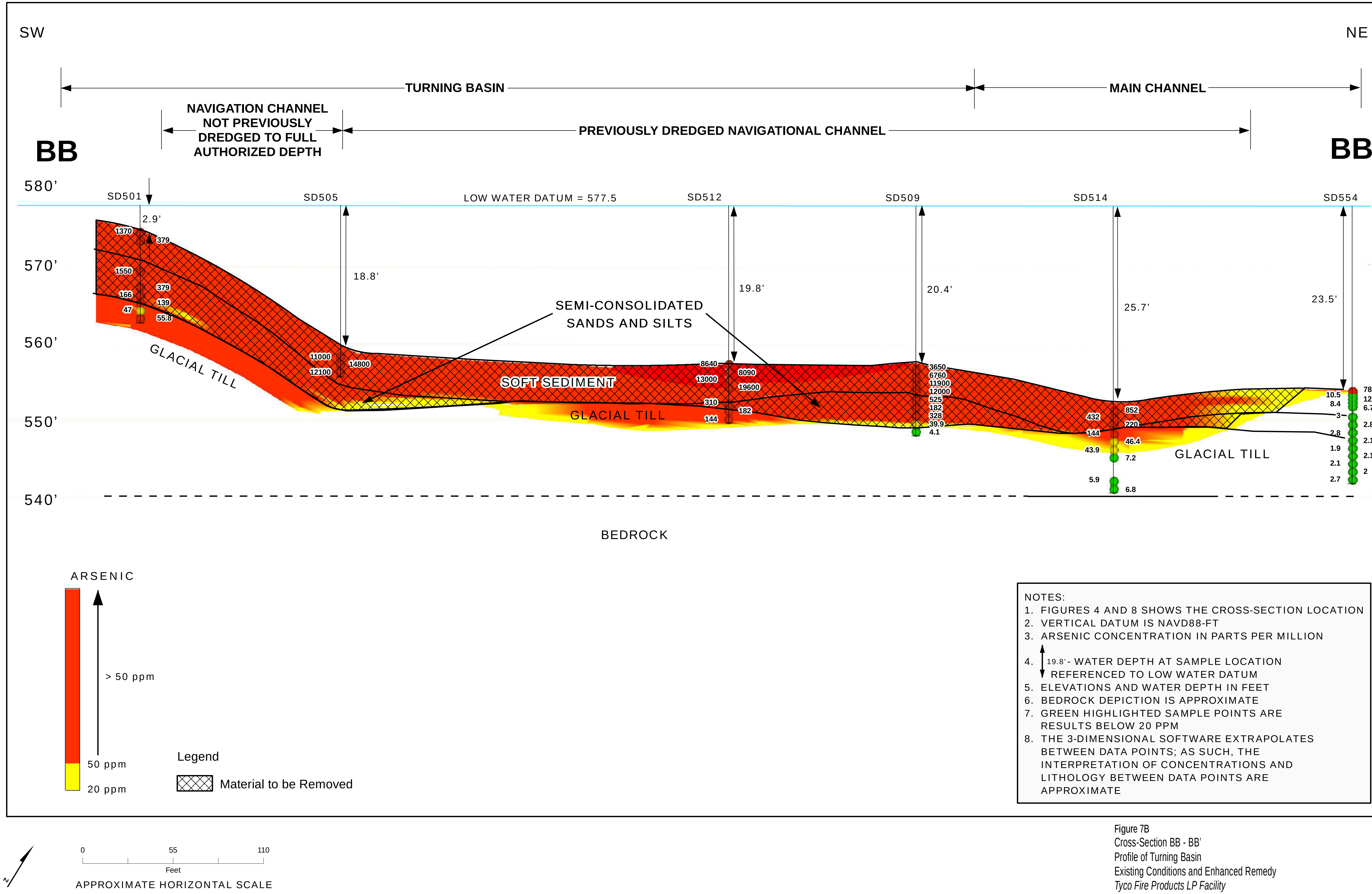

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Figure 7B
Cross-Section BB - BB'
Profile of Turning Basin
Existing Conditions and Enhanced Remedy
Tyco Fire Products LP Facility
Marinette, WI

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Beneath Areas Where Chemical Isolation Layer is Proposed

Existing Conditions

	Low	High	Average
soft sed	2.1	5,030	497
subsoil	1.4	1,410	158
till	1.6	246	26

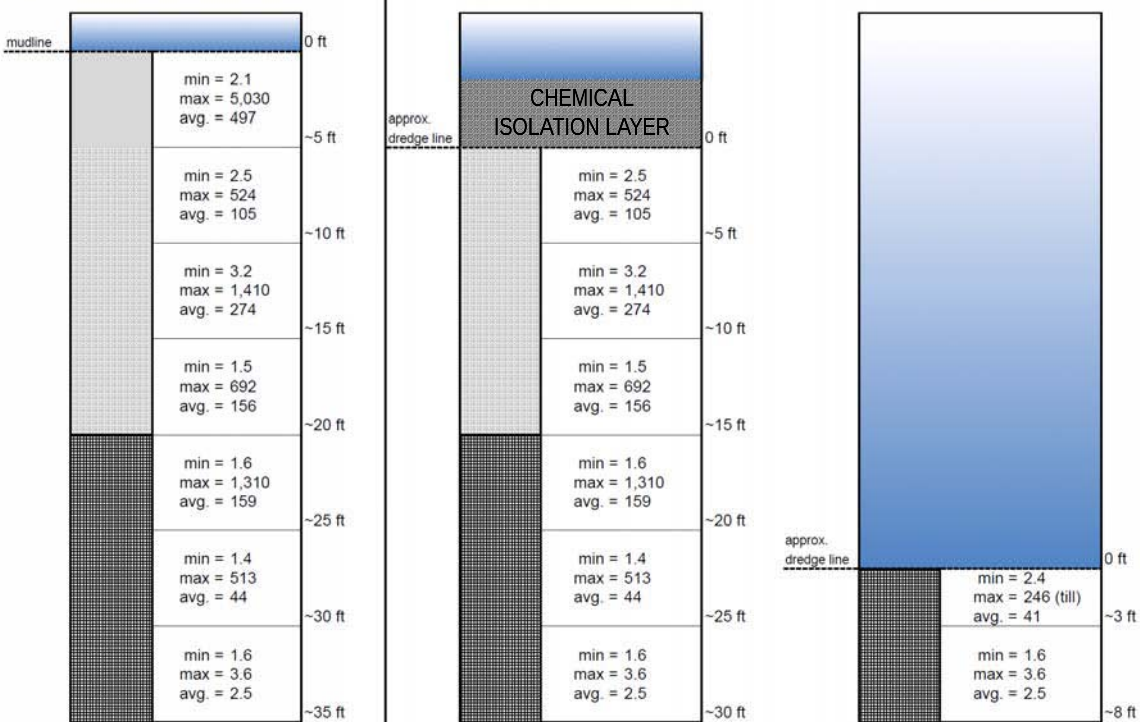
Post-Remedy Conditions

Alternative Approach (w/capping)

Low	High	Average
2.3	8.7	4.7
1.4	1,410	158
1.6	246	26

Approved Approach

Low	High	Average
2.3	8.7	4.7
1.4	49	10
1.6	246	26



Within Turning Basin

Existing Conditions

	Low	High	Average
soft sed	4.5	19,600	5,624
subsoil	26	2,870	545
till	2.6	310	100

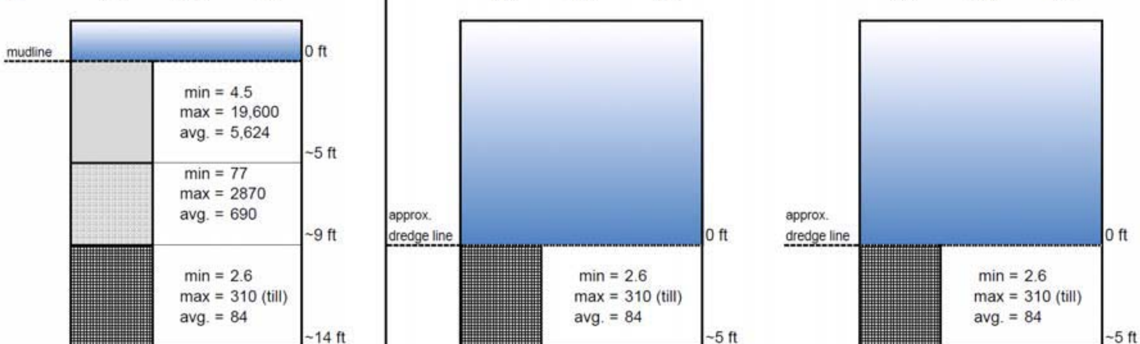
Post-Remedy Conditions

Alternative Approach

Low	High	Average
---	---	---
26	40	36
2.6	310	100

Approved Approach

Low	High	Average
---	---	---
26	40	36
2.6	310	100



Legend

- water column
- soft sediment
- subsoils (semi-consolidated)
- subsoils and/or glacial till

Notes:

1.) --- : indicates all soft sediments removed under this approach
2.) depths and thicknesses are approximate in order to depict general conditions
3.) height of water column is not to scale
4.) all concentrations reported in milligrams per kilogram (mg/kg)

Figure 8
Profiles of Sediment Arsenic Concentrations
Existing Conditions and Following ESRP
Tyco Fire Products LP
Marinette, Wisconsin

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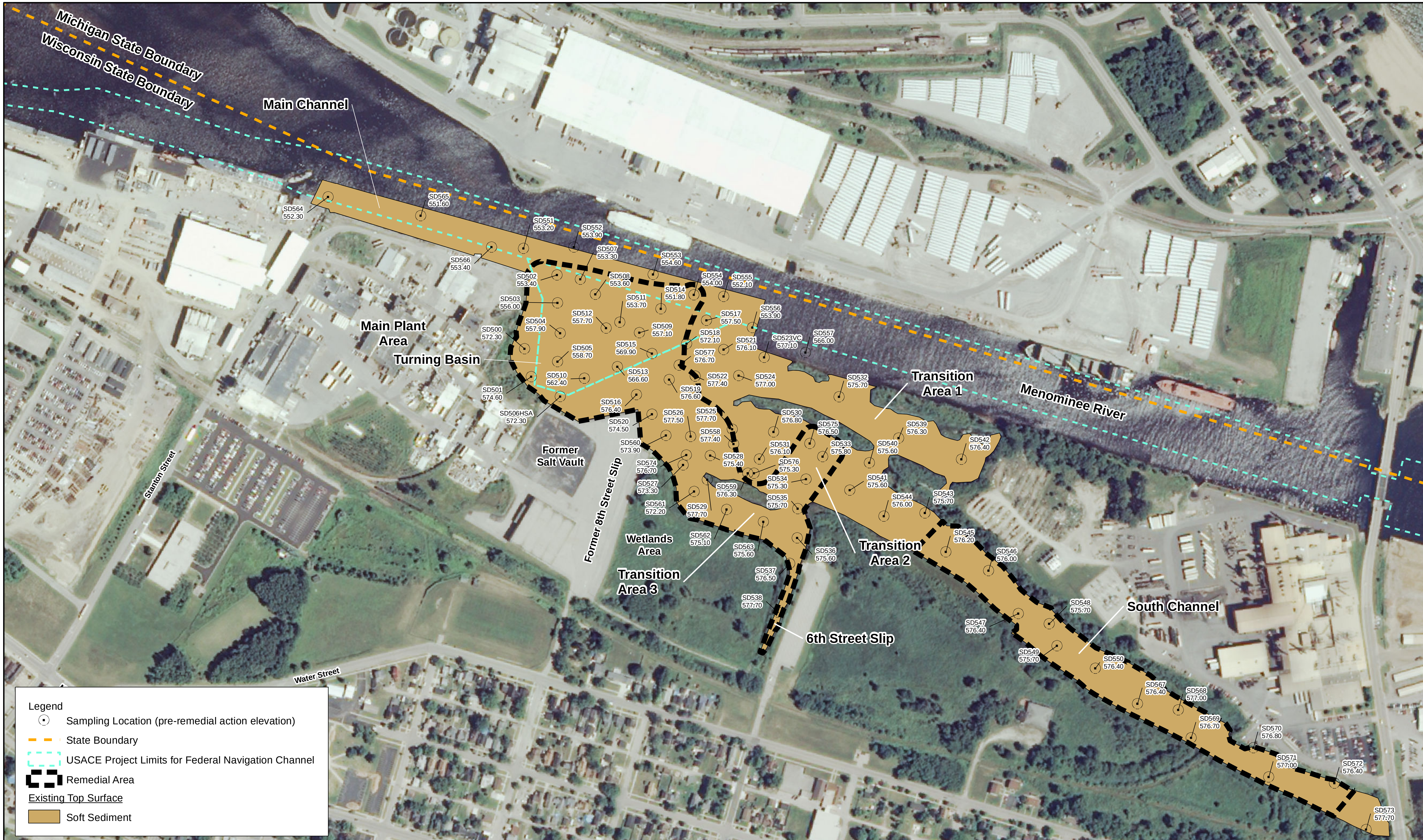

N

0 200 400

Feet

Figure 9
Pre-Remedial Action Conditions
Tyco Fire Products LP Facility
Marinette, WI

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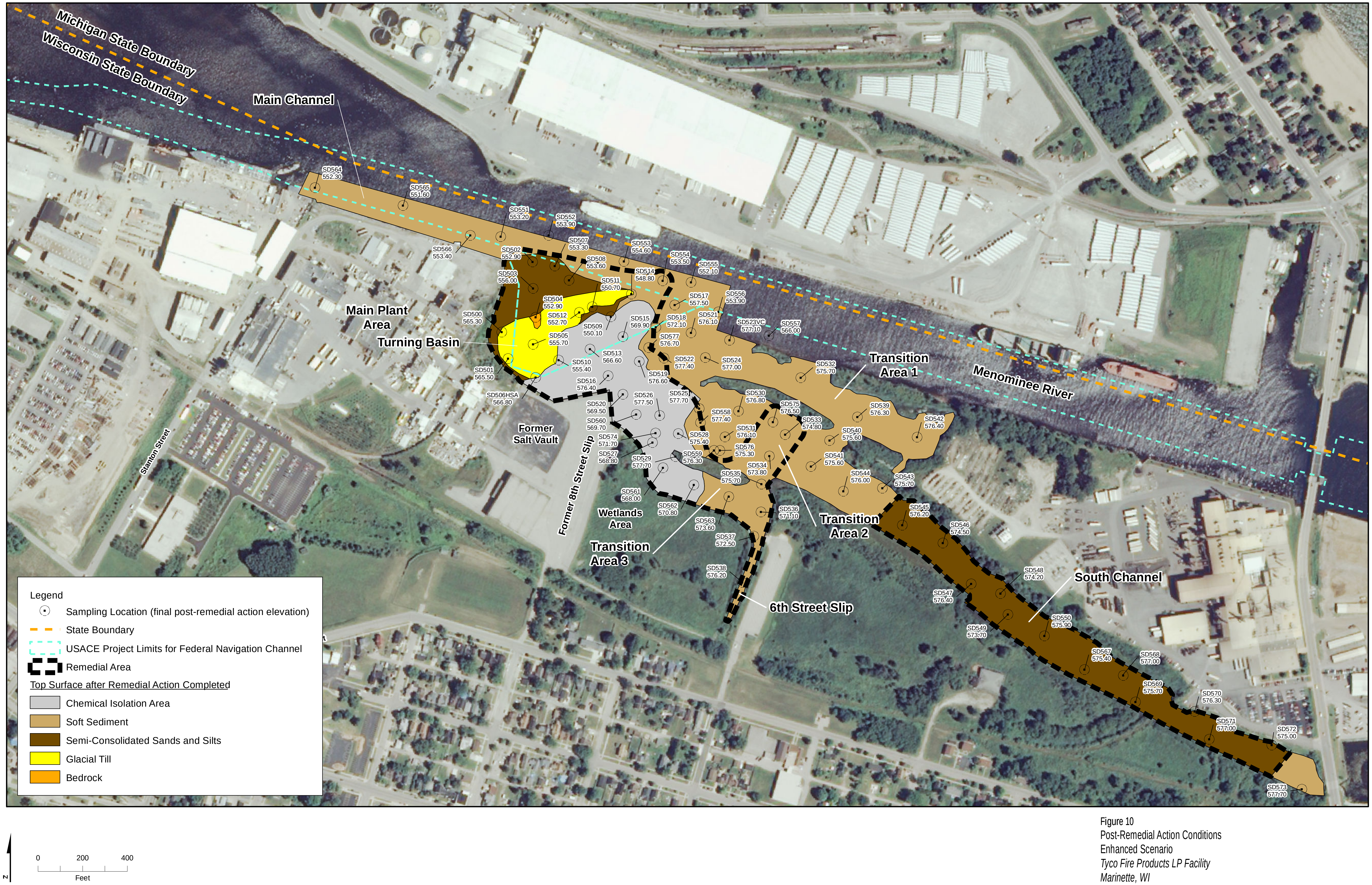

Figure 10
Post-Remedial Action Conditions
Enhanced Scenario
Tyco Fire Products LP Facility
Marinette, WI

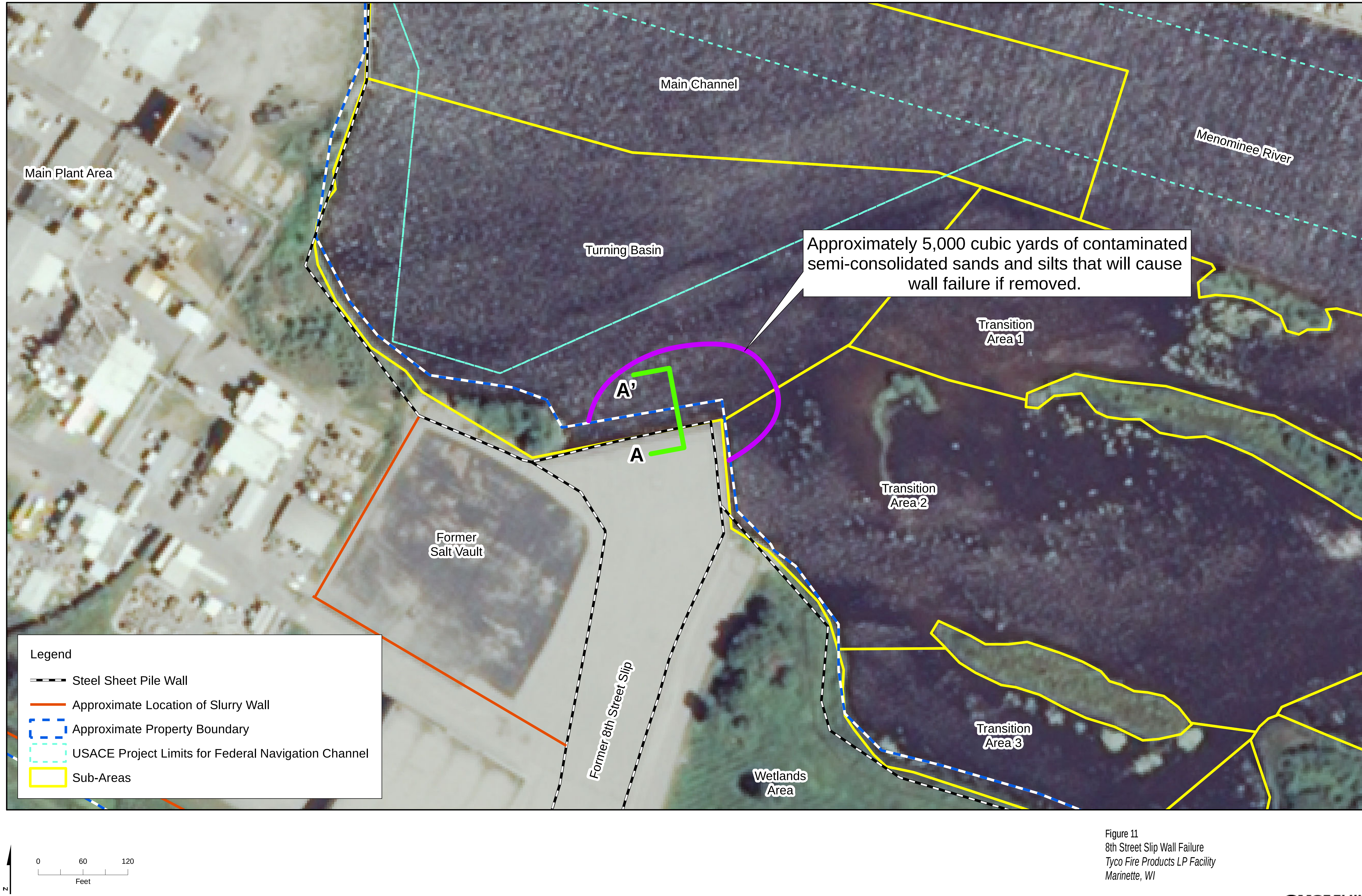

Figure 11
8th Street Slip Wall Failure
Tyco Fire Products LP Facility
Marinette, WI

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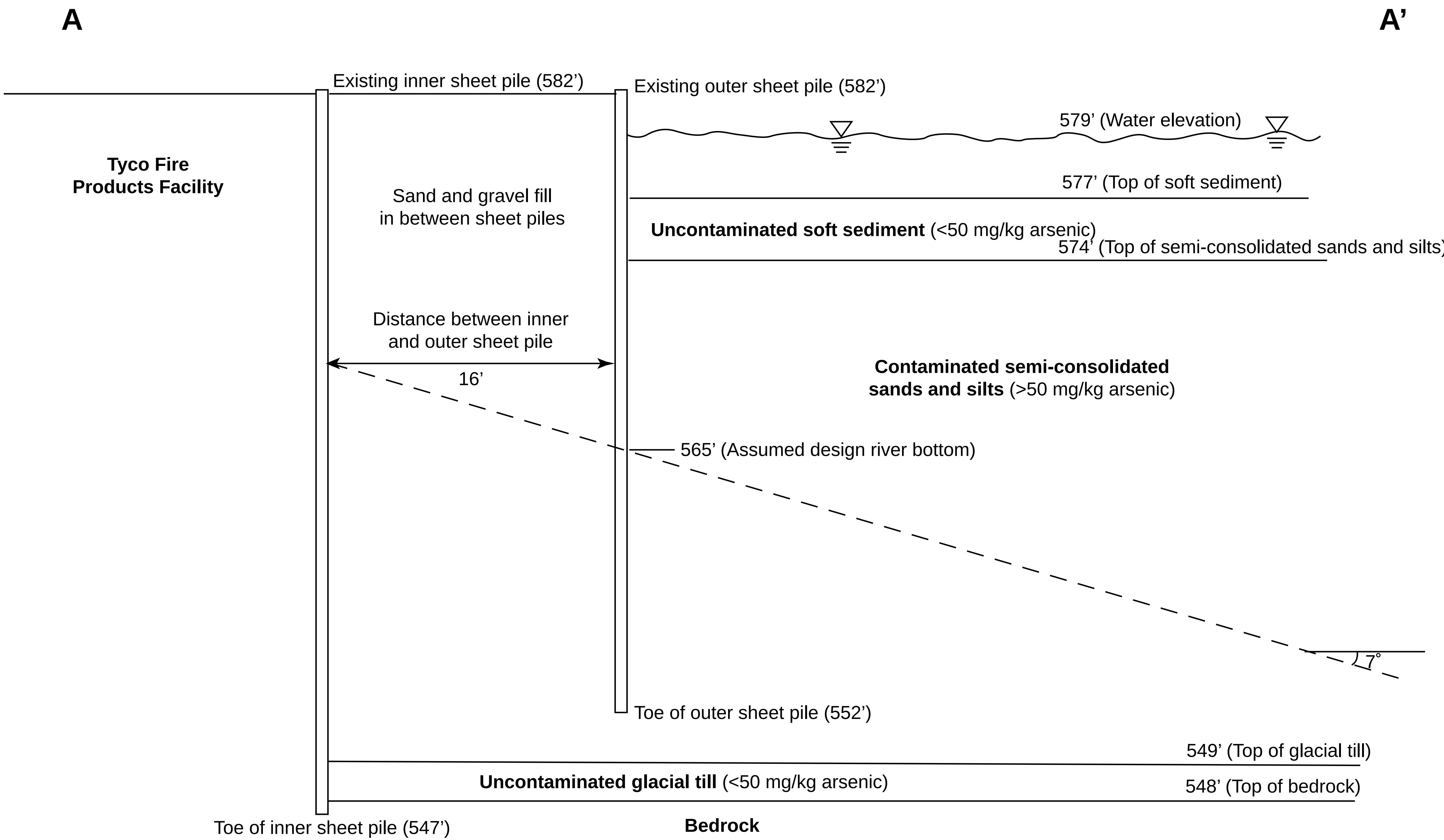


FIGURE 11A
Sheet Piling Assessment
Cross Section A-A'
Tyco Fire Products Facility

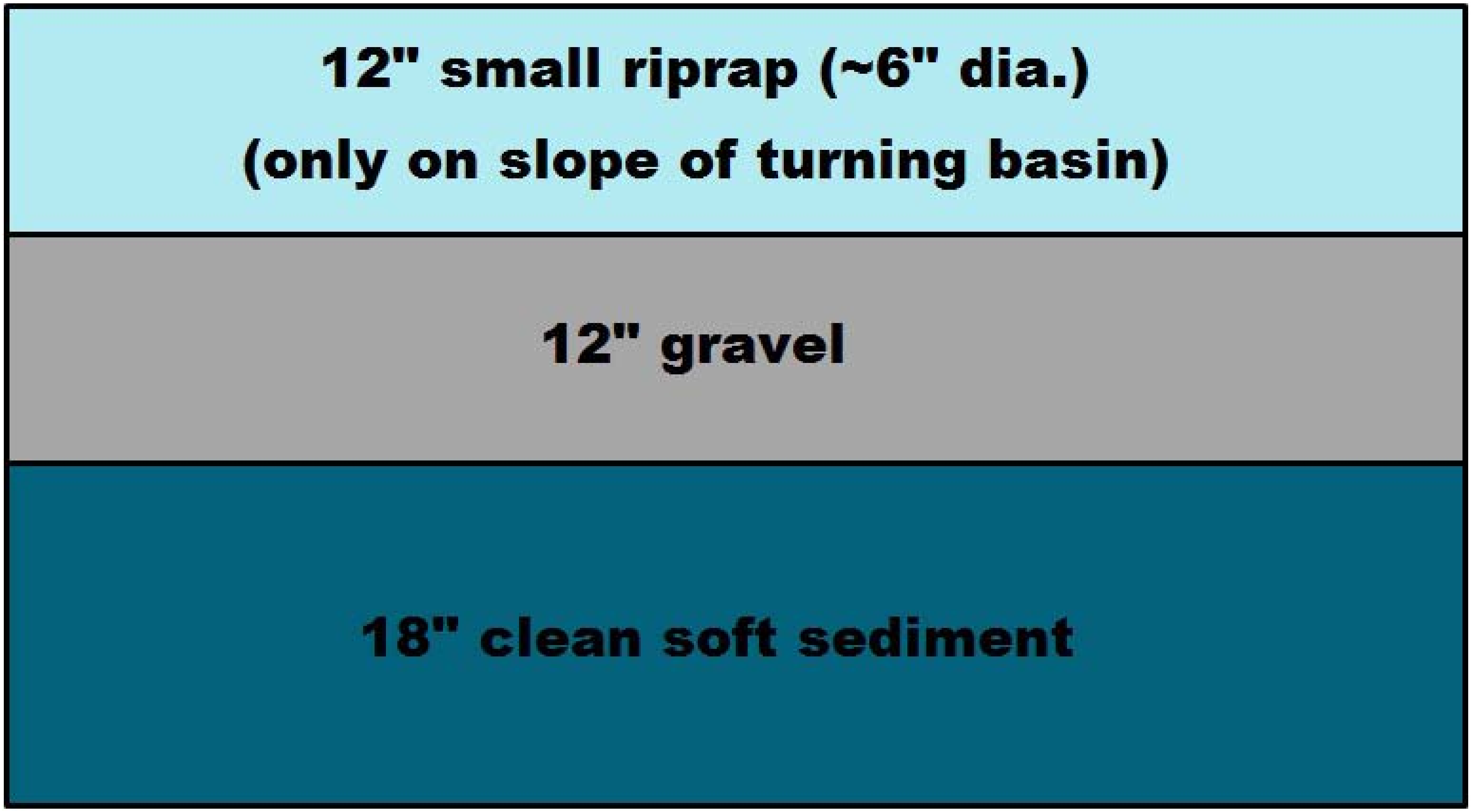
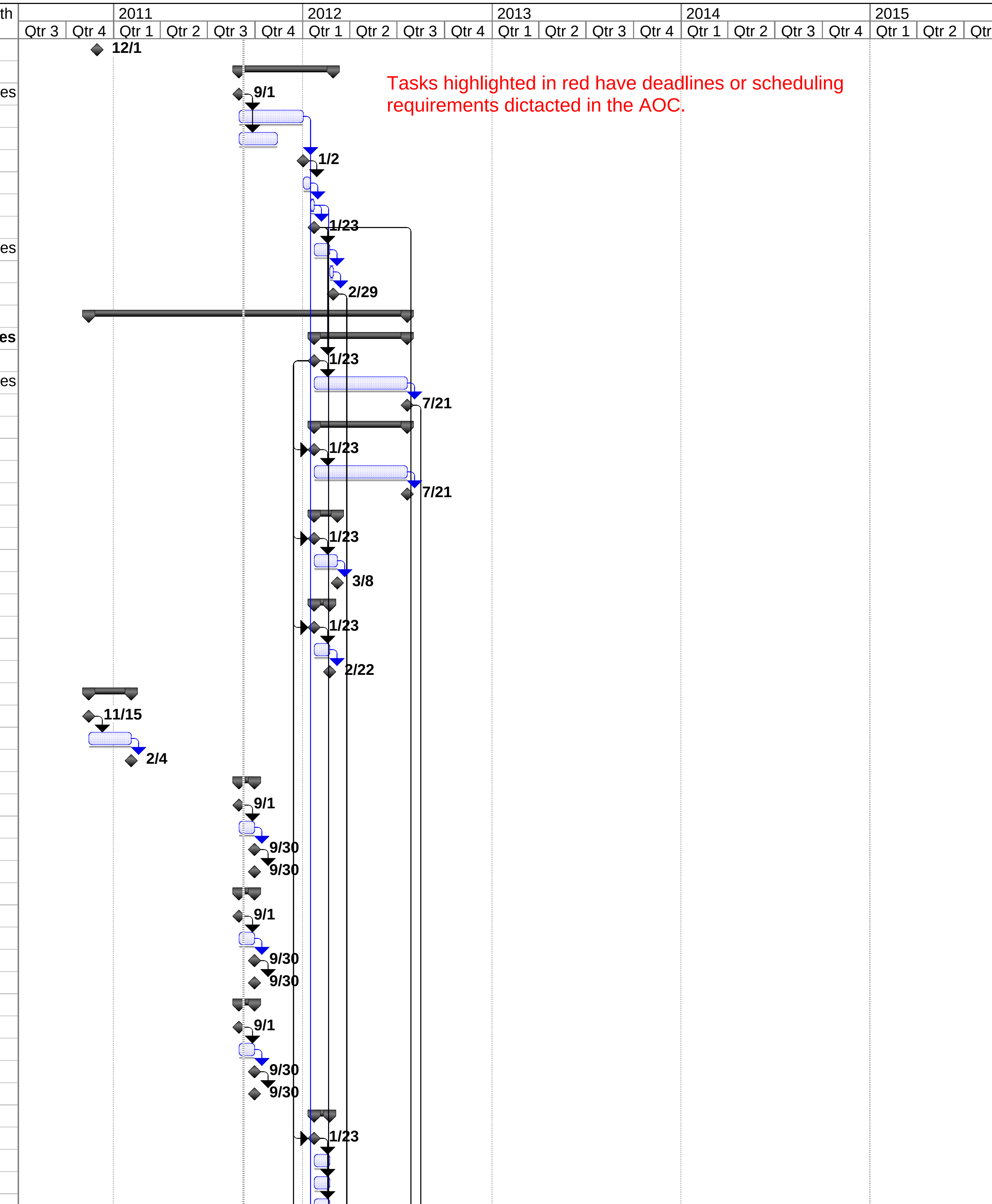


FIGURE 12
Proposed Chemical Isolation Layer
Enhanced Scenario
Tyco Fire Products Facility
Marinette, WI

Figure 13 - Proposed Enhanced Sediment Removal Plan Project Schedule

Task Name	Duration	Start	Finish	Critical Path
Submittal of SRWP, AMRSRP, & Schedule	0 days	Wed 12/1/10	Wed 12/1/10	
Design Activities	**182 days**	**Thu 9/1/11**	**Wed 2/29/12**	
Design Start Date	0 days	Thu 9/1/11	Thu 9/1/11	Yes
Development of Final BODR, Plans, & Specs	124 days	Thu 9/1/11	Mon 1/2/12	
Treatability Study Phase 2	74 days	Thu 9/1/11	Sun 11/13/11	
Submit Pre-final Design to Tyco for Review	0 days	Mon 1/2/12	Mon 1/2/12	
Tyco Review Final Design	14 days	Tue 1/3/12	Mon 1/16/12	
Incorporate Tyco Comments	7 days	Tue 1/17/12	Mon 1/23/12	
Pre-final Design Completed, to EPA for Review	0 days	Mon 1/23/12	Mon 1/23/12	
EPA Review	30 days	Tue 1/24/12	Wed 2/22/12	Yes
Incorporate EPA Comments	7 days	Thu 2/23/12	Wed 2/29/12	
Final Design Completed	0 days	Wed 2/29/12	Wed 2/29/12	
Permitting and Other Agreements	**551 days**	**Mon 11/15/10**	**Sat 7/21/12**	
Submit Dredging Permit Application	**180 days**	**Mon 1/23/12**	**Sat 7/21/12**	**Yes**
Submit Dredging Permit Application	0 days	Mon 1/23/12	Mon 1/23/12	
Agency Review Period	180 days	Tue 1/24/12	Sat 7/21/12	Yes
Permit Approved	0 days	Sat 7/21/12	Sat 7/21/12	
WDNR Waterway Marker Permit	**180 days**	**Mon 1/23/12**	**Sat 7/21/12**	
Submit Permit Application	0 days	Mon 1/23/12	Mon 1/23/12	
Agency Review Period	180 days	Tue 1/24/12	Sat 7/21/12	
Permit Approved	0 days	Sat 7/21/12	Sat 7/21/12	
WDNR NR216- Construction Stormwater Permit	**45 days**	**Mon 1/23/12**	**Thu 3/8/12**	
Submit Permit Application	0 days	Mon 1/23/12	Mon 1/23/12	
Agency Review Period	45 days	Tue 1/24/12	Thu 3/8/12	
Permit Approved	0 days	Thu 3/8/12	Thu 3/8/12	
WDNR NR205- Carriage and Interstitial Water from Dredging Operations General Permit	**30 days**	**Mon 1/23/12**	**Wed 2/22/12**	
Submit Permit Application	0 days	Mon 1/23/12	Mon 1/23/12	
Agency Review Period	30 days	Tue 1/24/12	Wed 2/22/12	
Permit Approved	0 days	Wed 2/22/12	Wed 2/22/12	
WDNR Water Quality Variance	**60 days**	**Mon 11/15/10**	**Fri 2/4/11**	
Submit Variance Request	0 days	Mon 11/15/10	Mon 11/15/10	
Agency Review Period	60 days	Mon 11/15/10	Fri 2/4/11	
Varinace Approved	0 days	Fri 2/4/11	Fri 2/4/11	
Section 7 Endangered Species Consultation -U.S. Fish and Wildlife Service	**30 days**	**Thu 9/1/11**	**Fri 9/30/11**	
Submit Letter	0 days	Thu 9/1/11	Thu 9/1/11	
Agency Review Period	30 days	Thu 9/1/11	Fri 9/30/11	
Letter Response Received	0 days	Fri 9/30/11	Fri 9/30/11	
Possible Field Check - Assumes No Activity Required	0 days	Fri 9/30/11	Fri 9/30/11	
WDNR Natural Heritage Inventory Review	**30 days**	**Thu 9/1/11**	**Fri 9/30/11**	
Submit Letter	0 days	Thu 9/1/11	Thu 9/1/11	
Agency Review Period	30 days	Thu 9/1/11	Fri 9/30/11	
Letter Response Received	0 days	Fri 9/30/11	Fri 9/30/11	
Possible Field Check - Assumes No Activity Required	0 days	Fri 9/30/11	Fri 9/30/11	
Section 106- Cultural Resources Review - Wisconsin State Historical Society	**30 days**	**Thu 9/1/11**	**Fri 9/30/11**	
Submit Letter	0 days	Thu 9/1/11	Thu 9/1/11	
Agency Review Period	30 days	Thu 9/1/11	Fri 9/30/11	
Letter Response Received	0 days	Fri 9/30/11	Fri 9/30/11	
Possible Field Check - Assumes No Activity Required	0 days	Fri 9/30/11	Fri 9/30/11	
Local Permits	**30 days**	**Mon 1/23/12**	**Wed 2/22/12**	
Submit Local Permits	0 days	Mon 1/23/12	Mon 1/23/12	
Wastewater Coordination- City of Marinette	30 days	Tue 1/24/12	Wed 2/22/12	
Soil Erosion and Sediment Control (SESC) Permit- City	30 days	Tue 1/24/12	Wed 2/22/12	
Building Permit - City	30 days	Tue 1/24/12	Wed 2/22/12	

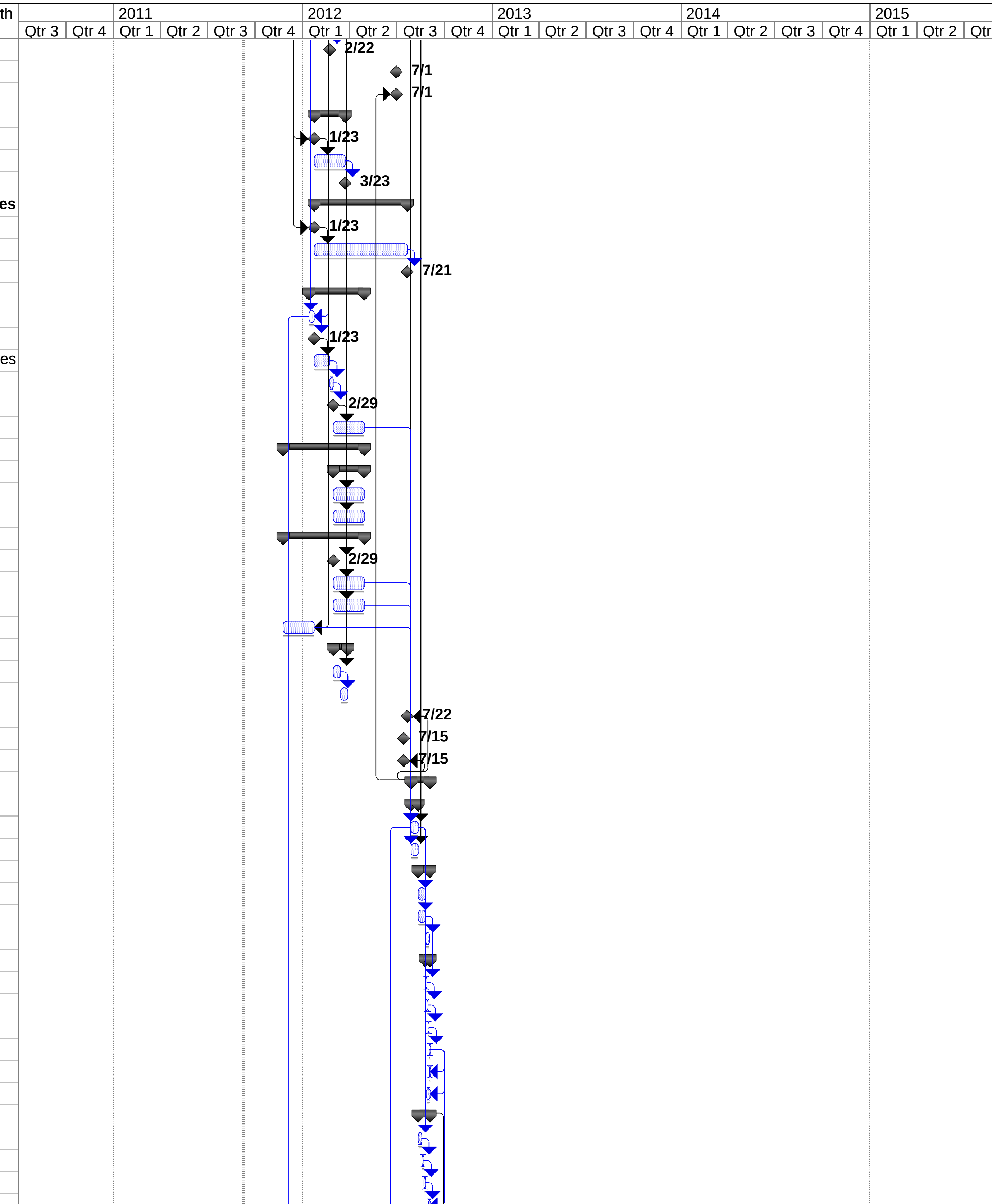


Project: Tyco Combination Remedy
Date: Thu 9/8/11

Legend: Task; Split; Progress; Milestone; Summary; Project Summary; External Tasks; External Milestone; Deadline

Figure 13 - Proposed Enhanced Sediment Removal Plan Project Schedule

Task Name	Duration	Start	Finish	Critical Path
Local Permits Approved	0 days	Wed 2/22/12	Wed 2/22/12	
Coast Guard Bulletin	**0 days**	**Sun 7/1/12**	**Sun 7/1/12**	
Notification	0 days	Sun 7/1/12	Sun 7/1/12	
Access Agreements	**60 days**	**Mon 1/23/12**	**Fri 3/23/12**	
Submit Agreements to Property Owners	0 days	Mon 1/23/12	Mon 1/23/12	
Property Owner Review Period and Negotiations	60 days	Tue 1/24/12	Fri 3/23/12	
Agreement Signed	0 days	Fri 3/23/12	Fri 3/23/12	
Resource Conservation and Recovery Act - Onsite Treatment Variance	**180 days**	**Mon 1/23/12**	**Sat 7/21/12**	**Yes**
Request Submittal to Agencies	0 days	Mon 1/23/12	Mon 1/23/12	
Agency Review Period	180 days	Tue 1/24/12	Sat 7/21/12	
Permit Approved	0 days	Sat 7/21/12	Sat 7/21/12	
Procurement	**107 days**	**Sat 1/14/12**	**Sun 4/29/12**	
Prepare Bid Package	10 days	Sat 1/14/12	Mon 1/23/12	
Pre-final Bid Package Completed, to EPA for Review	0 days	Mon 1/23/12	Mon 1/23/12	
EPA Review	30 days	Tue 1/24/12	Wed 2/22/12	Yes
Incorporate EPA Comments	7 days	Thu 2/23/12	Wed 2/29/12	
Final Bid Package Completed	0 days	Wed 2/29/12	Wed 2/29/12	
Procurement of Dredger	60 days	Thu 3/1/12	Sun 4/29/12	
Prepare Plans and Fact Sheets	**157 days**	**Fri 11/25/11**	**Sun 4/29/12**	
Plans without AOC-specified Deadlines	**60 days**	**Thu 3/1/12**	**Sun 4/29/12**	
H&S Plan	60 days	Thu 3/1/12	Sun 4/29/12	
QA/QC Plan	60 days	Thu 3/1/12	Sun 4/29/12	
Plans with AOC-specified Deadlines	**157 days**	**Fri 11/25/11**	**Sun 4/29/12**	
Project Manual (combined design plan and bid package)	0 days	Wed 2/29/12	Wed 2/29/12	
Confirmation Sampling Plan	60 days	Thu 3/1/12	Sun 4/29/12	
Construction Quality Assurance Plan	60 days	Thu 3/1/12	Sun 4/29/12	
O & M Plan	60 days	Fri 11/25/11	Mon 1/23/12	
Fact Sheet	**28 days**	**Thu 3/1/12**	**Wed 3/28/12**	
Distributed to USEPA	14 days	Thu 3/1/12	Wed 3/14/12	
Distributed to Public	14 days	Thu 3/15/12	Wed 3/28/12	
Pre-construction Inspection Meeting	0 days	Sun 7/22/12	Sun 7/22/12	
Work Start Notification	**0 days**	**Sun 7/15/12**	**Sun 7/15/12**	
Notification of USEPA (14 days prior)	0 days	Sun 7/15/12	Sun 7/15/12	
Mobilization	**37 days**	**Sun 7/29/12**	**Mon 9/3/12**	
Set up Solidification Pad	**14 days**	**Sun 7/29/12**	**Sat 8/11/12**	
Install Sumps and Water Collection Piping	14 days	Sun 7/29/12	Sat 8/11/12	
Install Dock Upgrades	14 days	Sun 7/29/12	Sat 8/11/12	
Mobilize WWT System	**22 days**	**Sun 8/12/12**	**Sun 9/2/12**	
RO Unit	14 days	Sun 8/12/12	Sat 8/25/12	
Filter Press	14 days	Sun 8/12/12	Sat 8/25/12	
Pumps and Piping	8 days	Sun 8/26/12	Sun 9/2/12	
Mobilize Solidification Equipment	**9 days**	**Sun 8/26/12**	**Mon 9/3/12**	
Screening Plant	3 days	Sun 8/26/12	Tue 8/28/12	
Percarbonate pugmill	2 days	Wed 8/29/12	Thu 8/30/12	
Rapid Mix	2 days	Fri 8/31/12	Sat 9/1/12	
Conveyors	2 days	Sun 9/2/12	Mon 9/3/12	
Cement Pig	1 day	Mon 9/3/12	Mon 9/3/12	
Place Bin Blocks	7 days	Tue 8/28/12	Mon 9/3/12	
Mobilize Dredge	**23 days**	**Sun 8/12/12**	**Mon 9/3/12**	
Assemble Flexifloats	7 days	Sun 8/12/12	Sat 8/18/12	
Install Spuds	4 days	Sun 8/19/12	Wed 8/22/12	
Mob Excavator and Bucket	3 days	Thu 8/23/12	Sat 8/25/12	
Install and Configure GPS/Trimble	3 days	Sat 9/1/12	Mon 9/3/12	

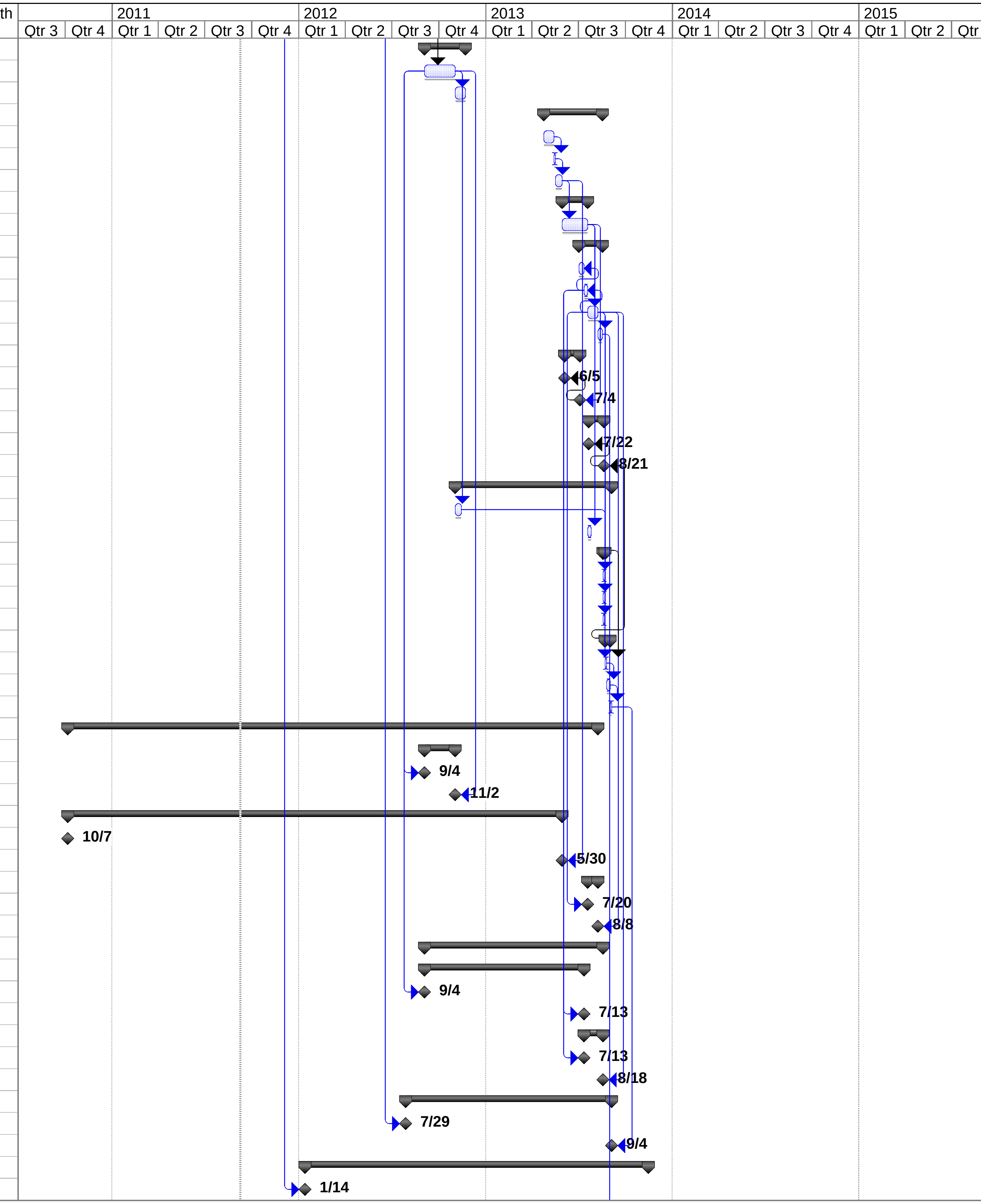


Project: Tyco Combination Remedy
Date: Thu 9/8/11

Task		Progress		Summary		External Tasks		Deadline
Split		Milestone		Project Summary		External Milestone		

Figure 13 - Proposed Enhanced Sediment Removal Plan Project Schedule

Task Name	Duration	Start	Finish	Critical Path
2012 Dredging Tasks	**80 days**	**Tue 9/4/12**	**Thu 11/22/12**	
Dredge Soft Sediment (75,000 CY)	60 days	Tue 9/4/12	Fri 11/2/12	
Interim Demobilization	20 days	Sat 11/3/12	Thu 11/22/12	
2013 Dredging Tasks	**115 days**	**Thu 4/25/13**	**Sat 8/17/13**	
Interim Mobilization	20 days	Thu 4/25/13	Tue 5/14/13	
Dredge Soft Sediment (3,000 CY)	3 days	Wed 5/15/13	Fri 5/17/13	
Dredge Semi-consolidated Materials (13,000 CY)	13 days	Sat 5/18/13	Thu 5/30/13	
Placement of Chemical Isolation Layer	**50 days**	**Fri 5/31/13**	**Fri 7/19/13**	
Placement of Chemical Isolation Layer Materials	50 days	Fri 5/31/13	Fri 7/19/13	
South Channel Dredging	**46 days**	**Wed 7/3/13**	**Sat 8/17/13**	
Install Sheet Pile	10 days	Wed 7/3/13	Sat 7/13/13	
Pump Free Water	7 days	Sat 7/13/13	Sat 7/20/13	
In-situ Stabilization	20 days	Sat 7/20/13	Thu 8/8/13	
Remove Sheet Pile	9 days	Fri 8/9/13	Sat 8/17/13	
Pre-final Constr. Inspection (at 80% compl.)	**30 days**	**Wed 6/5/13**	**Thu 7/4/13**	
Notification of USEPA (30 days prior)	0 days	Wed 6/5/13	Wed 6/5/13	
Pre-final Inspection	0 days	Thu 7/4/13	Thu 7/4/13	
Final Construction Inspection (at completion)	**30 days**	**Mon 7/22/13**	**Wed 8/21/13**	
Notification of USEPA (30 days prior)	0 days	Mon 7/22/13	Mon 7/22/13	
Final Construction Inspection	0 days	Wed 8/21/13	Wed 8/21/13	
Demobilization/Site Restoration	**306 days**	**Sat 11/3/12**	**Wed 9/4/13**	
Demobilize Solidification Equipment	12 days	Sat 11/3/12	Wed 11/14/12	
Demobilize Dredge	7 days	Sat 7/20/13	Fri 7/26/13	
Demobilize WWT System	**4 days**	**Mon 8/19/13**	**Thu 8/22/13**	
RO Unit	4 days	Mon 8/19/13	Thu 8/22/13	
Filter Press	4 days	Mon 8/19/13	Thu 8/22/13	
Pumps and Piping	3 days	Mon 8/19/13	Wed 8/21/13	
Site Restoration	**10 days**	**Fri 8/23/13**	**Sun 9/1/13**	
Clean Solidification Area	3 days	Fri 8/23/13	Sun 8/25/13	
Resurface Solidification Area	7 days	Mon 8/26/13	Sun 9/1/13	
Demob Project Trailer	3 days	Mon 9/2/13	Wed 9/4/13	
Transportation and Disposal	**961 days**	**Thu 10/7/10**	**Thu 8/8/13**	
Soft Sediment	**60 days**	**Tue 9/4/12**	**Fri 11/2/12**	
Start	0 days	Tue 9/4/12	Tue 9/4/12	
End	0 days	Fri 11/2/12	Fri 11/2/12	
Semi-consolidated Materials	**891 days**	**Thu 10/7/10**	**Thu 5/30/13**	
Start	0 days	Thu 10/7/10	Thu 10/7/10	
End	0 days	Thu 5/30/13	Thu 5/30/13	
South Channel Sediment	**20 days**	**Sat 7/20/13**	**Thu 8/8/13**	
Start	0 days	Sat 7/20/13	Sat 7/20/13	
End	0 days	Thu 8/8/13	Thu 8/8/13	
Water Treatment	**349 days**	**Tue 9/4/12**	**Sun 8/18/13**	
50 GPM Operations	**312 days**	**Tue 9/4/12**	**Sat 7/13/13**	
Start	0 days	Tue 9/4/12	Tue 9/4/12	
End	0 days	Sat 7/13/13	Sat 7/13/13	
150 GPM Operations	**37 days**	**Sat 7/13/13**	**Sun 8/18/13**	
Start	0 days	Sat 7/13/13	Sat 7/13/13	
End	0 days	Sun 8/18/13	Sun 8/18/13	
Project Oversight	**403 days**	**Sun 7/29/12**	**Wed 9/4/13**	
Start	0 days	Sun 7/29/12	Sun 7/29/12	
End	0 days	Wed 9/4/13	Wed 9/4/13	
Project Management	**672 days**	**Sat 1/14/12**	**Fri 11/15/13**	
Start	0 days	Sat 1/14/12	Sat 1/14/12	



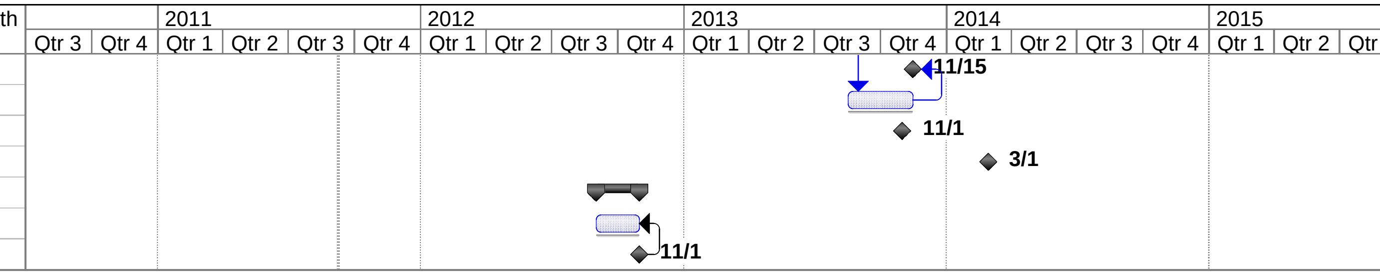
Project: Tyco Combination Remedy
Date: Thu 9/8/11

Task		Progress		Summary		External Tasks	
Split		Milestone		Project Summary		External Milestone	

Deadline

Figure 13 - Proposed Enhanced Sediment Removal Plan Project Schedule

Task Name	Duration	Start	Finish	Critical Path
End	0 days	Fri 11/15/13	Fri 11/15/13	
Final Report	90 days	Sun 8/18/13	Fri 11/15/13	
AOC Deadline for Sediment Removal Completion	0 days	Fri 11/1/13	Fri 11/1/13	
AOC Deadline for Sediment Construction Completion Report	0 days	Sat 3/1/14	Sat 3/1/14	
MNR Plan	**60 days**	**Sun 9/2/12**	**Thu 11/1/12**	
Development of MNR Plan	60 days	Sun 9/2/12	Thu 11/1/12	
Submittal of MNR Plan	0 days	Thu 11/1/12	Thu 11/1/12	



Project: Tyco Combination Remedy Date: Thu 9/8/11	Task		Progress		Summary		External Tasks		Deadline
	Split		Milestone		Project Summary		External Milestone		

Appendix A

Chemical Isolation Layer

Correspondence
10300 Indigo Broom Loop
Austin, TX 78733

From: Danny D. Reible, PhD, PE *Date: August 28, 2011*

To: Douglas Clark
P.O. Box 1497
150 South Gilman Street
Madison, Wi 53701-1497

Re: Tyco-Ansul Stanton Street Facility near the Menominee River

The protectiveness of a chemical isolation layer at this site was evaluated. This evaluation was based upon the following assumptions

- All soft sediments in excess of 50 mg/kg dredging will be removed
- Semi-consolidated sediments will also be removed as necessary to maintain the authorized navigation depth in previously dredged areas of the turning basin
- Sediment concentration profiles in the soft sediments and underlying semi-consolidated sediments are well represented by the sediment data collected in 2010 (the first to evaluate the semi-consolidated sediments in detail)
- Sediment-pore water partitioning is approximated by measurements of bulk solids As and filtered pore water concentrations in 2003 cores
- Onshore remedial efforts will effectively eliminate any potential groundwater upwelling in the near shore sediments leaving diffusion as the primary As transport mechanism

The dredging of the soft sediments and semi-consolidated sediments to the authorized navigation depths will remove a substantial fraction of the arsenic identified by the cores collected in 2010. Some arsenic will remain in the semi-consolidated sediments outside of the previously dredged areas where only the soft sediment containing As at concentrations greater than 50 mg/kg is expected to be dredged. The current evaluation will assess the protectiveness of a chemical isolation layer placed to effectively contain this remaining arsenic. This evaluation does not represent a final isolation layer design but instead evaluates the potential protectiveness of such a layer and identifies the key characteristics, such as thickness and sorption capacity, for such a layer to be protective.

Figure 1 summarizes the depth vs total arsenic concentration data below the proposed post-dredging sediment surface at all core locations where As is expected to remain. The data in the remaining sediments and cores are identified in Attachment A and the locations are shown in Attachment B. Based upon the observed sediment concentrations, a conservative (limiting) hypothetical profile of As was developed to employ in chemical isolation modeling. This is also shown in Figure 1 and represents an As concentration of 560 mg/kg in the upper 5 ft of the post-dredge sediment and an As concentration of 1410 mg/kg in the layer between 5 and 10ft below the sediment surface. An average As profile is also shown which is 79 mg/kg in the upper 5 ft of sediment and 153 mg/kg below that elevation. The average profile is more representative of the areal protectiveness of an isolation layer but the limiting profile shown in Figure 1 will be evaluated herein. For final design a more appropriate areal average concentration profile might be employed such as a 95% upper confidence limit on the mean concentration in each level.

The potential mobile As in the pore water, was estimated using the site specific sediment-water partitioning estimated from cores collected in 2003 as shown in Figure 2 and Attachment C. The observed partitioning was fit to a Freundlich isotherm and are summarized in both mg and µg as units in Equation 1 with ± 1 standard error in each parameter also shown. On average, the fitted isotherm overpredicts the pore water concentration of As in the 2003 data by 34%, thus overpredicting As availability and mobility.

$$W_s(mg/kg) = 46.8(\pm 22\%)C_w^{0.622\pm 0.044} \quad C_w - mg/L$$
$$W_s(\mu g/kg) = 637(\pm 22\%)C_w^{0.622\pm 0.044} \quad C_w - \mu g/L \qquad (1)$$

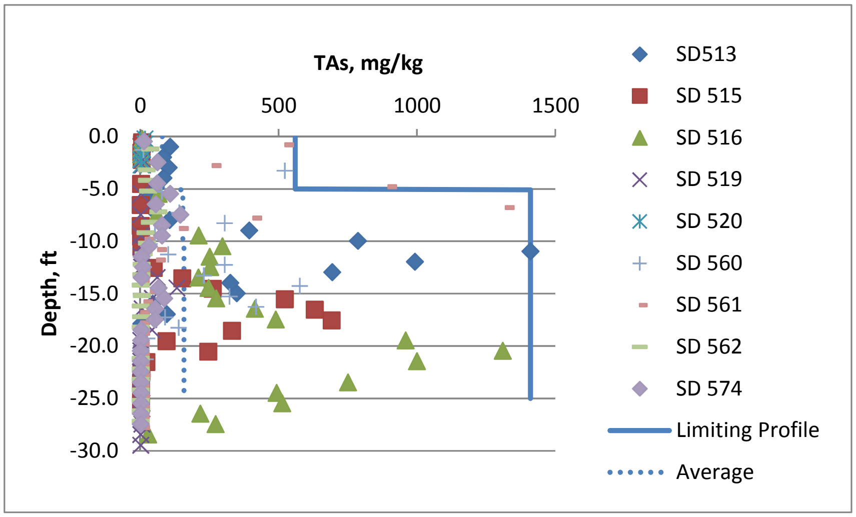


Figure 1- Total As concentration below proposed chemical isolation layer including limiting (maximum) profile and average profile

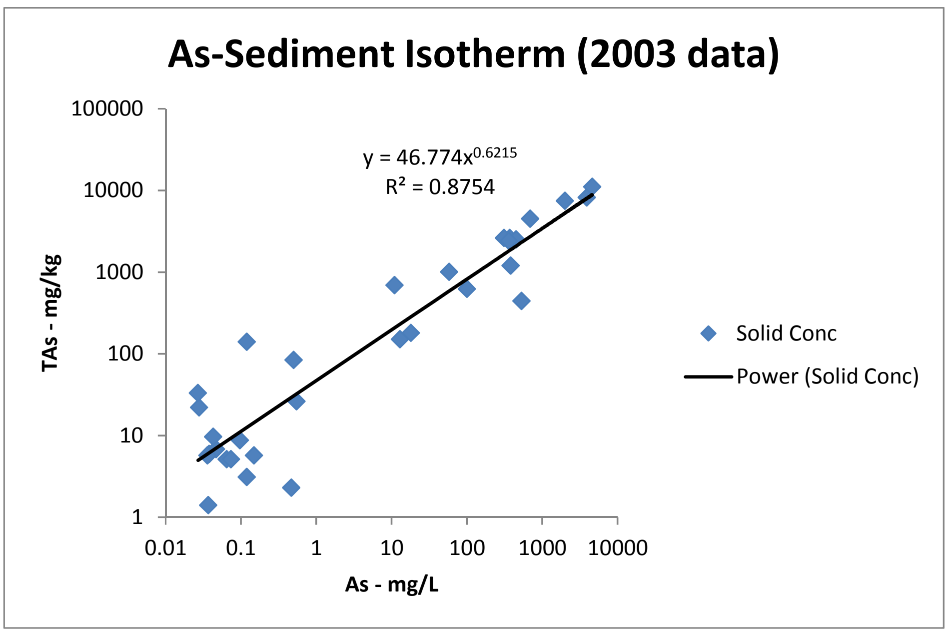


Figure 2 - As sorption isotherm based upon measured sediment and adjacent pore water concentrations (2003 data- included in Attachment C)

The measured partition coefficients of the arsenic range from 0.83 L/kg (at high sediment As concentrations) to 1222 L/kg (at low sediment As concentrations). The As thus behaves similar to a relatively mobile ground water contaminant like benzene at high concentrations and similar to a low molecular weight PAH such as phenanthrene at low concentrations. In general, the conditions at the site are such that the arsenic is quite soluble and mobile compared to many arsenic sites. It is possible that this is an artifact of the pore water sampling in the 2003 cores in which pore water was generated by centrifugation of sediment cores. Processing by centrifugation has the potential to generate additional solids, colloidal matter and arsenic and thereby artificially decrease the apparent solid-water partitioning coefficient. This cannot be confirmed without measurement of arsenic partitioning by other methods, however, and so the relatively low partition coefficients estimated by the 2003 data were employed in the current evaluations.

. For the two layers modeled below the isolation layer, the pore water concentrations are estimated by Equation 1 and are summarized below.

$$\begin{array}{lll} 0-5\text{ ft} & 560\text{ mg/kg} & 54.1\text{ mg/L }(54{,}100\ \mu\text{g/L}) \\ 5-10\text{ ft} & 1410\text{ mg/kg} & 239\text{ mg/L }(239{,}000\ \mu\text{g/L}) \\ >10\text{ ft} & 1410\text{ mg/kg} & 239\text{ mg/L }(239{,}000\ \mu\text{g/L}) \end{array} \quad (2)$$

The migration and release of As was evaluated for several scenarios

- Base case – best estimate of model parameters with various isolation layer thicknesses
- Sensitivity analyses with key model parameter variations

Each of these is described in more detail below. The base case simulation parameters are shown in Table 1 and represent expected values for these parameters. The use of a limiting (maximum) underlying sediment profile (Figure 1) and a sorption isotherm that generally overpredicts pore water concentration (Equation 1) results in predictions that are likely overpredictions of expected As migration in the base case simulation. A sensitivity analysis on key model parameters was also conducted. In all cases, the model predicted concentration at the top of the chemical isolation layer or the bottom of the biologically active zone was compared to Wisconsin surface water standards of 339.8 µg/L (acute) and 152.2 µg/L (chronic).

Table 1 Definition of base case simulation

Parameter	Value or Range	Parameter	Value or Range
Pore water/solid concentration partitioning	Eqn. 1	Particle effective diffusion coefficient in BAZ	1 cm/yr
Upwelling rate	0 cm/yr	Pore water effective diffusion coefficient in BAZ	100 cm^2/yr
Sediment/pore water concentrations under isolation layer	Eqn. 2	Benthic boundary layer mass transfer coefficient	1 cm/yr
Deep sediment concentration	1410 mg/kg	As diffusivity	$1.06\times10^{-5} cm^2/s$
Chemical Isolation Layer	18 in of sediment	Effective diffusivity	Method of Boudreau[1]
Armoring layer	61 cm sand, gravel, rock	Dispersivity	1 cm
Biologically active zone (BAZ)	15.2 cm or entire armor layer	Density, porosity of surface layer Density, porosity of consolidated sediment layers	$1.5 g/cm^3$,0.5 $1.74 g/cm^3$,0.3

1 Boudreau, B. 1997. Diagenetic Models and Their Implementation: Modeling Transport Reactions in Aquatic Sediments. Springer-Verlag, New York.

Base case isolation layer scenarios

Both sand and sediment were considered for isolation layer design. Sand exhibits minimal sorption and thus is unlikely to be an effective isolation layer for the relatively soluble and mobile As at this site. Substantial partitioning information exists for the river sediments, however, and these data suggest that an isolation layer constructed of such sediments could be very effective. Different isolation thicknesses of sediment were modeled assuming that borrow material could be identified from dredging in an uncontaminated portion of the river (e.g. to maintain navigational channel depths) . Sand or sediment would likely not be stable in the face of erosional forces in the river and 24 inches of armoring material are included in the preliminary design. The actual armoring thickness to be employed will depend upon final design based upon expected erosive forces. The thickness of overlying armoring material does not significantly influence the time until surface water criteria are exceeded at the top of the chemical isolation layer. Isolation layers with the following components were evaluated

- Armoring layers
    - o 12 inch armoring layer composed of cobble and rock
    - o 12 inch armor filtering layer of sand and gravel
- Isolation layer
    - o 24 inches of sand, or,
    - o 12 inches of river sediment, or,
    - o 18 inches of river sediment, or,
    - o 24 inches of river sediment.

Evaluation of the protectiveness of the isolation layer was defined by comparison of chronic and acute Wisconsin surface water criteria, 339.8 µg/L and 152.2 µg/L, respectively, to pore water concentrations to at the top of the isolation layer (bottom of the armoring layer, 24 inches below the armor-water interface). Chemical isolation modeling was undertaken assuming diffusion was the primary transport mechanism in base case evaluations, which is consistent with the groundwater cutoff features of the upland remedy. Other model parameters were based upon site specific data or established estimation approaches (1) and were included in Table 1.

Results are summarized in Table 2. Sand is not an effective isolation material due to the high mobility of the arsenic. Sediment, however, can be an effective isolation material and even a 12 inch thick sediment isolation layer will delay the release of As at levels of concern (i.e. greater than surface water criteria concentrations) for more than 100 years. This provides time for natural attenuation processes to ensure recovery of the sediments. The effect of a single natural attenuation process, deposition of clean sediments, is evaluated in the analysis of model sensitivity below.

Alternative sorbent materials could also be used as components of the isolation layer. Activated carbon, organoclay and other sorbents may be effective as a sorbent for arsenic, particularly with the organic As complexes present at this site. Site specific information is needed, however, to select and evaluate the effectivenss of these alternative materials. In general, such an isolation layer will be as successful as the sediment layer as long as $L_{sorbent}W_{sorbent} \geq L_{sediment}W_{sediment}$, where L represents the thickness of the layers and W represents the sorption capacity.

Table 2- Base case isolation layer design based upon diffusion. Time to exceedance of criteria estimated at top of chemical isolation layer and bottom of 24 in (61)

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1 Lampert, D.J., D. D. Reible, An Analytical Modeling Approach for Evaluation of Capping of Contaminated Sediments, Soil and Sediment Contamination: An International Journal, 18, 4, 470-488 (2009)

cm armor layer

Description	Thickness (Inches)	Flux at time of chronic criteria (mg/m^2/yr)	Time until exceedance of chronic criteria assuming no natural attenuation (years)	Time until exceedance of acute criteria assuming no natural attenuation (years)
Cap – Sand	**24**	**4**	**0.9**	**1.1**
Chemical isolation layer	**12**	**3.1**	**132**	**141**
	18	**2.3**	**247**	**264**
	24	**1.3**	**531**	**572**

Sensitivity Analysis

The effect of natural attenuation was assessed by considering the deposition of clean sediment in the armoring pore space. For purposes of this calculation, half of the armor pore space was assumed to accumulate deposited sediments over the course of 100 years. As shown in Table 4, this dramatically increased the period over which an 18 inch isolation layer was expected to be protective to 745 years. This illustrates how the chemical isolation layer can provide containment until natural containment/attenuation processes become dominant and ensure the remedy remains protective indefinitely.

The sensitivity of the isolation layer design to ground water upwelling was assessed by increasing vertical Darcy velocities to 2 and 10 cm/yr. These simulations evaluate the possibility of incomplete isolation of the ground water flow although the upland remedy is designed to eliminate ground water exchange between the river sediments and the contaminated upland soil. These reduced the period of time over which the isolation layer would be expected to be protective but containment can still be assured for significant periods of time (147 years at 2 cm/yr and 57 years at 10 cm/yr, both scenarios assuming no natural attenuation). The period of protectiveness would also increase substantially if any natural attenuation were assumed, for example, if clean sediment were to be deposited within the armoring layer.

Simulations were also conducted using a low sorption estimate and high sorption estimate in which both isotherm parameters were adjusted by their standard error.

$$W_s(\mu g/kg) = 524 C_w^{0.579} \quad C_w - \mu g/L \quad C_w(0-5\,ft) = 102{,}000\,\mu g/L \quad (Low\,sorption)$$

$$W_s(\mu g/kg) = 775 C_w^{0.666} \quad C_w - \mu g/L \quad C_w(0-5\,ft) = 31{,}000\,\mu g/L \quad (High\,sorption)$$

As shown in Table 3, the changes in the sorption parameters do affect isolation layer performance, but in no case was exceedances of surface water criteria in the porewater expected within 100 years, even in the absence of natural attenuation. The results of all sensitivity analyses are summarized in Table 4.

Table 3- Sensitivity analysis of chemical isolation layer design

Description Modification from base case (18 inch layer, no upwelling, best fit sorption)	Flux at time of chronic criteria ($mg/m^2/yr$)	Time until exceedance of chronic criteria assuming no natural attenuation (years)	Time until exceedance of acute criteria assuming no natural attenuation (years)
Base Case	2.3	247	264
Base Case w/deposition of sediment filling half of armor porespace*	5.7	745	817
Base Case + 2 cm/yr	7.7	147	150
Base Case + 10 cm/yr	55	57	57
Base Case + High Sorption	1.3	524	585
Base Case + Low Sorption	4.4	111	116
24" Sediment + Low Sorption	2.4	238	249

* the case of deposition into the armoring illustrates the effect of some natural attenuation by clean sediment deposition into the armor space. The base case is used for illustration but other scenarios would show similar increases in period of protectiveness with natural attenuation

Conclusions

Placing a chemical isolation layer over the sediments remaining after the proposed dredging activites suggests that such a layer can be protective if constructed from a sorbing material that exhibits at least as much sorption as the existing sediments. An effective chemical isolation layer thickness of 18 inches would result in an essentially permanent remedy once expected natural attenuation processes such as deposition of clean sediment are taken into account. The actual material employed as a containment material could be natural sediments from the adjacent channel or artificial material with sorption equal to or greater than the adjacent sediments. Additional study is warranted to evaluate the site specific performance of any artificial amendments.

The information on the existing sediments, however, provides a high degree of confidence that the As can be absorbed and migration retarded sufficiently to develop a protective isolation layer design using only river sediments. Maximum effectiveness can be achieved by ensuring that the containment layer remains in place (i.e. through armoring) and by maintaining the effectiveness of the hydraulic isolation from the upland contamination.

It should be emphasized that the evaluation presented herein is based upon concentrations in the most impacted cores and uses a sorption isotherm that generally overpredicts pore water concentrations and As availability and mobility. On average and in other locations, the chemical isolation layer would provide an even greater degree of protectiveness than predicted herein.

Attachment A – Cores in the area where residual As is expected. Red indicates concentrations in excess of 50 mg/kg and yellow between 20 and 50 mg/kg in the residual sediments.

Residual Concentrations																	
Depth, ft	SD513	Depth, ft	SD 515	Depth,ft	SD 516	Depth, ft	SD 519	Depth, ft	SD 520	Depth, ft	SD 560	Depth, ft	SD 561	Depth, ft	SD 562	Depth, ft	SD 574
-0.3	4.2	-0.55	6.9	-0.25	6.8	-0.25	8.7	-0.25	17.7	-1.3	10.8	-0.8	524	-1.2	37	-0.5	13.2
-1.0	108	-1.55	4.6	-0.75	5.6	-0.75	8.5	-0.75	17.5	-3.3	523	-2.8	261	-3.2	23.3	-2.5	62.4
-2.0	82.6	-2.25	4.8	-1.25	4.3	-1.25	3.1	-1.25	8.6	-5.3	77.1	-4.8	896	-4.2	24.1	-4.5	61.3
-3.0	103	-4.55	3	-1.75	3.5	-1.75	2.5	-1.75	3.9	-7.3	141	-6.8	1320	-5.2	28.8	-5.5	108
-4.0	83.7	-6.55	2.5	-2.2	5.9	-2.25	2.3	-2.25	2.1	-8.3	305	-7.8	408	-7.2	65.6	-6.5	55.7
-5.0	52.6	-8.55	2.5	-5.5	66.5	-2.75	2.6	-2.75	2.9	-9.3	52.7	-8.8	143	-8.2	34.6	-7.5	145
-6.0	24.4	-9.55	3.2	-7.5	60.3	-5.5	4.3			-10.3	33.3	-9.8	18.4	-9.2	19.5	-8.5	79.1
-7.0	44.7	-10.55	3.8	-9.5	211	-7.5	4.8			-11.3	101	-10.8	64.3	-10.2	24.7	-9.5	78.4
-8.0	106	-12.55	48.8	-10.5	297	-9.5	61.7			-12.3	305	-11.8	60	-11.2	12.5	-10.5	31.3
-9.0	394	-13.55	152	-11.5	251	-10.5	133			-13.3	230	-12.8	4	-12.2	5.3	-11.5	5.5
-10.0	787	-14.55	262	-12.5	253	-11.5	44			-14.3	577	-13.8	2.4	-13.2	4.1	-12.5	10.5
-11.0	1410	-15.55	522	-13.5	210	-12.5	6.9			-15.3	322	-14.8	38.2	-14.2	2.2	-13.5	5.1
-12.0	993	-16.55	631	-14.5	247	-13.5	30.9			-16.3	418	-15.8	14.2	-15.2	5.8	-14.5	66.3
-13.0	694	-17.55	692	-15.5	275	-14.5	42.5			-17.3	89.5	-16.8	3.2	-16.2	2.5	-15.5	87.2
-14.0	326	-18.55	332	-16.5	414	-15.5	2.3			-18.3	139	-17.8	2.3	-17.2	3.4	-16.5	53.8
-15.0	349	-19.55	94.6	-17.5	490	-16.5	1.7			-19.3	25.8	-18.8	3	-18.2	2.3	-17.5	53.2
-16.0	45.1	-20.55	246	-19.5	959	-17.5	2.3			-20.3	4	-19.8	2.1	-21.2	2	-18.5	4.5
-17.0	95.7	-21.55	22.1	-20.5	1310	-18.5	1.5			-21.3	19.8	-20.8	2.2	-22.2	1.7	-19.5	2.8
-17.9	4.6	-22.55	4.3	-21.5	1000	-19.5	2.3			-22.3	1.4	-21.8	2.4	-23.2	1.9	-20.5	2.4
		-23.55	3.3	-23.5	751	-20.5	1.6			-23.3	8.7	-22.8	5.9	-24.2	2.1	-21.5	2.1
		-24.55	2.7	-24.5	493	-21.5	6			-24.3	1.7	-23.8	2.5	-25.2	2.4	-22.5	2
		-25.55	3.3	-25.5	513	-22.5	1.9			-25.3	3.5	-24.8	2.6	-26.2	1.9	-23.5	2.3
				-26.5	217	-23.5	6.3			-26.3	2.9	-25.8	2.9	-27.2	1.6	-24.5	3.1
				-27.5	273	-24.5	1.8					-26.8	2.1			-25.5	3.1
				-28.5	28.6	-25.5	2.5					-27.8	2.7			-26.5	2
						-26.5	2.4									-27.5	2.1
						-27.5	2.6										
						-28.5	3										

Attachment B – Core locations

Attachment C –
Dissolved As vs Sediment Concentration (2003 data). On average the fitted isotherm overpredicts As pore water concentration (and therefore its availability and mobility) by 34%

Dissolved As in Pore Water					
		Sed Conc (mg/kg)	Dissolved As (ug/L)	Dissolved As (mg/L)	Pred Diss. As (mg/L)
PW302002.5	0.5 - 2.5	150	13000	13	6.51
PW303000.5	0.0 - 0.5	2600	370000	370	638.30
PW303002	0.5 - 2	8200	3900000	3900	4045.97
PW304000.5	0.0 - 0.5	690	11000	11	75.65
PW304001.5	0.5 - 1.5	2500	450000	450	599.30
PW305000.5	0.0 - 0.5	8.7	97	0.097	0.07
PW306000.5	0.0 - 0.5	2600	310000	310	638.30
PW306002.5	0.5 - 2.5	7400	2000000	2000	3430.42
PW306003.75	2.5 - 3.75	11000	4600000	4600	6488.33
PW307000.5	0.0 - 0.5	1200	380000	380	184.15
PW308000.5	0.0 - 0.5	180	18000	18	8.72
PW309000.5	0.0 - 0.5	84	500	0.5	2.56
PW310000.5	0.0 - 0.5	5.1	65	0.065	0.03
PW311000.5	0.0 - 0.5	5.1	74	0.074	0.03
PW311002.5	0.5 - 2.5	5.9	38	0.038	0.04
PW311003.6	2.5 - 3.6	6.8	47	0.047	0.04
PW312000.5	0.0 - 0.5	2400	360000	360	561.23
PW312002.2	0.5 - 2.2	440	530000	530	36.70
PW313000.5	0.0 - 0.5	140	120	0.12	5.82
PW313002.5	0.5 - 2.5	620	100000	100	63.69
PW313003.5	2.5 - 3.5	4500	690000	690	1541.88
PW314000.5	0.0 - 0.5	1000	58000	58	137.36
PW316000.5/D	0.0 - 0.5	26	550	0.55	0.39
PW317000.5	0.0 - 0.5	5.7	36	0.036	0.03
PW319000.5	0.0 - 0.5	22	28	0.028	0.30
PW319002.5	0.5 - 2.5	9.6	43	0.043	0.08
PW320002.8	0.5 - 2.8	3.1	120	0.12	0.01
PW321001.0	0.5 - 1.0	5.7	150	0.15	0.03
PW321002.8	0.5 - 2.8	1.4	37	0.037	0.00
PW322000.5	0.0 - 0.5	33	27	0.027	0.57
PW325000.5	0.0 - 0.5	2.3	470	0.47	0.01
			Average	445	596

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Appendix B
Cost Estimate

APPENDIX B
Enhanced Scenario Cost Estimate with Full Cap and Dry Excavation Expansion to 50 mg/kg
Tyco Fire Products, LP, Marinette, Wisconsin

Item	Task	Estimated Quantity	Unit	Unit Price	Extended Total
A	Lump Sum Items				
A.1	Insurance Premiums	1	LS	$234,867.81	$234,868
A.2	Performance and Payment Bonds	1	LS	$234,867.81	$234,868
A.3	Mobilization	1	LS	$489,683.38	$489,683
A.4	Infrastructure Construction	1	LS	$244,801.03	$244,801
A.5	Site Maintenance (includes pumping wastewater to water treatment system)	1	LS	$40,000.00	$40,000
A.6	Surveys	1	LS	$86,481.40	$86,481
A.7	Site Restoration	1	LS	$50,000.00	$50,000
A.8	Demobilization	1	LS	$328,231.25	$328,231
A.9	Subcontract Closeout	1	LS	$11,000.00	$11,000
A.10	Interim Demobilization	1	LS	$695,544.88	$695,545
B	Unit Price Items				
B.1	Mechanical Dredging of Soft Sediment	77,673	CY	$19.97	$1,550,909
B.2	Mechanical Dredging of Semi-consolidated Sands and Silts	12,887	CY	$25.52	$328,852
B.3	Dry Excavation of Soft Sediment	12,028	CY	$12.93	$155,481
B.4	Phase 2B - Dry Excavation of Semiconsolidated Sand and Silt	0	CY	$-	$-
B.5	Supply Fluidized Bed Boiler Ash Reagent	6,225	TON	$60.50	$376,636
B.6	Supply Portland Cement Reagent	0	TON	$-	$-
B.7	Supply Sodium Polyacrylate (SAP) Reagent	0	TON	$-	$-
B.8	Supply 60% Ferric Sulfate Solution Reagent	1,038	TON	$286.00	$296,743
B.9	Supply Calcium Hypochlorite Reagent	623	TON	$2,090.00	$1,301,105
B.10	Mix Reagents, Stockpile Sediment on Pad	92,923	CY	$9.90	$919,496
B.11	Load Stabilized Materials into Trucks, Transport and Dispose at RCRA Subtitle D Landfill	124,252	TON	$31.69	$3,937,050
B.12	Load Stabilized Materials into Trucks, Transport and Dispose at RCRA Subtitle C Landfill	0	TON	$-	$-
B.13	Water Treatment	5,016,112	GAL	$0.67	$3,349,304
B.14	Debris Removal and RCRA Subtitle D Disposal	168	TON	$111.43	$18,704
B.15	Mechanical Dredge Standby Time	50	HR	$1,087.80	$54,390
B.16	8th Street Slip Sheet Piling Reinforcement	0	LS	$1,417,836.00	$-
B.17	CAMU Construction	0	LS	$4,508,160	$-
B.18	Demolition of Building 59	0	LS	$1,237,559	$-
B.19	Chemical Isolation Layer Placement	29,900	SY	$77.33	$2,312,117
				Total:	**$17,016,265**
	TOTAL WITHOUT CONTINGENCY				**$17,016,265**
	Project Management		0%		$-
	Remedial Design				$600,000
	Construction Management		7%		$1,191,139
	Other Contingency				$4,500,000
	Total Estimated COST				**$23,307,403**
	Estimate Range				
	Top estimate range +50%	50%			$34,961,105
	Bottom estimate range -30%	-30%			$16,315,182

This estimate is offered as an opinion of cost to perform the work and is not an offer to contract for construction services, procure and/or provide such services